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RESEARCH ARTICLE

Influence of agricultural infrastructure construction on agricultural total factor productivity

Diane Benavides

Asia Pacific Academy of Science Pte. Ltd.

***CORRESPONDENCE:** Diane Benavides; d.benavides@apacsci.com

ABSTRACT

The development of agriculture has been attracting worldwide attention. At present, in order to realize the transformation from traditional agriculture to modern agriculture and from extensive management to intensive management, the development of agricultural economy mainly depends on the improvement of factor input efficiency, optimization of the combination mode of production factors, technological progress, organization and system innovation. It means that the growth of agriculture depends on the growth of total factor productivity. This article mainly discusses the influence of rural infrastructure investment on agricultural total factor productivity, and studies the way to promote the transformation of agricultural economic growth mode through rural infrastructure investment so as to provide decision-making basis for formulating scientific rural infrastructure investment policies. It is of great theoretical and practical significance to study the growth of agricultural total factor productivity from the perspective of rural infrastructure investment.

Keywords: *infrastructure; agricultural total factor productivity; trend analysis; agricultural economy*

1. Introduction

Infrastructure can not only promote economic growth directly, but also indirectly through scale effect and network effect. In the process of agricultural development, the role of infrastructure cannot be underestimated. The National Development and Reform Commission divides rural infrastructure into four categories: agricultural productive infrastructure (including irrigation and drainage facilities, and circulation facilities of agricultural products), rural living infrastructure (including rural road facilities, energy facilities, and drinking water facilities), infrastructure for rural social development, and ecological environment construction. Among them, irrigation and drainage facilities are the main requirements for increasing agricultural production and income; rural road facilities play an important role in strengthening urban-rural ties and circulation of agricultural products; and rural power facilities are necessary conditions for rural residents' production and life.

In recent years, there has been more research on the relationship between rural infrastructure construction and agricultural development, which mainly focuses on the impact of rural infrastructure on agricultural output, while there are relatively few discussions about the

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impact of rural infrastructure construction on agricultural productivity, and few literatures have analyzed the effect of infrastructure on agricultural technical efficiency. Mamatzakis believes that infrastructure is complementary to agricultural intermediate products and private capital, substitutable to labor, and can effectively reduce agricultural production costs and improve efficiency[1]. On this basis, Teruel and Kuroda studied the Philippines' highway facilities, irrigation facilities and power facilities, and found that there was a complementary relationship between highway facilities and private agricultural inputs, while irrigation facilities had a substitute relationship with labor and intermediate inputs, thus reducing agricultural production costs[2]. In addition, some scholars in China have studied the influence of agricultural public investment, transportation infrastructure construction and agricultural research investment on agricultural technology efficiency and agricultural development.

2. Theoretical research on agricultural infrastructure construction and agricultural total factor productivity

2.1. Theoretical research on agricultural infrastructure construction

Scholars at home and abroad have done a lot of research on the impact of agricultural infrastructure investment on agricultural production, and most of the empirical studies took the economic growth model as the research framework to study the contribution of infrastructure investment to agricultural output. The effects of infrastructure investment on agricultural production are mainly reflected in three aspects: promoting agricultural growth, reducing production costs and promoting the adjustment of agricultural industrial structure. Theoretical literature analyzes the impact mechanism of infrastructure investment on agricultural production, and empirical literature provides a lot of empirical evidence for the impact effect of rural infrastructure investment.

Most of the existing literatures take the economic growth theory as the framework, and introduce the variables reflecting infrastructure investment into the production function model to estimate the marginal effect of infrastructure on agricultural growth. The measurement of agricultural growth in empirical models is usually reflected by agricultural gross output, agricultural added value or agricultural growth rate. In terms of the estimation method of empirical research, Antle[3], Mundlak[4], etc. ignored the influence of economic environment on rural infrastructure in empirical models, and did not consider the endogeneity of rural infrastructure investment variables, and used ordinary least squares to estimate the parameters; however, Bingswanger, Khandker and Rosenzweig[5], Fan, Zhang and Zhang[6], Fan and Chan-kang[7], etc. advocated to consider the endogenous problem of infrastructure investment variables and the two-way causal relationship between infrastructure investment and economic output in empirical research, and apply simultaneous equations models or generalized method of moments to estimate marginal effect of infrastructure investment.

