International Journal of Intelligent Information and Management Science

Volume 4, Issue 4, August 2015

Part I

http://www.hknccp.org

Publisher: HongKong New Century Cultural Publishing House
Address: Unit E79, 3/F., Wing Tat Commercial Building, 97 Bonham Strand East, Sheung Wan, HK

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H K . N C C P
International Journal of Intelligent Information and Management Science
ISSN: 2307-0692 *Volume 4, Issue 4, August 2015*

Empirical Study on the Effect of China's Fiscal Policy in New Energy Vehicles Industry

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Abstract: New energy vehicles are the development direction of automobile industry in the future, and fiscal policy is the main policy tool to promote the industry development. In recent years, China takes developing new energy vehicles as national strategy and promotes the industry development with fiscal policy. Taking the new energy vehicles industry as the breakthrough point, this paper makes analysis on China's fiscal policy in new energy vehicles industry and measures the fiscal policy effect with Hotelling's model of spatial competition. The results show that fiscal policy has played an important role in reducing the sales price and promoting the application of new energy vehicles; the demonstration of public sector's application is obvious; the technology level of new energy vehicles has a significant impact on the application and popularization. At last, this paper puts forward policy recommendations for China. Those are government should continue to play the effect of fiscal policy, and increase support for consumer purchase, enterprise's technology research and infrastructure construction.

Keywords: New energy vehicles industry; Fiscal policy; Effect measure; Hotelling's model of spatial competition

1. Introduction

New energy vehicles are the development direction of automobile industry in the future. While bring convenience to human life, the automobiles also have produced more and more serious energy problems and environmental pollution. According to statistics, the world's car ownership has exceeded 1 billion. Annual transportation energy consumption accounts for about 60% of world energy consumption. Meanwhile, automobile emission, of which is the world's second-largest carbon emission industry, account for about 17% of the world's carbon emission. In China, the problems of energy consumption and environmental pollution that faced by the automobile industry are more serious. China's dependence on foreign oil is about 60% in 2014. With the increase of automobiles, the dependence on foreign oil will further increase. And automobile exhaust emission has also caused serious air pollution. Take PM2.5 in Beijing as an example, in the Beijing local pollution sources, automobile exhaust emissions account for 31.1 percent. In the future, with the rapid development of China's economy, the demand of the car will grow rapidly, and the problems of energy shortage and environmental pollution will become more prominent. So developing new energy vehicles is a strategic choice for easing the problems of energy, environmental and promoting automobile industrial upgrading.

Fiscal policy is the main policy tool in promoting the development of new energy vehicles industry. Fiscal policy can reduce R & D costs and consumer costs, and then promote the industrialization of new energy vehicles. At present, the new energy vehicles industry is still in the start-up period. The key technology is not mature and the industrialization base is also weak. So, the world's major automobile production countries take developing new energy vehicles as national strategy and promote the industry development with fiscal policy. America is one of the earliest countries that propose the plan of developing new energy vehicles. During the oil shocks of the 1970s, America has begun to promote the development of new energy vehicles industry. Japan is also one of the earliest countries that take measures to promote the development of new energy vehicles industry. In order to solve the issues of environmental pollution and energy, in 1970s, Japan's government putted the electric vehicles research into national project, and provided financial to support. From then on, Japan had formulated a series of fiscal policies to promote the electric vehicles' application.

Developing new energy vehicles is also an important target for China. In 1998, China launched the "China Clean Vehicle Action", of which marked that China entered a new stage of promoting technology research and industrialization of new energy vehicles industry. After that, government has launched a series of preferential

policies to promote the new energy vehicles industry development. Especially since the international financial crisis of 2008, China further increased financial support for technology research and development, and set up special funds for the new energy vehicle demonstration and extension project. At present, making the analyses on China's fiscal policy in new energy vehicles industry and measures the effect of fiscal policy are not only beneficial to evaluate the effectiveness of existing financial policy, but also beneficial to China improve fiscal policy.

