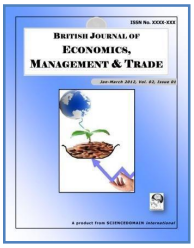

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Studies of Green Financial Performance System with Comparative Analysis of China's Eight Economic Regions

Lan Xu[1*]

[1]*School of Business and Economics, East China University of Science and Technology, 130 Meilong Road, Shanghai, 200237, China.*

Author's contribution

This whole work was carried out by the author LX.

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ABSTRACT

Green Finance directs funds to transfer to the green industries by providing environmental friendly financial services, to support technical development and creations, which plays an important role in improving ecological environment and promoting sustainable economic development. Besides, green finance, as an important part of the financial system, promote the formation of new financial products, can also help the sustainable development of financial sector itself. The purpose of this article is, by comparing the green financial implementation among China's 28 provinces and directly affiliated municipalities and among the eight major economic regions, to research the comprehensive effects on the performance and efficiency of the financial sector by implementing the green financial policies. It also analyzes the decomposition factors that affect the green financial performance, as well as the sources that contribute to the green

**Corresponding author: Email: xuxx0026@ecust.edu.cn;*

financial productivity growth.
This paper adopts the traditional method of production efficiency analysis, using Malmquist productivity growth index to build the evaluation system on the overall result of the green financial implementation, for which it requires to set up the green financial distance function before the productivity index can be calculated. During the process, two-stage linear optimization programming methods are used to obtain the most reliable and best-fitted distance functions.
As a result, technical progress serves as an important criterion to judge whether economic growth is sustainable, according to this study for nearly 10 years' time period of sustainable development of China's financial sector. It is confirmed that the sustainable development of the financial productivity also depends on the technological progress, after investigating its further sources, financial technological progress or total factor productivity (TFP) is more dependent on the management of labor inputs, while the scale effect of financial capital accumulation has minor impact.

Keywords: Green finance; sustainable development; productivity growth; distance function; performance evaluation.

1. INTRODUCTION

At present, accelerating transformation of the mode of economic growth and promoting reform on industrial economic structural optimization has risen to become a major strategic national policy, critical to the economic stability and continued development of the nation. At the same time, as the international economic and financial situation progresses into a difficult dilemma, green industry, low carbon economics and sustainable development issues become increasingly a consensus among peoples of whole society, new growth mode characterized by low energy consumption, low pollution gradually become the world's economic engine for the development.

Finance as a core sector of a country's economy plays an important role in directing to allocate resources optimally. Namely, the more perfect a country's financial system is, the more advanced are the financial institutions, and the more efficient are the social resources being allocated. It is proved repeatedly by the economic development of human history that major technical innovation and economic restructuration can rarely leave aside the effect of financial leverage, while well-functioned operation of financial system can fasten the process of the development of technological innovation and economic transformation. Developing green industry and green economy relies on supports of the financial mode and financial system. Green finance through providing financial services to protect ecological environment guides social capitals to the green industries and green consumption, support research and creation of new technological inventions. It also takes effect on the environmental pollution control, the ecological environmental improvement, and the sustainability of economic development. In the sense, the development of green finance is necessarily the premise of realizing China's economic transformation and sustainable developing strategies. Green finance, on the other hand, as an important part of financial system incents the reform and innovation of traditional financial system, propels to create new financial products, helpful to sustain development of the financial sector itself.

"Green finance" can be derived from the early 90s of last century, when the environmental program department of the United Nations (UNEP) published the Declaration of Financial Environment and Sustainable Development, in which it proposes the concept of low carbon

financial practice, on the purposes that financial institutions and activities should make use of relevant financial products and financial services to support environmental protections, improve the efficiency of energy utilization, and promote sustainable economic and social development. So, it is also known as “Low Carbon Finance”, “Environmental Finance”, or “Sustainable Finance”. That is to say, green finance emphasizes that the financial sector should pay more attention to the protection of ecological environment, providing supports to the development of environmental protection and technological innovation. In the sense, through directing social and economic resources transferring to the green industry, green consumption, and green services, green finance speeds up the upgrading of economic mode and incents the whole economic society moving into a virtuous cycle of the sustainable development of the ecological environment.

From the perspective view of the current international financial practice, green finance mainly includes two categories, one is a series of financial products supported by direct financial tools that are conducive to the environmental protection, such as “green credit”, “green insurance”, “green securities”, and etc. issued as investment and financing products in accordance with the “Equatorial Principles”. Another category is a series of financial activities for the purposes of pollution emission control, supplemented by a series of financial markets and financial derivatives, a typical example of this kind is the carbon financial products. And the carbon trading market is established abiding by the Kyoto Protocol which stipulates the abatement targets and financial transaction standards, to ensure that the global carbon emissions are kept under the level of international standard.

Since 2007, China has also issued a series of policies and regulations successively, regarding green credit, green insurance, and green securities, respectively, carrying off a prelude to the development of green finance plan. In July 2007, the Environmental Protection Administration, the People’s Bank of China, and the China’s Banking Regulatory Commission jointly published the document of “Opinions on the Implementation of Environmental Policies and Regulations to Prevent Credit Risks”, putting forward to the implementation of green credit and related requirements of specific provisions, and actually making clear about the importance and urgency in implementing the green credit principle, which also marked the official beginning of the green financial implementation in China. The issuance of other two documents, “Working Guidance about the Environmental Pollution Liability” in December 2007, and “Guidelines of Green Credit” in February 2012, has marked the China’s green financial practice moving in comprehensive all-round directions [1,2].