A large number of literatures focusing on the effect of infrastructure on agricultural growth have emerged in recent years. Antle used the data of 47 developing countries and 19 developed countries to analyze the impact of transportation and communication infrastructure on agricultural output by establishing Cobb Douglas production function model. The research showed that there was a significant positive correlation between the development level of transportation and communication infrastructure and agricultural output. Fan found that the government's expenditure on rural infrastructure and agricultural R&D has an obvious effect on agricultural growth[8]. The research of Bhalla and Singh showed that irrigation investment is beneficial to increase agricultural output, and the diffusion of agricultural technology, such as adopting new varieties, also depends on the improvement of material and institutional infrastructure[9]. Thorat and Sirohi used 10 explanatory variables covering physical infrastructure, finance and research infrastructure, namely transportation, electricity, irrigation, tractor, research, technology extension institutions, rural credit resources, wholesale market, convenience of fertilizer stores and commercial bank outlets, to study the effects of infrastructure on agricultural development. They found that transportation, electricity, irrigation and R&D have the most significant effects on increasing agricultural output[10]. Teles and Mussolini found that the debt crisis in Argentina, Brazil and Mexico in 1970s led to a large-scale reduction in infrastructure investment, which led to a sharp decline in agricultural productivity[11].

2.2. Theoretical research on agricultural total factor productivity

The connotation of agricultural total factor productivity

Total factor productivity (TFP) reflects the efficiency of transforming input into output by decision-making units in the production process, and reflects the comprehensive effect of various factors except input factors. Single factor productivity measures the ratio of output to single factor input, and its calculation method is simple and intuitive. For example, in agricultural production, land single factor productivity is the agricultural output of unit land, while labor single factor productivity is the agricultural output of unit labor. Total factor productivity can make up for the deficiency that single factor productivity can not fully reflect the process of economic growth, opening up a new research field for analyzing the source of economic growth. Total factor productivity consists of technical progress and technical efficiency. The former reflects the change of frontier output level of constant factor input, and measures the movement of frontier production.

The concept of total factor productivity was first put forward in 1942 by Jan Tinbergen, winner of the first Nobel Prize in Economics. In the production function model, Tinbergen included not only the traditional production factor capital and labor input variables, but also the time trend variables to reflect the production efficiency. However, the influence of non-material production factors such as R&D and education on output was not considered in this model. Subsequently, American economist Stiglitz first measured the TFP of American manufacturing industry in 1947. In 1954, economist Hiam Davis clearly defined the connotation of TFP for the first time in the monograph *Productivity Accounting*, pointing out that all input factors such as labor, capital and raw materials, instead of only some input factors, should be considered comprehensively when calculating TFP. Solow (1956) put forward Solow residual, which holds that the technological progress rate is the residual of deducting the output growth rate from the input growth rate in constant scale return[12]. However, Hulten thought that Solow's residual is actually more in line with the connotation of total factor productivity, as it reflects the proportion in output growth that can not be explained by input growth. Solow's residual reflects not only the change of technological progress, but also the influence of measurement errors, missing variables, random factors, etc., thus it is more appropriate to be treated as total factor productivity[13]. Dension drawing lessons from Solow model, pointed out that TFP growth rate can be measured by the output growth rate minus the growth rate of various factor inputs[14]. According to Jorgenson and Grilliches, if all input factors are taken into account in the production function model with no measurement error in various input factor variables, the total factor productivity should be zero[15]. Jorgenson made a systematic study on TFP in 1980s and pointed out that TFP describes the part of output growth that cannot be explained by factor input growth, and reflects the part of output growth brought by factors other than factor input, such as new technology, organization and management ability. Total factor productivity can be decomposed into technological progress, technological efficiency and scale efficiency.