2. Literature Review

In recent years, with the development of new energy vehicle industry, new energy vehicle industry has become a hot spot research in the field of industrial economics. In the existing research results, most scholars have made studies from the perspective of development strategy, path and countermeasures of new energy vehicles industry. Li Dayuan (2011) has researched on the problems of China's new energy vehicles industry, and finds that China's new energy vehicles industry faces with the problem of lack of core technology, weak industrial basis and so on. Government should increase the support to the industry, and clear the technical path of industrial development [1]. Ai Min and Han Huaiyu (2011) has analyzed the competitive advantage and disadvantage of China's new energy vehicle industry, and consider that China has advantages in the aspects of basic natural resources and market potential, but it is a disadvantage in technology and supporting infrastructure. Therefore, China should increase the support for new energy vehicle technology research and infrastructure construction [2]. Zhang Zheng and Zhao Fei (2014) have studied China's new energy vehicle industry from the perspective of the development strategy, and argue that China's strategic goals of developing new energy vehicle industry is the industry development-oriented. That is enhancing the total GDP through bigger and stronger new energy vehicle industry [3].

Some scholars have done researches on measuring the effect of fiscal policy, but most of the results focus on the macro perspective. Wang Liyong and Liu Wenge (2009) have studied China's fiscal policy by Barrow - Grossman macro general non-equilibrium model, and the results show that China's fiscal policy has significant non-linear effects [4]. Wu Jinguang and Xiao Yaping (2013) have made empirical research on the fiscal policy effect of strategic emerging industries by using panel data model, and argue that, on the whole, the financial policy plays an important role in improving the value of strategic emerging enterprises [5]. With the development of new energy vehicle industry, some scholars have studied the fiscal policy effect of the new energy vehicle industry using the Hotelling spatial competition model. Shi Feng and Yuan Yongke (2011) [6], Zhang Bo (2014) [7] have studied the fiscal policy effect of the new energy vehicle market in the United States and Japan respectively.

In summary, some scholars have studied China's new energy vehicle industry, but most of these are from the macroscopic perspective. The research results about measuring the financial policy effect of the China's new energy vehicle industry are less or blank. Therefor, taking new energy vehicles as the research object, this paper will sort out the financial policies of China's new energy vehicle industry, and quantitative analysis the effect of the policy by the Hotelling spatial competition model. Through the research, this paper will give some policy recommendations to improve fiscal policy and the policy efficiency.

3. China's Fiscal Policy on New Energy Vehicles Industry

Since 1990s, China began to support the development of new energy vehicles industry. During the period of the "Eighth Five-Year Plan", government put the electric vehicles technology research into "863" National High Technology Research and Development Program for the first time. In 1998, China launched the "China Clean Vehicle Action", of which marked that China entered a new stage of promoting technology research and industrialization of new energy vehicles industry. After the financial crisis of 2008, China launched a series of fiscal policies to promote the R & D and application of new energy vehicles. In general, in the aspect of promoting the development of new energy vehicles industry, China's main fiscal policies were financial subsidies, tax incentives, government procurement and infrastructure construction investment.

3.1. Fiscal subsidies policies

China's fiscal subsidies on new energy vehicles mainly include new energy vehicles application's subsidies, infrastructure construction subsidies and R&D subsidies. In terms of new energy vehicles application's subsidies, government carried out the experimental work of energy-saving and new energy vehicles demonstration and extension for the first time in 2009. During 2010-2012, government gave price subsidies for buying electric vehicles, hybrid vehicles and other new energy vehicles. There were maximum subsidies 60000 Yuan per electric vehicles and 50000 per plug-in hybrid vehicles. In 2013, government introduced the policy once again that continued to provide subsidies for buying new energy vehicles. In terms of infrastructure construction, government gives land preferential policies and subsidies for construction operations. In terms of technical research, during the period of the "Eighth Five-Year Plan", government put the electric vehicle technology research into "863" National High Technology Research and Development Program. During the period of the "Ninth Five-Year Plan", gov-

ernment put the electric vehicle technology research into major industrial projects. During the period of the "Tenth Five-Year Plan", government spent 950 million Yuan in the "863" major projects of electric vehicles. In the period of the "Eleventh Five-Year Plan", government had spent 1.1 billion Yuan in the "863" major projects of energy saving and new energy vehicles [8]. Since 2012, government carried out new technology innovation project and launched 25 new energy vehicles technology innovation projects.

3.2. Tax incentives

Tax incentive is another major policy tool to promote new energy vehicles applications. In 2012, government implemented the vehicle and vessel tax incentives policies for new energy vehicles. Since 2012, using energy saving vehicles would get 50% of the vehicle and vessel tax cuts, and using new energy vehicles would exempt from the vehicle and vessel tax. During the period of September 2014 to December 2017, purchasing and using electric vehicles, plug-in hybrid vehicles and fuel cell vehicles would exempt from acquisition tax. In terms of technical research, government implements income tax incentives policies for R&D of new energy vehicles [9].