However, from the perspective view of China’s status quo of green finance practice, many problems still exist, but it also reflects that there is a huge development potential. The implementation of green finance needs government administrations, credit banking departments, and main financial bodies to work cooperatively and communicate closely by exchanging information among the three parties. But it lacks the effective information communication mechanism among the governments, banks, and enterprises in the green financial market, which causes problems with incomplete and asymmetric information, coupled with market failures for which the pollution control and environmental investment has the typical “public goods” and “externality”, and other economic phenomena, that in turn leads the interest groups facing many difficulties in implementing the green finance policies and gaming each other on uneven distribution of interests, and eventually making the entire society to suffer social and economic losses.

For the above reasons, this study proposes that the priority business and development stages of the green financial practice is to establish a set of feasible evaluation system,

strengthening the standardized assessment on the effect of the green financial implementation of the financial institutions in the areas of green credit, green insurance, green securities, and etc., combining with the laws and regulations, constraints and incentive mechanism of rewards and punishments, to make the implementation of the green financial system to obtain real and reliable effects.

2. LITERATURE REVIEWS

So far, most of the green financial research is based on the qualitative analysis, confined to the study of the implementation status of green economic activities, including green credit, green insurance, and green securities, and the policies and regulation provisions formulated by domestic and foreign nations, as well as the introduction and comparison of background, progress and present situation of green finance practice. And its main purpose is to deepen cognition of green financial objectives, that is, to reduce environmental and financial risk, in attach with great importance to the social responsibility of the enterprises, and to disclose environmental information and enhance the efficiency of green financial services. From the international point of view, early research mainly focuses on studying the definition of environmental finance and progress of environmental financial history, with the main point that environmental finance is the financial innovation in the financial sector in demand for the environmental economics. For example, Marcel Jeucken [3] in his book “Sustainable Development of Finance and Financial Sector” analyzes the relationship between financial industry and sustainable development, stressing the importance of environmental issues in the financial banking system. Sonia Labatt [4] in his masterpiece paper “Financial Environment” mainly discusses the relationship between financial innovation and the environment, and how financial services may conduct environmental risk assessment and provide financial products. Mathews and Kidney [5] in their paper “Financial Bonds Promoting Environmentally Friendly Low Carbon Economy” emphasizes that the green bond financing play active role in the low carbon economic development, and sustainable development of the financial sector, that reducing financial risks, through comparing the green financial practice over world-wide nations. And Wagner & Blom [6] in analyzing financial performance and sustainable development for different classified enterprises between linear and nonlinear correlation test, found that their positive correlation is only applicable to financially sound enterprises, and for enterprises’ financial situation is not ideal, there exists somewhat negative correlation.

Domestic study of green financial performance in recent years includes papers by Ba & et al. [7], Du [8], Miao & et al. [9], Wang & et al. [10,11], and Hu & et al. [12], basically analyzes the status quo of implementation of the green finance plan, and rules and regulations of green finance in China’s financial institutions. For instance, Ba & et al. [7] summarizes the development trend, opportunities and challenges, and existing problems and countermeasures of China’s green financial system in the era after the financial crisis. Research works by Du [8] and Wang [11] sum up the green financial experiences and lessons both domestically and abroad, putting forward to the future developing directions and countermeasures of green financial practice. From the perspective view of economic theory, Hu & et al. [12] illustrates the conflicting interests between financial institutions and the environmental protection enterprises adopting the Nash equilibrium of game theoretical model, concluding that to achieve the Pareto efficiency of green financial result requires certain conditions. Miao & et al. [9] investigated, from the perspective of low-carbon economy, the importance of green financial system in supporting for the transformation of economic growth mode to realize the economic sustainable development, and points out that the development of green financial products and services propels economic development

and financial innovation after empirical studies on the correlation between carbon emissions and economic growth.

Given the difficulties in executing the green financial policies, in recent years research academia generally proposes that the green financial performance should be examined under the assessment system of the financial sector according to different projects and objects. For example, for the implementation of green credit policy, a set of completely standardized assessment rules, including before, during and after the loan, should be established, and an information communication platform of special green credit loan programs should be set up as an information-shared mechanism among governments, banking system, and enterprises. However, theoretical and empirical researches on the integrated effect of green financial implementation are relatively few thus far. Among them, Wang & et al. [12] provided a theoretical prove on the evaluation system of the implementation of the green credit policy, consisting of the assessment bodies, procedures, and management entities, from the moral concept of green credit rules.

3. OBJECTIVE OF THE STUDY

For the reasons partly mentioned in the above text, this study proposes that the priority business and development stages of the green financial practice is to establish a set of feasible evaluation system, strengthening the standardized assessment on the effect of the green financial implementation of the financial institutions in the areas of green credit, green insurance, green securities, and etc., combining with the laws and regulations, constraints and incentive mechanism of rewards and punishments, to make the implementation of the green financial system to obtain real and reliable effects.

Practically, the purpose of this article is to study the comprehensive effects of green financial implementation on the performance and efficiency of the financial industry, and to analyze the decomposition factors that affect the change of green financial performance, as well as to discuss sources of green financial productivity growth. In the paper, we will continue to adopt the traditional method of production efficiency analysis, using Malmquist productivity growth index to build the evaluation system on the overall result of the green financial implementation. By comparing the 28 provinces and directly affiliated municipalities, and also comparing eight major economic regions of China, the paper will discuss the impacts of green financial policies on the economic performance of the financial sector, and decomposition factors of these impacts. Finally, in the paper, it will also discuss the present situation, existing problems, countermeasure and suggestions on the implementation of green financial plan in China, and also future development directions as well.