The calculation method of agricultural total factor productivity

There are four methods to measure agricultural total factor productivity: growth accounting, index method, Stochastic Frontier Analysis (SFA) and Data Envelope Analysis (DEA). The first two methods assume that all decision-making units are technically effective, which is usually used to measure technological progress or TFP change of total time series samples, while the latter two methods do not assume that decision-making units are completely technically effective, and are usually used for cross-sectional data to measure the relative efficiency of decision-making units. With panel data, DEA and SFA can also measure the change of technological progress and technological efficiency. While growth accounting and SFA are parametric methods, index method and DEA are nonparametric methods.

(1) Growth accounting

Growth accounting is based on Solow's residual, using the production function model to estimate the elasticity of input to output. The total factor productivity is equal to the difference obtained by subtracting the weighted sum of input growth rate from output growth rate. As shown in the following formula, Y represents output, and L and K represent labor input and capital input respectively.

$$\frac{d(TFP)}{TFP} = \frac{dY}{Y} - \alpha\frac{dL}{L} - \beta\frac{dK}{K}$$

The key of growth accounting is how to estimate the elasticity of output to input. The common practice in the existing literature is to use the production function model to estimate the elasticity of output to input, or to use the empirical value method to determine it. Therefore, the different estimation methods of input-output elasticity make the calculation results of growth accounting less comparable. In addition, the calculation result of TFP by this method also depends on the choice of production function form. If Cobb-Douglas production function is adopted, it means that the elasticity of output to input is constant, and the marginal substitution rate between inputs is fixed; however, these assumptions may be inconsistent with reality.

(2) Index method

The core idea of index method is to express total factor productivity by the ratio of output index to input index. In the calculation of output index and input index, how to choose the weights of different types of outputs and inputs in the process of summation is involved. Some experts put forward that in the calculation of factor productivity index, the weights of different types of inputs and outputs can be determined by four methods, namely empirical weight, specific weight, sampling weight or elastic weight. There are many other forms of TFP index, such as Divisia index and Tornqvist index.

(3) SFA

Aigner, Lovell and Schmidt[16] and Meeusen and Van Den Broeck[17] independently put forward the basic framework of the stochastic frontier production function model, in which the error term in the traditional production function model is divided into two parts: one part represents the influence of random factors, and the other represents technical inefficiency. SFA mainly follows the idea of traditional production function, and describes the production frontier by determining a suitable frontier production function, that is, first determining the specific production function form accordingly, then using econometric methods to estimate the unknown parameters in the frontier production function, and then calculating the ratio of actual output to potential output. The stochastic frontier treats the production frontier as the result of the interaction of controllable deterministic factors and uncontrollable random factors, and expresses the whole error term as a compound error term, the technical inefficiency term and the random error term.

The advantage of SFA is that it can carry out statistical test on model setting and parameter estimation, and the constructed production frontier is random and can distinguish the influence of random disturbance term and technical inefficiency, and it can also analyze the influencing factors of technical inefficiency by one-step method. However, SFA also has the defect that it needs to determine the production function form and the distribution form of technical inefficiency, and can only analyze the production issue with single output and multiple inputs.

(4) DEA

DEA mainly applies linear programming technology and Dual Approach to determine the production frontier, whose essence is to construct the production frontier envelope with the help of the observed data of actual production points, then map non-DEA-effective production units to DEA-effective production frontier envelope, then find the relative effective points on the envelope based on certain effectiveness criteria, and evaluate the relative efficiency of each production unit by comparing the degree that non-DEA-effective production units "deviate" from DEA-effective production frontier. The advantage of DEA is that it can analyze the problem of multi-input and multi-output without assuming the form of production function, but the disadvantage is that the frontier constructed by DEA is certain with random errors also classified as technical inefficiency, and it can't carry out statistical test on the results by linear programming method, making the estimated results highly sensitive to abnormal data points.

