



Can employment structure promote environment-biased technical progress?



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ABSTRACT

Environment-biased technical progress can stimulate improvement in environmental quality, leading to coordinated development between the economy and the environment. However, the existing literature scarcely refers to the factors influencing the technical progress bias. We use the overlapping generations model to realize the endogenesis of biased technical progress in the Chinese context. We show that an increase in the aging population will encourage the use of pollution-biased technology and focus the attention of enterprises on improving economic benefits rather than environmental quality. We measure the directions of technical progress during 2003 to 2013 and estimate regressions for the relevant indicators of the labor force employment structure. Under equilibrium, increased ratios of the aging population and state-owned enterprises will stimulate environment-biased technical progress. Further, the effects of research and development and clustering of state-owned enterprises on environmental technology improvement are significant.

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1. Introduction

Economic growth is usually accompanied by deterioration of environmental quality. While economic growth improves people's quality of life, the accompanying environmental pollution and resulting degradation simultaneously lowers the same. Besides, the worse the environmental pollution, the greater its influence on economic growth. As per the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), the global gross domestic product (GDP) will reduce by 5% for every 4 °C rise in the global temperature. At present, the Chinese government strongly advocates a cyclic economy to construct a resource-saving and environmentally friendly society. Though a series of environmental regulations and policies have been implemented to this end, they are likely to increase the production costs of polluting enterprises, may cause significant unemployment, and aggravate the gap between the rich and the poor in China.

Compared with the short-term effects of environmental regulations and policies, technical progress in energy conservation and emissions reduction is more likely to bring about long-term benefits to the society. Innovation in clean technology has become an effective way to realize a win-win situation between environmental protection and economic growth. However, though the importance of progress in environmental technology is self-evident, hardly any literature identifies the factors influencing this progress. The existing literature mostly focuses on analyzing the relationship between environmental regulations and

clean technology; examples include the study of the relationship between environmental regulations and the number of patent applications by Arduini and Cesaroni (2001); Aiken et al.'s (2009) study regarding the influences of environmental regulations on pollution control costs, Popp et al.'s (2009) analysis of the economic incentives of environmental regulations on enterprise innovations, and the construction of the endogenous growth model by Acemoglu et al. (2012b) to analyze the influence of environmental policies on innovation. However, environmental regulation is an exogenous variable. Is there an endogenous variable that can affect environmental technology?

Stricter environmental regulations are likely to increase unemployment, which poses serious problems for any country (Greenstone, 2002). As per the data released by the Ministry of Human Resources and Social Security and the annual China Statistical Yearbook, though the registered urban unemployment rate since 2002 has not increased beyond 4.3%, total unemployment has risen to more than 7.7 million, mainly due to China's enormous population. At the end of 2014, the actual registered urban unemployment rate for China as a whole rose to 4.09%. Increasing unemployment will have tremendous impacts on the physiology and psychology of workers (Roh et al., 2014). Unemployment and the resulting unbalanced employment structure have become serious hindrances to China's economic growth. Peroni and Gomes Ferreira (2011) considered that enterprises with a high level of competition would stimulate investments in research and development (R&D). The increased intensity of competition would stimulate technical progress. If so, can China improve its progress in environment-biased technology by adjusting its employment structure, namely, by adjusting its employment structure in industries with weak

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environmental regulations or in environmentally friendly industries? One the one hand, environmental regulation raises production costs of enterprises and forces them to retrench labor, leading to considerable unemployment; on the other hand, the increasing stringency witnessed by the environmental protection industry increases the demand for labor, thus promoting employment. If the employment structure of Chinese labor undergoes a reasonable shift from the production industry to the environmental protection industry, will the unemployment rate effectively decline? Furthermore, can the increase in employment in the environmental protection industry promote environment-biased technological progress? Can we achieve sustainable development in both environmental and economic terms by adjusting the employment structure rather than implementing mandatory environmental regulation? This study attempts to answer these questions.

The rest of this paper is structured as follows. [Section 2](#) presents the literature review. [Section 3](#) discusses the theoretical models, and [Section 4](#) refers to indicator selection and model construction. [Section 5](#) presents the results of model estimation and testing, while [Section 6](#) concludes.

2. Literature review

The concept of biased technical progress was first put forward by [Hicks \(1932\)](#), who considered that changes in the relative prices of factors would force entrepreneurs to innovate technologies and use low-cost factors. If the technical progress is beneficial in that it can increase the marginal output of capital, then such progress is referred to as capital-biased technical progress. If it increases the marginal output of labor, then it is defined as labor-biased technical progress. [Acemoglu \(2003, 2007\)](#) further extended the concept of biased technical progress. Technical progress may occur in either direction between any two input factors. Given the increasing attention being paid to environmental issues in recent research on economic theories, the environmental factor, which reflects the quality of life, has been included by most researchers in the production function. However, environment-biased technical progress differs from production-biased technical progress in that the latter requires outputs to increase, while the former requires energy consumption and undesirable outputs to decrease along with technical progress ([Wang and Song, 2014](#)). Hence, environment-biased technical progress includes technical progress related to both energy saving and emissions reduction. In this context, [Acemoglu et al. \(2012b, 2014\)](#) took the lead in theoretically defining and analyzing the components of environment-biased technical progress.