4. THEORETICAL MODEL

Traditional performance evaluation is mainly conducted through comparing the difference between costs of enterprises' operation and sale's incomes, for instance, cost-benefit analysis. A major drawback of such analysis is that it does not take into account efficiencies of resource utilization, which mainly includes two aspects of complaints, that is, resource allocation and technical innovation. Efficiency, in economic terms, is the ratio of input and output measures. The role of financial institutions is to act as a financial intermediary service and credit financing channel, in order to allocate financial capitals and social resources optimally, thus in turn to promote economic development and improve social productivity. In the progress of capital financing, banks and other financial institutions aggregate idle funds, thus to reconfigure among other enterprise bodies and production departments for higher

efficiency purposes, so as to increase the total outputs of the whole society. In particular, assessing the efficiency of the financial industry is to investigate the ability of absorbing deposits of the financial institutions, and transforming credit loans, as well as the profitability of transforming credit funds to capital interests. Given the other condition unchanged, the stronger the ability of the financial system is to transfer funds to credit loans, and the higher the ability of earning the capital interests, the greater the efficiency of the financial industry in operating management and the greater its contribution to the society.

In considering the efficiency use of production resources and technological investment, this research applies the method of productivity growth index analysis to assess the operational performance of a company, which also reflects the enterprise's overall profitability of integrated resource allocation, technological performance, and labor input usages. Similarly, after having implemented the green financial policy, it also adopts the same productivity growth index analysis to evaluate the comprehensive operational profitability of the financial industry. Theoretically, Malmquist Productivity Growth Index measures the growth rate of production efficiency of the input factor usage according to the level of output as a reference benchmark. Because not all factor inputs of production can be measured by market prices for their values, so that Malmquist Productivity Growth Index introduces the distance function to define production frontiers. In this way, it can get rid of the inconvenience of using market prices of input factors, plus it provides an important method feasible to analyze some production factors lacking unified market valuation standards, for instance, environmental resources.

This research utilizes the similar definition of Malmquist Green Financial Productivity Growth Index to assess the overall profitability of the financial industry after considering environmental resources as input factors [13,14,15]. Due to environmental resources as inputs of operating management that can't be measured by standardized terms of pricing mechanism, we also use input-output distance function to define Malmquist Green Financial Productivity Growth Index, which requires firstly to set up the green financial distance function before the productivity index can be calculated. Therefore, the green financial distance function and Malmquist Green Financial Productivity Growth Index are of great importance, which guide how to build the green financial performance evaluation system for the banking and financial institutions in a feasible way and thus play a significant role in realizing economic transformation for the social sustainability.

Theoretically, the distance function is the basic element in defining the Malmquist Growth Index. In fact, it is the form of expression for the production function with multiple inputs and multiple outputs. That is, for each period t=1,...,T, production technological set S(T) describes all the possible technologies that the inputs $x(t) \in R(m,+)$ can be transformed to outputs $y(t) \in R(m,+)$. In this way, the output distance function is defined as, for any given period t and given inputs x(t), it is the reciprocal of output ratio of the maximum possible production. That is to say, for any period t, the output distance function D (t, o) is looking for the reciprocal of the output proportion as large as possible. If and only if production results in a boundary or frontier, the distance of the output function is equal to 1, namely, D(x(t), y(t))=1.

To define Malmquist Productivity Growth Index, in the paper, it specifies to measure two different time periods, noted for t and t+1, then to take the geometric average of the two output Malmquist Productivity Indexes for the two consecutive periods, which can be expressed as follows:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \right) \left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right) \right]^{\frac{1}{2}}. \quad (1)$$

By this expression, Malmquist Productivity Growth Index can be broken down into two components: efficiency change (EFFCH) and technological change (TECHCH). The fraction outside the bracket is noted as the efficiency change, which describes the effects of scale and catching-up of the relative efficiency change for the two time periods t and t+1, or sometimes called "catching-up effect"; The geometric average of the two fractions inside the brackets captures the effect of innovation of the frontier technology for the two consecutive time periods, or sometimes called "technological or innovative effect". Thus, the Malmquist Productivity Index can sometimes be simply expressed in words as the multiplication of technological change and efficiency change. Namely,

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = EFFCH * TECHCH. \quad (2)$$

Here, EFFCH denotes the efficiency change, and TECHCH represents the change of technology. And the efficiency change can be further broken down into the change of scale efficiency and pure efficiency. That is,

$$EFFCH = SCALE * PEFF. \quad (3)$$

In estimating the green financial distance function, it utilizes, in the study, the inter-temporal two-stage optimization linear programming method, to avoid problems of discontinuity, piecewise, and estimation errors handled by the traditional stochastic production frontier and distance function for a single period of time. In addition, by using the parametrical Translog form of the equation to estimate the distance function in the second stage, a more fitted and reliable distance function characterized with smoothness and continuity can be obtained, which provides theoretical basis and feasible method to calculate the potential marginal value for the environmental financial input. Furthermore, by using the method of stacking the historical data to construct the inter-temporal production technological frontier, this study also corrects the mistake made by the same time technological frontier, that the production and operation are unrelated each other for several years.

Finally, using the formula introduced above, the "green financial distance function" and "Malmquist Green Financial Productivity Growth Index" for the China's financial industry can be calculated, and thus the determinant factors that affect the financial productivity growth and its decomposition effects of efficiency change and technological change can be analyzed.