Factors affecting agricultural total factor productivity

The macro level

(1) Institutional reforms

It is found that the household-based contract system has different effects on agricultural growth in different regions, and institutional reforms have more obvious contribution to TFP than technological progress. The research by Fan et al. also shows that 60% of China's agricultural growth during 1978 to 1984 originated from rural reform, while the rural system reform did not contribute significantly to agricultural growth from 1985 to 2000[18]. Lin pointed out that 47% of the increase in agricultural output during 1978 to 1984 could be attributed to the implementation of household-based contract system, but with the gradual emergence of the effects of institutional reforms, household-based contract system no longer made significant contribution to agricultural growth during 1984 to 1987[19].

(2) Agricultural policies

Research shows that the higher the agricultural tax, the lower the agricultural production efficiency in countries. Main factors affecting agricultural TFP are: agricultural R&D expenditure, technology extension, education investment, agricultural tax and agricultural product price policies. Chen Weiping found that the total factor productivity of corn planting industry was mainly affected by grain circulation system, technological innovation and corn price fluctuation[20]. From 1985 to 2005, the average annual growth rate of total factor productivity of China's planting industry was 1.44%. Among the factors affecting the total factor productivity index of China's planting industry, factors of policies such as reform and opening-up contributed most.

(3) Natural climatic conditions

From 1984 to 1990, China's agricultural growth rate was 1.8%, which was obviously lower than the 4.7% in 1978–1984. Experts believe that the deterioration of local environment, including the decline of soil fertility, soil acidification and salinization, led to the slowdown of agricultural growth. The total factor productivity of rice, wheat and corn production in China from 1980 to 1995 was calculated by Tornqvist-Theil TFP index, and the results showed that climate had a significant impact on TFP of rice, wheat and corn production.

(4) Labor mobility

Some studies have adopted the research framework of labor transfer to study the impact of immigration and remittance on China's agricultural productivity. They found that the net effect of immigration and remittance on corn production was negative.

Microscopic level

(1) Scale of peasant households

There has been a debate about the relationship between peasant households' scale and agricultural efficiency. Incomplete factor markets, differences in cultivated land utilization, heterogeneity of farmers, and differences in supervision and incentive mechanisms of transaction costs within organizations may lead to negative correlation between farmers' scale and agricultural production efficiency. Dispersion of land parcels increases agricultural operating costs, hinders the popularization and application of large-scale agricultural machinery, as well as reduces agricultural production efficiency. However, in developing countries, the dispersion of cultivated land is also beneficial for farmers to give full play to the advantages of intensive cultivation, accumulate planting experience, diversify the use of agricultural land and alleviate the seasonal shortage of agricultural labor because of few people and land. Empirical research shows that the dispersion of cultivated land will not significantly affect farmers' efficiency.

(2) Non-agricultural business activities

Non-agricultural business activities enable farmers to obtain more cash flow and improve agricultural production conditions. But on the other hand, the rural labor force going out to work will cause the seasonal shortage of labor force for agricultural operation, and will also make it difficult for agricultural technology to be popularized among the remained rural labor force. According to some studies, the non-agricultural business activities of farmers have an adverse impact on the total factor productivity of farmers.

(3) Individual characteristics of farmers: their cadre status, age of heads of households, degree of specialization, etc.

3. Trend analysis of China's rural infrastructure construction and agricultural total factor productivity

3.1. Trend of China's rural infrastructure construction

Rapid growth of the scale of rural

infrastructure investment

The scale of rural infrastructure investment can be investigated from two aspects, absolute scale and relative scale. There is no special index of rural infrastructure investment in China's current statistical investigation system, and the index close to rural infrastructure investment is the agricultural capital construction investment issued by the Ministry of Agriculture. According to the *Measures for the Administration of Agricultural Capital Construction Projects* issued by the Ministry of Agriculture, the investment in agricultural capital construction is mainly used for public welfare, basic and demonstration-oriented agricultural projects that need to be invested and constructed. In principle, investment in agricultural capital construction must form new fixed assets and production (business) capacity, excluding the purchase of sporadic single equipment, instruments and appliances and single civil engineering projects with investment below 50,000 yuan (including 50,000 yuan); excluding production costs, administrative costs, scientific research, education and training costs in project construction. Investment in agricultural capital construction is mainly used in infrastructure projects in non-business areas, and has a wide range of beneficiaries. In this sense, the investment in agricultural capital construction can be regarded as an index reflecting the scale of rural infrastructure investment.

