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ScienceDirect

Energy Procedia 5 (2011) 1003–1007

Energy Procedia

IACEED2010

# R&D for Environmental Innovation and Supportive Policy: The Implications for New Energy Automobile Industry in China

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**Abstract**

As resource scarcity and environmental degradation has aroused global concern, new energy vehicles have become the developing trend of automobile industry all over the world. However, there is lack of incentive for innovations on more environmentally friendly automobile technology. This paper introduces endogenous and directed technology progress into the growth model to analyze the decision-making on R&D of environmental technology and concludes that automobile enterprises are less willing to engage in the energy-saving technological innovation as traditional fossil-fuel-based automobile technology is relatively mature. Therefore, it is necessary for the government to formulate some temporary supportive policies at the initial stage of the development of new energy automobile industry in China, to stimulate the initiative of vehicle manufacturers to innovate on environmental automobiles.


Selection and peer-review under responsibility of RIUDS

*Keywords*: resource constraint; environmental innovation; R&D; new energy vehicles

## 1. Introduction

With the rapid growth of global economy, the issues on resources and the environment, which become the key bottlenecks of sustainable economic development, have aroused common concern. How to ease the conflicts between economic growth and high energy consumption as well as environmental deterioration is a challenge for the whole world. Transportation is a large fossil fuel consumer and also a major source of greenhouse gas emission, air pollution and global warming. Vehicle industry faces increasing pressure from energy saving and environmental protection. At present, petrol and diesel consumption by vehicles in China has accounted for approximately 86% of gasoline output and 24%of

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doi:10.1016/j.egypro.2011.03.177

diesel output respectively. Automobile gas emission has taken up over 70% of urban gas pollution. Therefore, R&D of environmentally friendly vehicles will be the mainstream in the future.

How to promote the R&D activities in environmental automobiles has aroused common attention. Domestic studies such as Xu Bo et al.(2007),Xiao Yin (2008), Xing Hongjin et al. (2009)mostly focus on the necessity, urgency and means of developing new energy automobile industry from macro perspective. However, theoretical analysis on the incentives for R&D of clean technology has been neglected and previous studies seldom involve the decision-making of firms on environmental innovations from micro perspective. Foreign scholars like David A. & Glemm M. M. (1998), Geroski P. A. (2000) set up some theoretical models to analyze technology diffusion. Acemoglu (1998, 2002, 2009) explored the influential factors over the direction of technology change and concluded that market size effects and price effects encouraged more innovations happen in the sector with greater employment and higher prices respectively. This paper draws on Acemoglu's analytical framework by introducing endogenous and directed technology progress into the growth model to explore the incentives for R&D of new energy automobiles in response to resource constraint and environmental pressure and then proposes some suggestions for the development of new energy automobile industry in China.

The remainder of the paper is organized as follows:Section 2 introduces the basic settings of the model. Section 3 characterizes the decision-making on environmental innovations. Section 4 summarizes the implications for the development of new energy auto industry in China.

## 2. Basic Settings of the Model

Suppose there is a unique final good and the aggregate production function takes the form of constant elasticity of substitution (CES), using two intermediate inputs $Y_{ct}$ and $Y_{dt}$ in the form of $Y_t = (\gamma_{ct} Y_{ct}^{\frac{\varepsilon-1}{\varepsilon}} + \gamma_{dt} Y_{dt}^{\frac{\varepsilon-1}{\varepsilon}})^{\frac{\varepsilon}{\varepsilon-1}}$,wher $\varepsilon$ is the elasticity of substitution between the two inputs and $\varepsilon \in (1,\infty)$ as the two inputs are substitutes in the production. $Y_{ct}$ and $Y_{dt}$ represent "clean" and "dirty" inputs respectively and the differentiation is based on the degree of pollution and energy consumption in the production process and by the use of the intermediate inputs. Environmentally friendly automobiles rely more on clean inputs whereas traditional gasoline-based vehicles make more use of dirty inputs. $\gamma_{ct}, \gamma_{dt} > 0$, denotes the importance weights of two inputs in the aggregate output and satisfies $\gamma_{ct} + \gamma_{dt} = 1$.Both the two inputs are produced competitively by labors and a continuum of sector-specific machines according to the production functions: $Y_{ct} = L_{ct}^{1-\alpha} A_{ct}^{1-\alpha} \int_0^1 x_{cvt}^{\alpha} dv$ , $Y_{dt} = L_{dt}^{1-\alpha} A_{dt}^{1-\alpha} \int_0^1 x_{dvt}^{\alpha} dv$ ,where $\alpha \in (0,1)$ , $A_c$ and $A_d$ represent the aggregate productivity in clean and dirty sectors respectively to reveal the average quality of machines used in the sector. $x_{cvt}$ 、 $x_{dvt}$ corresponds to the quantities of machine of type v used in clean and dirty sectors and the types of machines v in two sectors range from 0 to 1 continuously. Labor market clears when the total labor demand in both sectors doesn't exceed the total labor supply, which has been normalized to be 1, that is $L_{ct} + L_{dt} \le 1$.Assume that all the machines used in both sectors are supplied competitively by monopolistic firms. No matter how the quality of machines is and which sector the machines are utilized in, producing one unit of any machine should cost $\psi$ units of final goods.

Researchers can direct their efforts to either clean or dirty technology freely and devote themselves to the improvement of the quality of machines used in the sector with the probability of success $\beta_c$ or $\beta_d$ respectively, where innovation improves the quality of machine by $1+\lambda$ times, that is from $A_{jvt}$ to $(1+\lambda)A_{jvt-1}$, $j \in \{c,d\}$. The successful researcher, who has invented a higher-quality machine, owns the complete patent of the innovation and enjoys the monopolistic profits. We normalize the total number of researchers to 1 and $s_{ct}$ 、 $s_{dt}$ represents the number of researchers undertaking R&D of clean or dirty technology respectively. Therefore, market clearing for researchers satisfies $s_{ct} + s_{dt} \le 1$.