It is worth to mention that the issue of sources of the green financial productivity growth can be further examined. For this purpose, this paper adopts the traditional method of economic growth accounting to calculate the contribution ratios of input factors to the technological change. According to the method, the output growth is divided into three different sources: labor input, capital accumulation, and the technological progress or Solow residual, usually called total factor productivity (TFP). In this study, the total factor productivity (TFP) is substituted with the effect of technological change (TECHCH) of the Malmquist productivity growth index. In this way, the effect of technological change into different sources of factor

inputs is decomposed, as shown in the following basic growth accounting formula for the green financial productivity growth:

$$TECHCH = \frac{\Delta TFP}{TFP} = \frac{\Delta y}{y} - \sum_{i=1}^{n} s_i \frac{\Delta x_i}{x_i} \tag{4}$$

Where, TECHCH represents the technological change of the Malmquist green financial productivity index, TFP is the total factor productivity, y is the output, x_i is for the production inputs, s_i denotes for the factor share of production output, also known as the marginal value of input factor. So, the technological progress of green financial productivity growth can be decomposed into the production contribution rates of inputs, including the labor input, the accumulation of green financial capital, and the other relevant factors in the study.

5. DATA ANALYSIS

When considering inputs and output indicators for banks and financial institutions, this research follows the popular method of the existing accounting literature, by using the analysis of intermediary and capital valuation, savings and deposits are regarded as capital inputs. By absorbing savings and lending as credit loans, financial institutions earn interest incomes for the intermediary businesses. In addition, other input expenditures for the financial institutions are mainly spent due to the managerial and operational costs of human resources, while the operating expenses recorded in the accounting statement for financial institutions largely reflect this category of resource inputs. Generally to speak, all input factors of financial institutions are mainly divided into saving and operating cost expenditures, each represented for capital accumulation and labor usages, the two major input elements. On the other hand, we consider the income or profit of operation of the financial institutions as an output variable, mainly including two categories, interest incomes and non-interest incomes. Interest incomes reflect the money earned by the financial institutions due to the scale effect of production, and interest spreads from credit loans due to differences of term structures and industrial structures in financial products, while the non-interest income reflects the profitability of financial intermediary businesses. The combination of the two categories of incomes represents the overall profitability and innovative capability of the financial sector. The general nationwide input and output measures of financial institutions can be found in the China's Financial Yearbook and the China's Statistical Yearbook, both providing historical statistical panel data.

In the view point of different financial tools to conduct the policy, the green financial products are classified generally into the following three groups: green operating products, green credit loans, and the green financial innovative products (equivalently, green insurance, green securities, green derivatives, and etc.). The green products scope widespread, from personal consumptive credit loans to the commercial construction loans, and to the large-scale project financing, almost all general credit fields have developed green financial products. Also, foreign financial institutions have actively developed relevant green financial derivatives. However, the majority of these products aren't available in the domestic financial market. Besides, domestic financial institutions generally focus on green industrial credit financing of large projects, at the same time, classification of financial services is limited under a regulatory system, the green investment is basically lacking in the personal consumptive and financial derivative markets, if there is any, their number and scale are both limited.

In this paper, the green financial indicator of financial sector is collected from the official publication of the China's Statistical Yearbook, in which the total dollar value of all credit financing projects of the large scale environmental pollution treatment are collected for those funded by domestic financial institutions annually between 2003 and 2009, but the government special funds, self-raised funds by enterprises, and foreign capital investment funds are generally excluded because of irrelevance in this study.

Thus, the data analysis and empirical research covers the time period between 2003 and 2009 for 28 provinces and affiliated municipalities, which have complete data reports. Following the division of economic regions given by the Chinese National Bureau of Statistics, provinces and municipalities are further grouped into eight major economic regions.

Finally, by using computer programming and statistical software based on the above introduced two-stage linear programming optimization theory and Malmquist Productivity Index calculation, the China's green financial productivity growth index for recent seven years (2003-2009) is estimated, and simultaneously the scale effect and technical effect for the decomposition analysis, that contribute to the green financial productivity growth are calculated.

6. EMPIRICAL RESULTS AND ANALYSIS

Obviously, after more than 30 years of sustained economic growth since reform and opening up, China's economy has been gradually entering the relatively steady growth period of time. As the driving force of economic and social development, the developing trend of the financial sector also follows the same pattern as revealed in the life cycle of economic growth. As can be seen in Table 1 from the estimation covered by the studying period, the financial industrial productivity grows steadily in recent seven years, with the average growth rate of slightly above zero point, at 0.03%. As a result of nationwide calculation, each follows the similar pattern for the 28 provinces and directly affiliated municipalities (except for the provinces of Hainan and Tibet without complete data coverage). According to the standard eight economic divisions given by the National Bureau of Statistics, the average financial productivity growth rates of the Eastern Coast, the Middle Reaches of Yellow River, the Middle Reaches of Yangtze River, the Northeast, the Northern Coast, the Northwest, the Southern Coast, and the Southwest are 0.02%, 0.03%, 0.03%, 0.06%, 0.01%, 0.02%, 0.04%, and 0.04%, respectively, all growing at a narrow span between 0% and 0.05%.

It is at the beginning of the 21st centuries, China, with advocates of world's green economy, low carbon finance, and the Equatorial Principle, began stepping forward with full implementation of green financial plan. However, when we examine the progress of green financial productivity performance for the financial sector during the studying period, the progress trend shows no big difference compared to the above financial productivity growth with no environmental considerations for the same period (also can be referenced to Fig. 1 and Fig. 2). That is, the national green financial productivity growth rate maintained slightly above zero, at the level above 0.01% and slightly below 0.02% in the period from 2003 to 2009.

But it is worth noting, in consideration of the green financial performance, the average growth of the Eastern Coast and the Northern Coast show a negative increasing trend, and the two regions are the fastest growing areas of China in the latter 10 years after the reform and opening up. It reflects that the implementation of low carbon economy and green

financial policy stimulated the development of technologies in energy-saving and emission reduction and transformation of the economic structure, which also exerts pressure and costs to further increase in the fast-growing areas, and embedded the potential that the technological innovation and the development of low carbon economy is imperative as well.