Investigating the proportion of agricultural capital construction investment in capital construction investment in each five-year plan period, it can be found that the proportion of agricultural capital construction investment in capital construction reached 7.1% in the First Five-Year Plan period (1953–1957) and reached the historical maximum of 11.3% in the Second Five-Year Plan period (1958–1962). The absolute scale of agricultural capital construction investment in the "Second Five-Year Plan" period is 3.25 times that in the First Five-Year Plan period. Although the scale of agricultural infrastructure investment and its proportion in capital construction investment have increased significantly, this is at the expense of the "Great Leap Forward" movement since 1958, the imbalance of national economy and fiscal deficit. During the Third Five-Year Plan period (1966–1970), the scale of investment in agricultural capital construction declined, accounting for 10.7% of the capital construction investment. The "Cultural Revolution" started in 1966 disrupted the normal social and economic construction, and the state concentrated on developing heavy industry construction, which reduced the support for agricultural construction. During the Fourth Five-Year Plan period (1971–1975), China appropriately changed the economic construction thought that was centered on preparing for war and the third-line construction, and attached importance to the investment in agriculture. During this period, the scale of investment in agricultural capital construction increased significantly compared with the previous stage, accounting for 9.8% of the capital construction investment. During the Fifth Five-Year Plan period (1976–1980), the central government shifted the focus of its work to socialist modernization and proposed to speed up agricultural construction. In this period, the investment in agricultural capital construction reached 24.61 billion yuan, accounting for 10.5% of the capital construction investment. In 1979, in order to adjust the seriously unbalanced proportion of the national economy, the central government of China proposed to reduce capital construction investment in the next two years, which directly led to the decline of agricultural capital construction investment to 17.28 billion yuan during the Sixth Five-Year Plan period (1981–1985), accounting for 5.1% of the capital construction investment. During this period, due to the obvious effect of fiscal revenue increase of industrial projects, China's local governments attached importance to industrial development and often ignored agricultural development, resulting in less expenditure on agricultural capital construction and supporting rural production. In the Seventh Five-Year Plan period (1986–1990), the investment in agricultural capital construction reached 24.12 billion yuan. Although the absolute investment scale increased significantly compared with the previous stage, its proportion in capital construction investment declined to 3.3%, showing that the increase scale of investment in agricultural capital construction was much smaller than that in other industries. During this period, China's agriculture grew rapidly, but due to the relatively insufficient financial investment in supporting agriculture, the agricultural foundation was weak, and the stamina for agricultural growth was insufficient. During the Eighth Five-Year Plan period (1991–1995), China put forward a slogan of "the development of agriculture depends on policies, science and technology, and investment". The investment in agricultural capital construction reached 69.78 billion yuan, with an average annual increase of 26.7%, but the proportion of agricultural capital construction investment in capital construction investment dropped to the lowest point in history, 3.0%. During the Ninth Five-Year Plan period (1996–2000), the focus was on "increasing investment through multiple channels, strengthening agricultural infrastructure construction, constantly improving agricultural production conditions, and gradually forming a mechanism of supplementing agriculture by industry, building agriculture by industry, and leading agriculture by industry". The investment in agricultural capital construction increased rapidly, which was 4.50 times that of the Eighth Five-Year Plan period. During the Ninth Five-Year Plan period from 1996 to 2000, the investment in agricultural capital construction reached 31.79 billion yuan, 41.27 billion yuan, 63.71 billion yuan, 83.55 billion yuan and 94 billion yuan respectively. Since 2000, the Chinese government has issued a series of policies to benefit farmers, and the investment in rural infrastructure construction has increased year by year, with a significant improvement in agricultural production conditions.

Generally speaking, the scale of investment in agricultural capital construction in China is closely related to the overall national economic situation and macro estimation policies. When the national economy is facing difficulties, the proportion of investment in agricultural capital construction is rapidly reduced, and when the three rural issues (agriculture, rural areas, farmers) are highly valued by the state, the investment in agricultural capital construction increases significantly.