Many researchers have focused on biased technical progress ever since [Acemoglu \(2003\)](#) proposed the concept. However, empirically, there is still no accepted method to measure the same. Most of the literature only adopts a substitution of indicators to express biased technical progress ([Harrison, 2002](#); [Welsch and Ochsen, 2005](#); [Arnberg and Bjorner, 2007](#); [Ma et al., 2008, 2009](#)). Although some studies estimated the index of the direction of technical progress through the normalized supply-side system approach ([Klump et al., 2007](#)) or the generalized non-linear least square method ([Leon-Ledesma et al., 2010](#)), fitting precision was still low. A non-parametric method, however, offers advantages while estimating biased technical progress. Data envelopment analysis (DEA) has become the method of choice in this regard ([Bogetoft and Wang, 2005](#)); because there is no need to preset the production function, hidden or ignored relationships in the environment system can be revealed ([Liu et al., 2010](#)), and it is easy to compare efficiency across firms and even analyze ineffective decision-making units ([Lv et al., 2013](#)). [Manne and Richels \(2004\)](#) introduced the biased technical progress theory into climatic change models and noted the reduction of various technical costs alongside the increase in experience. They observed the effects of biased technical progress on cost and time in the context of CO₂ emission reductions. [Popp \(2004\)](#) introduced biased technical progress in the energy sector into the DICE model of climatic change evaluation and effectively calculated the welfare cost

of the optimum carbon tax. In 2012, [Acemoglu et al. \(2012a\)](#) used the biased technical progress in growth models with environmental restrictions and limited resource conditions and analyzed the costs and profits of different environmental policies based on clean technology and pollutive technology. In the same year, [Acemoglu et al. \(2012b\)](#) established an endogenous model from the viewpoint of input, assuming that clean technology and pollutive technology, that is, productive technology, compete with each other. Additional inputs on clean technology would reduce inputs on pollutive technology; the 'extrusion' effect would be observable in scientists' research activities. [Greger and Heggedal \(2012\)](#) considered that clean technologies are effective in the long run, thus amending [Acemoglu et al.'s \(2012b\)](#) conclusion that research and development pertaining to clean technology was over-subsidized.

As one of the world's largest growing economies, China ranked first globally in terms of carbon emissions in 2006, exceeding those of the U.S. for the first time ([Gong et al., 2014](#)). Hence, there is an urgent need for the country to reduce its carbon emissions. Besides, China also faces challenges from the recent slowdown in economic growth. Can reforms of state-owned enterprises via a transformation of the labor force employment structure and innovation help improve environmental quality as well as coordinate development between the environment and the economy? Empirically, biased technical progress can reveal important differences in skill premiums ([Van Reenen, 2011](#)), income gaps among countries ([Acemoglu et al., 2012a](#)), and changes in environmental technologies ([Aghion et al., 2012](#)). [Ji \(2011\)](#) observed the effects of market structure on biased technical progress and found that fixed costs of intermediate products and R&D efficiency are two important factors that affect the degree of bias. [Acemoglu et al. \(2012b\)](#) discussed the factors that influence the direction of technical progress from the perspective of the speed of factor accumulation but did not analyze the factors that affect the relative speed of factor accumulation. According to [Hicks \(1932\)](#) and [Acemoglu \(2007\)](#), the relative prices of input factors decide the degree of biasness of technical progress and the relative factor inputs decide the relative prices of the factors. Therefore, relative factor inputs are decisive to technical progress bias.

Labor force is one of the most important inputs to the production process. Many scholars, for example, [Bullock-Yowell et al. \(2014\)](#); [Chillas et al. \(2015\)](#), and [Vayre and Pignault \(2014\)](#), studied the relationship between the labor force and unemployment. Studying the effects of the labor force employment structure in both state-owned and private enterprises on biased technical progress is vital in the Chinese context. We consider that state-owned enterprises in China exercise the will of the state, while private enterprises reflect changes in the market. Hence, on the issue of environmental protection, state-owned enterprises have more impetus than private enterprises. Further, state-owned enterprises hold more capital and technologies and are better placed to realize the objectives of energy saving and emissions reduction. An increase in the ratio of state-owned enterprises causes the labor force to become scarce and the capital to grow, or an increase in the ratio of state-owned enterprises reduces the labor force and increases capital. Consequently, the relative price of labor-capital will increase, and the direction of technical progress will be inclined toward labor. As state-owned enterprises hold more capital and have the resources to practice clean production, private enterprises may undertake polluting production, thus inclining the direction of technical progress toward pollution. Since wages in state-owned enterprises are lower than those in private enterprises, an increase in the ratio of state-owned enterprises will affect not only the employment structure but also total savings. Hence, it is necessary to analyze the equilibrium effects of the employment structure on the direction of technical progress if we want to clarify the effects of changes in the said structure on the direction of technical progress.

Accordingly, this study analyzes the effects of China's labor force employment structure on environment-biased technical progress from both the theoretical and the empirical aspects. We establish an overlapping generations (OLG) model for our study. In the empirical analysis,

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