Then the research investigates the two decomposition elements of the financial productivity growth, the technological effect and efficiency effect.

Table 1. Green financial productivity growth index of China's eight major economic Regions

Econ Region	Year	2004	2005	2006	2007	2008	Avg.
EastCoast	Malmquist	0.9993	1.0003	1.0027	0.9993	0.9981	0.9999
	Efficient	0.9978	0.9954	1.0010	0.9994	0.9987	0.9992
	Technology	1.0015	1.0049	1.0017	0.9999	0.9995	1.0015
MidYellow	Malmquist	0.9996	0.9990	1.0021	1.0000	0.9995	1.0000
	Efficient	0.9985	0.9928	0.9998	1.0010	1.0013	0.9997
	Technology	1.0011	1.0063	1.0023	0.9991	0.9982	1.0014
MidYangtze	Malmquist	0.9997	1.0000	1.0021	1.0009	0.9974	1.0000
	Efficient	0.9987	0.9947	0.9999	1.0028	0.9971	0.9989
	Technology	1.0010	1.0053	1.0022	0.9981	1.0003	1.0014
NorthEast	Malmquist	0.9992	1.0007	1.0031	0.9978	1.0012	1.0004
	Efficient	0.9976	0.9962	1.0018	0.9966	1.0048	1.0000
	Technology	1.0016	1.0045	1.0013	1.0013	0.9964	1.0010
NorthCoast	Malmquist	0.9991	1.0003	1.0023	0.9981	0.9994	0.9998
	Efficient	0.9974	0.9953	1.0003	0.9972	1.0012	0.9990
	Technology	1.0017	1.0050	1.0020	1.0010	0.9982	1.0016
NorthWest	Malmquist	0.9982	1.0013	1.0026	0.9995	0.9983	1.0000
	Efficient	0.9957	0.9973	1.0009	0.9998	0.9989	0.9997
	Technology	1.0025	1.0039	1.0018	0.9996	0.9994	1.0015
SouthCoast	Malmquist	1.0015	0.9978	1.0018	0.9998	1.0001	1.0002
	Efficient	1.0021	0.9904	0.9992	1.0004	1.0026	0.9995
	Technology	0.9994	1.0074	1.0026	0.9993	0.9975	1.0013
SouthWest	Malmquist	0.9995	0.9999	1.0024	1.0004	0.9988	1.0002
	Efficient	0.9982	0.9945	1.0004	1.0017	1.0000	0.9993
	Technology	1.0013	1.0053	1.0020	0.9987	0.9988	1.0012
Overall Average	Malmquist	0.9994	1.0000	1.0024	0.9996	0.9990	1.0001
	Efficient	0.9981	0.9947	1.0004	1.0000	1.0004	0.9994
	Technology	1.0013	1.0053	1.0020	0.9995	0.9986	1.0014

Note: Figures are calculated in this paper by the author

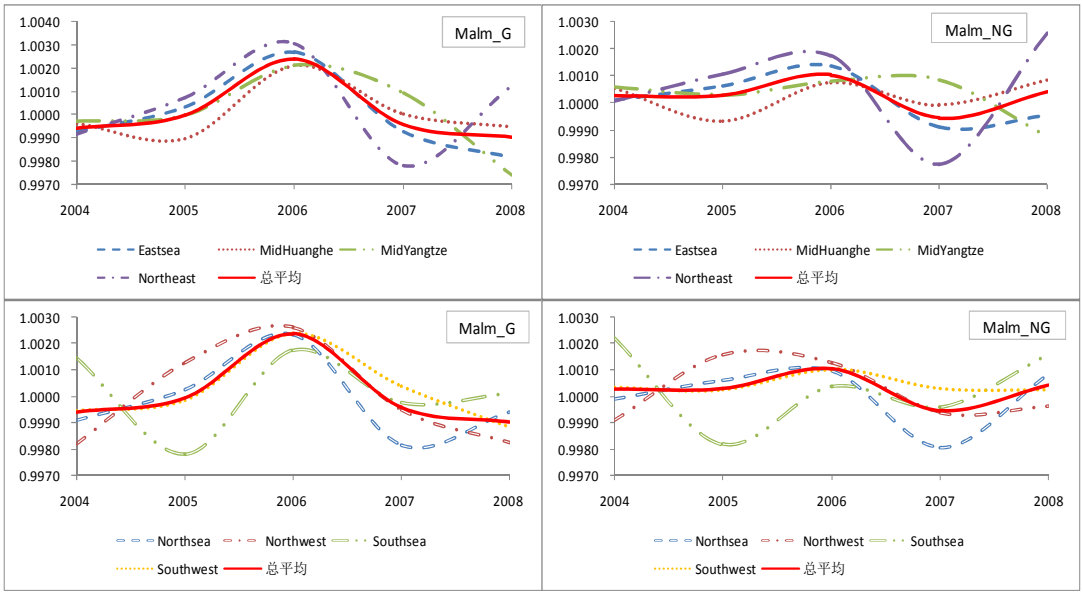

Fig. 1. Comparison of green financial productivity of China's eight major economic regions

Notes: (1) Malm_G: Green financial Malmquist index; Malm_NG: Non-green financial Malmquist index. (2) Dark solid line represents for the overall average. Eastsea = EastCoast, Northsea = NorthCoast, Southsea=SouthCoast, MidHuanghe = Mid Yellow River region.