Insufficient relative growth rate of infrastructure investment

Although the absolute scale of rural infrastructure investment has increased significantly, the relative growth rate is not obvious. The proportion of agricultural capital construction investment in capital construction reached 5.1% during the Sixth Five-Year Plan period (1981–1985), decreased to 3.3% during the Seventh Five-Year Plan period, 3.0% during the Eighth Five-Year Plan period, and dropped to the lowest point of 2.4% in 1994 and 5.6% during the Ninth Five-Year Plan period. After 2000, the proportion of agricultural capital construction investment in capital construction rose back to more than 6%.

Investment intensity of rural infrastructure

Investment intensity is the proportion of total investment among various investment projects. The larger the investment proportion, the greater the investment intensity of the project. In this study, three types of rural infrastructure are mainly investigated, namely roads, irrigation and power, so the total investment in these three

Table 1. Investment intensity of rural roads, farmland water conservancy and rural hydropower in China

Year	Rural road	Farmland water conservancy	Rural hydropower
2006	56.0%	27.0%	17.0%
2007	56.9%	27.2%	15.9
2008	59.1%	27.8%	13.2%
2009	55.9%	31.6%	12.5%
2010	49.7%	38.9%	11.4%
2011	42.4%	48.2%	9.5%

types is regarded as the total investment in rural infrastructure, and the proportion of rural road investment, irrigation investment and rural hydropower construction investment in the total investment in rural infrastructure is regarded as its investment intensity.

From 2006 to 2011, the investment intensity of rural roads fluctuated in the range of 40% to 60% among the three types of investment, and the investment intensity of rural roads declined slightly after 2009; investment intensity of farmland water conservancy increased significantly during this period, as shown in **Table 1**, from 27.0% in 2006 to 48.2% in 2011. However, the investment intensity of rural hydropower decreased year by year from 17.0% in 2006 to 9.5% in 2011, which means that the investment structure of the country in these three types in this period was inclined to farmland water conservancy investment.

Effectiveness of rural infrastructure investment in China

(1) Investment in rural roads

Rural roads are important carriers for the flow of agricultural production factors and the circulation of agricultural products. "Building roads before getting rich" has become the consensus of poor and backward areas to change the status quo. Rural roads are important infrastructure for farmers' production and life. According to the second paragraph of Article 2 of the *Measures for the Administration of Rural Roads Construction*, rural roads include county roads, township roads and village roads.

According to the investment level in rural roads, the construction of rural roads in China can be divided into three periods. The first period is before the reform and opening up, in which period the construction of rural roads was slow due to the shortage of financial funds; By the end of 1978, the mileage of rural roads in China was only 586,000 kilometers, and the access rate of roads in towns and villages nationwide was generally low. The second period is from the early stage of reform and opening up to 2002, during which period, with the rapid development of national economy, the demand for transportation infrastructure in rural areas was becoming more and more urgent, and the state increased investment in rural roads; by the end of 2002, the mileage of rural roads in China had reached 1.337 million kilometers. The third period is that the construction of new countryside was in full swing in 2003; the investment in rural roads increased significantly, resulting in a rapid increase in the access mileage of rural roads and a significant improvement in the grade quality of roads.

(2) Investment in irrigation

Agricultural production is highly dependent on natural climatic conditions and ecological environment. To promote stable and high yield of agriculture, the construction of farmland water conservancy facilities is very important. The purpose of farmland water conservancy construction is to adjust the temporal and spatial distribution of water resources by water storage, water diversion or water transfer system on the premise of making full use of water resources and soil environmental resources, and to adjust the soil moisture status through irrigation and drainage system, and improve the utilization rate of land resources.