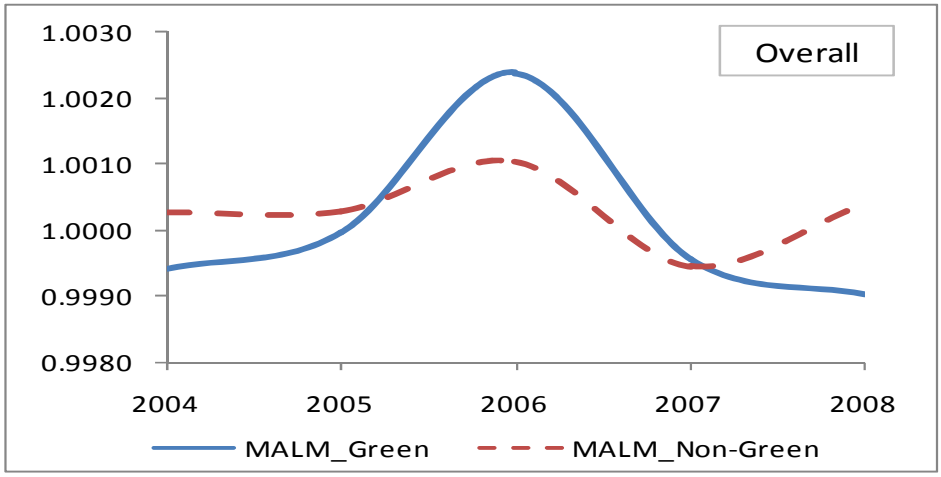

Fig. 2. General trend of China's green financial productivity (2003—2009)

Looking at the development history of the traditional financial industry, technological progress is critical to the financial productivity growth, and thus in turn the overall performance of profitability and product upgrading, and our research findings verify the point. See to the right three columns of Table 2, in only 0.03% average annual financial productivity growth for nearly seven years, technological progress contributes 0.2% of the total share, while the scale effect is the negative of 0.13%, namely, the financial productivity growth of the industry is completely pulled up by the technological progress, and the scale

efficiency actually plays a negative effect. That is to say, the growing performance of the financial industry is more come from the non-interest income of financial innovative products in the derivative market, while the interest income of pure deposit loans as the scale effect contributing to the overall financial performance is very limited. On the contrary, if the size of financial institutions becomes larger, expenditures of personnel services and costs of corporate internal management become incredibly increasing, it will necessarily reduce the efficiency of the financial productivity, squeezing the profit increasing room. The critical role of the technological progress playing in the productivity growth in the financial sector is also confirmed by empirical results for the eight economic regions of China. During the years from 2003 to 2009, the growth rates of technological change of all the economic regions increase from 0.1% to 0.3%, respectively, higher than the average rate of productivity growth, that is, their average scale effect is negative, so as to offset the difference between the two previous ratios.

Table 2. Comparisons between financial productivity and green financial productivity across Chinese provinces and directly affiliated cities

	Green Financial Productivity			Financial Productivity		
PROVINCE	Malmquist_GR	Efficient_GR	Technology_GR	Malmquist_NG	Efficient_NG	Technology_NG
Anhui	1.0003	0.9994	1.0011	1.0006	0.9987	1.0017
Beijing	0.9992	0.9983	1.0022	0.9995	0.9977	1.0028
Chongqing	1.0008	1.0002	1.0006	1.0010	0.9995	1.0013
Fujian	1.0005	0.9999	1.0009	1.0007	0.9992	1.0016
Gansu	0.9995	0.9992	1.0019	0.9997	0.9986	1.0026
Guangdong	0.9998	0.9991	1.0016	1.0000	0.9984	1.0023
Guangxi	0.9999	0.9982	1.0015	1.0001	0.9976	1.0022
Guizhou	1.0002	0.9993	1.0013	1.0004	0.9987	1.0019
Hebei	1.0005	0.9998	1.0009	1.0007	0.9991	1.0016
Helongjiang	1.0006	1.0002	1.0008	1.0008	0.9995	1.0015
Henan	1.0007	1.0002	1.0007	1.0010	0.9996	1.0014
Hubei	1.0003	0.9993	1.0011	1.0006	0.9987	1.0017
Hunan	0.9989	0.9970	1.0025	0.9992	0.9964	1.0032
Jiangsu	1.0004	1.0000	1.0010	1.0006	0.9993	1.0017
Jiangxi	1.0005	1.0000	1.0009	1.0008	0.9994	1.0016
Jilin	1.0005	1.0001	1.0009	1.0007	0.9995	1.0016
Liaoning	1.0001	0.9995	1.0013	1.0003	0.9989	1.0020
Neimenggu	1.0008	1.0017	1.0006	1.0010	1.0010	1.0013
Ningxia	1.0011	1.0009	1.0003	1.0013	1.0002	1.0010
Shandong	1.0005	0.9998	1.0009	1.0007	0.9992	1.0016
Shanghai	0.9990	0.9978	1.0024	0.9992	0.9971	1.0031
Shannxi	0.9993	0.9981	1.0021	0.9995	0.9974	1.0028
Shanxi	0.9994	0.9989	1.0021	0.9996	0.9983	1.0027
Sichuan	0.9999	0.9993	1.0015	1.0001	0.9986	1.0022
Tianjing	0.9991	0.9980	1.0023	0.9994	0.9973	1.0030
Xinjiang	0.9993	0.9991	1.0021	0.9996	0.9985	1.0027
Yunnan	1.0002	0.9994	1.0012	1.0005	0.9987	1.0019
Zhejiang	1.0004	0.9997	1.0010	1.0006	0.9990	1.0017
Overall Average	**1.0001**	**0.9994**	**1.0014**	**1.0003**	**0.9987**	**1.0020**
EastCoast	0.9999	0.9992	1.0015	1.0002	0.9985	1.0022
MidYellow	1.0000	0.9997	1.0014	1.0003	0.9991	1.0021
MidYangtze	1.0000	0.9989	1.0014	1.0003	0.9983	1.0021
NorthEast	1.0004	1.0000	1.0010	1.0006	0.9993	1.0017
NorthCoast	0.9998	0.9990	1.0016	1.0001	0.9983	1.0022
NorthWest	1.0000	0.9997	1.0015	1.0002	0.9991	1.0021
SouthCoast	1.0002	0.9995	1.0013	1.0004	0.9988	1.0019
SouthWest	1.0002	0.9993	1.0012	1.0004	0.9986	1.0019