Table 2 lists the investment scale of water conservancy capital construction and its proportion in agricultural capital construction investment in each five-year plan period since the founding of the People's Republic of China. It can be seen from the table that, except for the Three Five-Year Plan period (1966–1970), which just experienced the adjustment of national economy, and the Sixth Five-Year Plan period (1981–1985), the investment in water conservancy capital construction in other periods showed an obvious increasing trend, indicating that with the development of national economy, the scale of investment in water conservancy capital construction in China had been expanding continuously. Especially in the Ninth Five-Year Plan period (1996–2000), the investment in water conservancy capital construction reached 199.37 billion yuan, 4.52 times that of the previous period. Since 1995, the state's investment in water conservancy capital construction has obviously increased. The proportion of water conservancy capital construction investment in agricultural capital construction investment did not changed very much in each period, which was lower at 58.1% during the First Five-Year Plan period, adjusted to 71.2% during the Second Five-Year Plan period, and fluctuated between 60% and 70% in subsequent periods, indicating that water conservancy capital construction investment accounted for about two-thirds of agricultural capital construction investment and was an important part of agricultural capital construction investment.

(3) Investment in rural electric power

Rural areas are vast, with farmers living in scattered areas, making the cost of power construction high. Many rural areas had faced with the difficulty of "using electricity" for a long time. The "random apportionment, arbitrary charges and random price increases" in power construction increased the cost of electricity for farmers. In 1990, the investment in rural hydropower construction was 3.49 billion yuan,

Table 2. Investment in water conservancy capital construction and its proportion to agricultural capital construction investment in each five-year plan period

Period	The First Five-Year Plan	The Second Five-Year Plan	The Third Five-Year Plan	The Fourth Five-Year Plan	The Fifth Five-Year Plan	The Sixth Five-Year Plan	The Seventh Five-Year Plan	The Eighth Five-Year Plan	The Ninth Five-Year Plan
Investment in water conservancy capital construction (100 million yuan)	24.3	96.6	70.1	117.1	157.2	93	143.7	440.7	1993.7
The proportion of investment in water conservancy capital construction to investment in agricultural capital construction (%)	58.1	71.2	67.3	67.7	63.9	53.8	59.6	63.1	63.4

and then increased year by year, reaching 51.17 billion yuan in 2007, with an average annual growth rate of 17.1%. After 2008, due to the adjustment of statistical standards, the statistical scale of rural hydropower completed construction investment declined slightly to 45.69 billion yuan, 45.63 billion yuan, 43.98 billion yuan and 42.44 billion yuan in 2008 to 2011.

The focus of rural hydropower construction is the construction of village hydropower stations. In 1978, there were 82,387 rural hydropower stations in China. With the gradual closure of small rural hydropower stations, the number decreased year by year, to 52,387 in 1990, 29,962 in 2000 and 27,664 in 2007. In 2008, due to the change of the statistical standards, village hydropower stations were changed into rural hydropower stations, mainly referring to hydropower stations with installed capacity below 50,000 kilowatts and matched power grids. Therefore, the data after 2008 are not comparable with that before 2008. Under the new statistical standards, from 2008 to 2010, the number of rural hydropower stations was relatively stable and fluctuated from 44,000 to 45,000. Although the number of rural hydropower stations decreased year by year from 1978 to 2007, the installed capacity of increased from 2.284 million kilowatts in 1978 to 13.666 million kilowatts in 2007, with an average annual increase of 6.36%, also indicating that closure of the low-efficiency small hydropower stations did not cause a reduction of the power generation capacity of rural hydropower stations. Under the new statistical standards, the installed capacity of rural hydropower in 2008 was 51.274 million kilowatts, and increased to 62.123 million kilowatts in 2011, indicating that the construction of rural hydropower stations increased rapidly in this period. The power generation of rural hydropower stations increased from 48.111 billion kWh in 1990 to a peak of 204.44 billion kWh in 2010, and then dropped to 175.67 billion kWh in 2011. During the 20 years from 1990 to 2010, the power generation of rural hydropower stations increased by 3.89 times.

Although remarkable achievements have been made in rural hydropower construction, the increase of power generation capacity of rural hydropower stations still lags far behind rural electricity consumption, which shows that with the development of rural economy, rural hydropower generation capacity can not meet the demand in rural areas, and the power consumption gap in rural areas that only depends on rural hydropower generation capacity is getting bigger and bigger. Therefore, rural areas needs the support of the national power grid to meet the power demands.

3.2. Trend analysis of China’s agricultural total factor productivity

The total amount of rural infrastructure investment in China is increasing year by year, especially after 2009. The investment intensity of rural roads and rural water conservancy construction is greater than that of rural hydropower construction. Rural infrastructure investment focused more on improving transportation conditions and irrigation production conditions in rural areas. However, the investment intensity of rural hydropower has greatly damaged the natural environment and ecological balance due to low power generation efficiency in recent years. Investment in rural infrastructure has realized some achievement, obviously improving the production and living conditions in rural areas, but there are still big differences in rural infrastructure conditions in different areas.

Adoping DEA_Malmquist index method, the total factor productivity of agriculture in China from 1985 to 2011 was estimated, and the root of the change of total factor productivity was found by decomposing it into two parts: technical progress and change of technical efficiency. The results show that the growth of China's agricultural total factor productivity is obvious. From 1985 to 2011, the average annual growth rate of China's agricultural total factor productivity was 2.1%, the agricultural technology progress index increased by 3.9%, while the agricultural technology efficiency index decreased by 1.7%. The increase of agricultural total factor productivity in China was mainly led by technological progress, not by the improvement of technological efficiency. Technological progress and efficiency loss in China's agricultural production coexisted. Agricultural technological innovation represented by modern agricultural production factors, such as new varieties, agricultural machinery, and chemical fertilizers, is the main driving force for the increase of agricultural total factor productivity in this period, but China's agriculture is not very successful in the rational allocation of existing resources. Only relying on technical progress for a long time and neglecting the improvement of technical efficiency will inevitably lead to low performance in agricultural production and waste of resources.

A preliminary investigation of rural infrastructure investment and agricultural total factor productivity shows that under the background of public policies, China's agricultural total factor productivity is improving year by year, with a deterioration technical efficiency. It can be seen that despite the continuous increase of rural infrastructure investment, the deterioration of agricultural technical efficiency has not been reversed, leaving the reasons behind this phenomenon worth pondering.

4. Conclusion

Rural infrastructure investment provides an important material guarantee for agricultural development, and the research on the effect of rural infrastructure investment has always attracted wide attention from academia and government. Taking China's agricultural development as an example, this article discusses the effects of rural infrastructure investment on agricultural total factor productivity, agricultural technical progress and agricultural technical efficiency.

Based on the national data from 1985 to 2011, in the long run, irrigation investment has the greatest elasticity to agricultural total factor productivity, followed by electric power investment and road investment the least. However, in the short term, road investment has the greatest increasing effect on agricultural total factor productivity, followed by irrigation investment and electric power investment. The research conclusion shows that the investment focus of long-term and short-term policies should be considered accordingly when formulating rural infrastructure investment policies. The long-term investment of infrastructure policies should be inclined to irrigation and electric power, while the short-term policies can focus on road and irrigation investment.

Rural infrastructure investment, including investment in roads, irrigation and electric power, plays a positive role in promoting agricultural total factor productivity. Road investment mainly influences agricultural total factor productivity through technical progress, and irrigation through technical efficiency, while electric power investment has a significant effect on both technical progress and technical efficiency.

According to the research, it is found that: first, in the process of developing rural infrastructure investment, rural infrastructure investment should adapt to modern agricultural production methods, and the government should increase rural infrastructure investment and improve rural infrastructure investment performance at the same time. Rural infrastructure investment should aim at promoting the transformation of agricultural growth mode and provide material guarantee for intensive agricultural production mode. Secondly, rural infrastructure investment should be scientifically planned and fully demonstrated according to local conditions, combining regional rural production conditions, agricultural economic development and the degree of concentration of peasant households, and considering the long-term and short-term effects of different types of rural infrastructure investment. Third, to establish and improve the rural infrastructure investment system. To be specific, it is necessary to establish a scientific and standardized rural infrastructure investment system, improve the efficiency of capital use, strengthen the supervision of capital and labor services, implement democratic management, and strengthen the maintenance and management of completed infrastructure.

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