Notes: (1) GR: Green finance; NR: Non-green finance. (2) Figures are calculated in this paper by the author

See to the left three columns of Table 2, from the empirical results of green financial study covering from 2003 to 2009, technological progress and scale effect account for the same contribution shares to the total green financial productivity growth, when compared to the productivity growth without considering the green financial practice. The annual average growth rate of technological progress of the green financial productivity is about 0.14%, higher than the average green financial productivity growth of 0.01% annually, which is similar to the previous result. In the same way, the efficiency change in the green financial productivity accounts for negatively 0.06%, basically identical to the general trend of productivity growth even without green financial plan. This shows that the implementation of the green financial plan makes social resources transferring to non-polluting, low energy consumptive green industry, at the same time it increases the cost of production, but this does not hinder the general developing trend of productivity growth, also does not affect sustained growth of financial performance. Actually, it can be expected that, with even further widespread of the green financial plan, the productivity growth of the financial sector will be more effectively realized.

It is worth noting that, in considering the green financial implementation of the eight economic regions for the same period between 2003 and 2009, the scale effect of the green financial productivity growth for the Northeast Region shows a positive value rather than a negative under a non-green financial plan, together with the positive technological progress to raise the green financial productivity in the region. One of the most likely explanation is that the financial capital of the region for a long time is insufficient, and any type of capital increases will show certain scale effect; second, the environmental quality is not seriously degraded, and the demand for the economic structural transformation is not yet on the timetable, thus the contribution of scale effect to the productivity growth is still very effective (also reference to Fig. 3 for the trend analysis).

In general, this study found that, as expected, the financial productivity growth mainly depends on the technical progress, and the role of scale efficiency is very small, even in the study, the latter shows a weak negative effect. After taking the green financial inputs into account, the above conclusion doesn't show great differences.

Then, in terms of sources of input contribution to the technological progress, it is interesting to know what factors play a decisive role? And what is the contribution share for each factor? To this end, the main inputs are divided into three sources: the operating expenses of the financial sector representing mainly for the labor resource costs, capital assets determinant on the basis of savings and deposits, as well as the green credit ratio to the total loans under the premise of existing green financial investment. See from Table 3, it is found that the labor resources play an absolutely leading role in the technological progress of the financial industry, accounting for 125% of the average contribution share; the role of scale effect of capital inputs accounts for even negatively 27%. The green financial investment is small, but still with 1.63% of the contribution ratio to the total financial technical growth, that is, it plays a certain role in promoting technological progress. The main reason is that China's green financial implementation is still in its beginning stage, with limited data available to cover long enough studying period. It can be expected, however, with further implementation of the green financial plan and continued development of low carbon economy, its contribution role to the technological innovation will be apparently increasing.

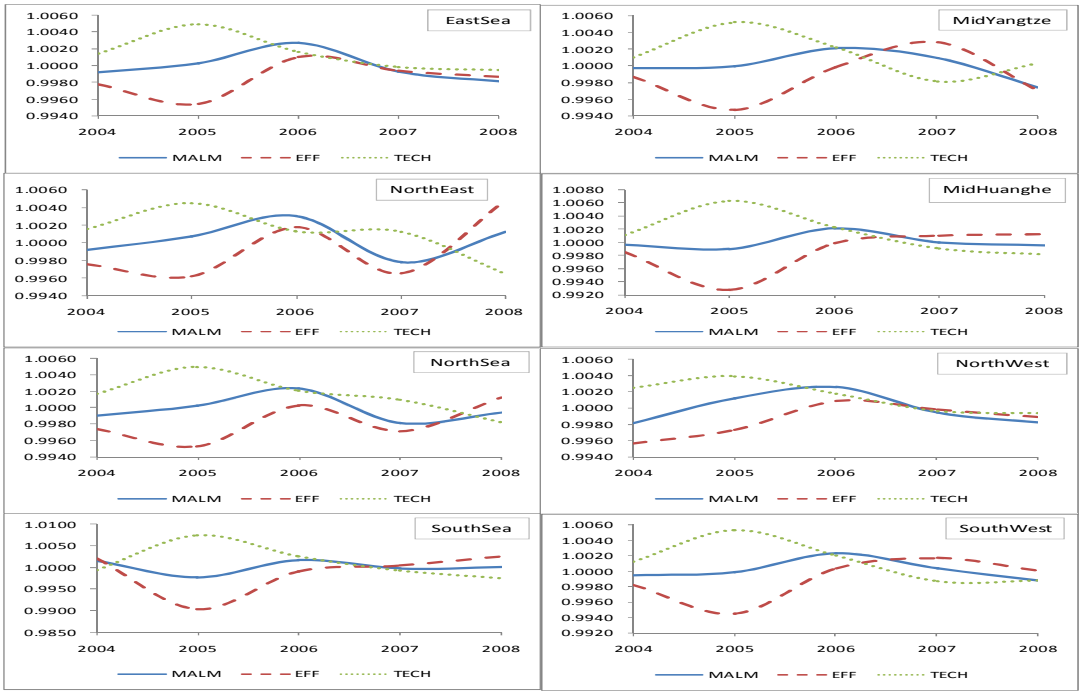

Fig. 3. Comparison of factor contribution ratios to green financial productivity decomposition analysis

Notes: (1) MALM: Green financial Malmquist index; EFF: Green financial efficient index; TECH: Green financial Technological index.(2) Eastsea = EastCoast, Northsea = NorthCoast, Southsea=SouthCoast, MidHuanghe = Mid Yellow River region

Table 3. Factor contributions to green financial technical progress (2003-2009)

ECONZONE	Technology (TFP)	COST	DEPOSIT	ENVLNRT*	
EastCoast	1.0015	0.0651	0.9358	0.00003	
	(t-value =	*0.3623*	*5.3942*	*0.00233*	)
MidYellow	1.0014	0.8737	0.1513	-0.02529	
	(t-value =	*2.3269*	*0.3949*	*-1.32540*	)
MidYangtze	1.0014	1.3652	-0.3553	-0.00917	
	(t-value =	*3.9143*	*-1.0334*	*-0.78210*	)
NorthEast	1.0010	2.4229	-1.4303	0.00799	
	(t-value =	*8.2379*	*-4.8505*	*0.90926*	)
NorthCoast	1.0016	0.5150	0.4679	0.01578	
	(t-value =	*1.8882*	*1.7750*	*0.73104*	)
NorthWest	1.0015	2.4497	-1.4688	0.01808	
	(t-value =	*3.9732*	*-2.3673*	*0.68769*	)
SouthCoast	1.0013	2.2418	-1.2352	-0.00564	
	(t-value =	*11.7181*	*-6.5580*	*-0.75758*	)
SouthWest	1.0012	2.2994	-1.2844	-0.01498	
	(t-value =	*5.8067*	*-3.2553*	*-1.03484*	)
Total	1.0014	1.2499	-0.2702	0.01634	
	(t-value =	*7.7452*	*-1.6926*	*1.78306*	)

*Notes: *(1) ENVLNRT: Environmental credit loan to the total loan ratio. (2) t-value > 1.5 is significant at 10% level. (3) Figures are calculated in this paper by the author*

Studying on each of the eight economic regions in the recent seven years, however, the above overall conclusions of the financial accounting to growth is not applicable regionally. Though the contribution share of the labor inputs to the technological progress for all eight economic regions are obviously the same, the scale effect of capital accumulation shows a weak negative contribution, consistent to the national overall effect, except for the two regions of the Eastern Coast and the Northern Coast that have a positive scale effect (but the result of the Middle Reaches of Yellow River is not significant with low t-value for either sign in Table 3). Finally, the result of green financial input is divided. In terms of an overall effect, its contribution share to the financial technological progress is very small, although half of the economic regions (Eastern Coast, Northern Coast, Northeast, Northwest) show a positive effect, while the other half (the Middle Reaches of Yellow River, the Middle Reaches of Yangtze River, Southern Coast, Southwest) have a negative effect, but the average contribution rate of them only spans a narrow spread between -2% and 2%. Due to the same reasons of the limitation of the existing data for the green financial inputs, only half of the estimated values of the green financial contribution ratio are significant at the 10% interval level (indicated by the t-values in the last column). But all the contribution ratios for the labor and capital statistics (except for only two numbers) exhibits statistically significant.

Conclusively, just as Lin (2004) [16] believed, technical progress serves as an important criterion to judge whether economic growth is sustainable, according to this study for nearly 10 years of sustainable development of China's financial sector, we confirm the notion that the sustainable development of the financial productivity also depends on the technological progress, investigating its further sources, financial technological progress or total factor productivity (TFP) is more dependent on the management of labor inputs, while the scale effect of financial capital accumulation is very small. Thus so far, the green financial investment plays a certain role, even though small, in promoting technological innovation in the financial industry.

7. CONCLUSIONS

Green finance direct funds to transfer to the green industry and support technical development and creation by providing financial services, which is important to promote sustainable economic development. Green finance, also as an important part of the financial system, promotes the formation of new financial products, helpful to the sustainable development of the financial sector itself. The purpose of this article is, by comparing the green financial productivity growth among China's 28 provinces and directly affiliated municipalities, and also among eight major economic regions, to study the overall impact of the green financial implementation on the performance and efficiency of the green financial sector, and to analyze the decomposition factors affecting the change of financial performance and input sources to the green financial technological increase.

After studying the period from 2003 to 2009 with complete data coverage, the average level of China's green financial productivity growth is low as a whole, ranging in a narrow interval from zero to 0.05%. And the green financial productivity growth basically maintains the same level, at slightly less than 0.02%. From decomposition factors of financial productivity growth and growth sources of financial productivity, technological progress for the industry has a leading role in the development of the financial productivity, and the scale efficiency actually takes a negative effect, namely, the financial productivity growth comes from the financial innovation and technological development. However, the implementation of green financial plan makes social resources transferring to non-polluting, low energy consumptive green industry, at the same time has increased the production costs, but this does not hinder the

general upward trend of productivity growth of the entire financial industry, neither affects continued growth of the financial performance, for which the factor of technological progress and innovation is critical. For the sources of technological progress and innovation in the financial productivity growth, it is found that the factor input of human resources plays an absolutely leading role, but the scale effect of capital accumulation is not obvious. However, the contribution of green financial input to the technological progress of the total financial productivity although small, but still shows an obvious positive effect.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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