3.3. Government procurement policies

In 2014, government launched "Government Agencies and Public Institutions to Buy New Energy Vehicles Scheme" and asked government to buy new energy vehicles. This document calls for that, during 2014-2016, the quantity of new energy vehicles that central government and pilot city government bought accounted for not less than 30% of the total proportion of new vehicles. The quantity of new energy vehicles that provincial government bought accounted for not less than 10% of the total proportion of new vehicles in 2014, not less than 20% in 2015 and not less than 30% in 2016.

4. Examine the Effect of China's Fiscal Policy in New Energy Vehicles Industry

In 1929, Harold Hotelling proposed Hotelling spatial competition model. The model's assumptions and simulation for market competition are similar to the situation of new energy vehicle market, and it has been applied to the study of fiscal policy effects of new energy automotive industry. Therefore, this paper uses the model to examine the effect of China's fiscal policy.

4.1. Theory analysis of hotelling spatial competition model

Suppose in a length of 1 linear market, supply two kinds of different goods. The two goods locate in different positions of a and b (0<a<b, a+b≤1), supply price are p_a and p_b respectively, and the marginal supply cost of the two goods are c. All consumers are evenly distributed in the market, and each consumer only buys one goods. With $x \in [0,1]$ represents the location of every consumer. When buying goods, consumer not only has to pay the selling price of goods, but also has to pay certain units acquisition costs t (such as tolls, taxes, etc.). Suppose acquisition costs associated with the consumer's location, and are a quadratic function. For example, acquisition costs of consumer located x to buy a is $t(x-a)^2$, and to buy b is $t(x-b)^2$.

The consumer's position represents the preference of consumers. In order to maximize their own utility, consumer always buys the goods that close to them. So, the total costs of consumer to buy goods a is $p_a + t(x-a)^2$, to buy goods b is $p_b + t(x-b)^2$. As consumers tend to buy low-price goods, if the highest price of a goods is higher than b goods price delivery at a:

$$p_a^H(p_b) = p_b + t[(1-b)^2 + a^2] \quad (1)$$

Then all consumers will buy b goods. On the contrary, if the lowest price of a goods delivery at b is lower than b goods:

$$p_a^L(p_b) = p_b - t[(1-a)^2 - b^2] \quad (2)$$

Then all consumers will buy a goods. When the market is in equilibrium, the market share of the two goods is determined, of which located in the two curves' intersection X^* (as shown in Figure1). The consumer located at X^*, buy goods a or goods b, will pay for the same total cost. Therefore, we can get the equation as follow:

$$p_a + t(X^* - a)^2 = p_b + t(X^* - b)^2 \quad (3)$$

By equation (1), we can obtain the equation as follow:

$$X^* = \frac{p_a - p_b}{2t(a-b)} + \frac{a+b}{2} \quad (4)$$

Market demand for a goods are:

$$q_a = \begin{cases} 1, & p_a < p_a^L(p_b) \\ \frac{p_a - p_b}{2t(a-b)} + \frac{a+b}{2}, & p_a^L(p_b) \le p_a \le p_a^H(p_b) \\ 0, & p_a^H(p_b) < p_a \end{cases} \quad (5)$$

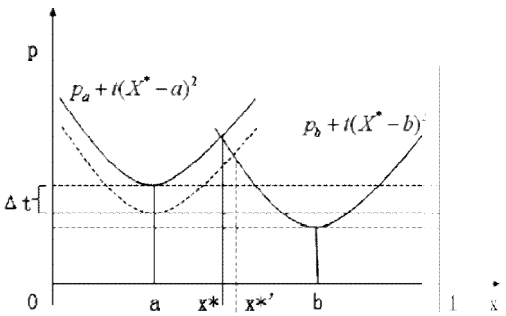


Figure 1. Equilibrium analysis of goods market

Because of the existence of the price competition and the long-term game between a and b, a goods is difficult to get all the market or the loss of the entire market. The result of the long-term game is that the price of a goods is between the upper and the lower limit. That is $p_a^L(p_b) \le p_a \le p_a^H(p_b)$.

At this point, the profit maximization decision function for sell goods a and goods b are respectively:

$$p_a \in \arg\max_{p_a}\{p_a=(p_a-c)\cdot X^*=(p_a-c)\left(\frac{p_a-p_b}{2t(a-b)}+\frac{a+b}{2}\right) \quad (6)$$

$$p_b \in \arg\max_{p_b}\{p_b=(p_b-c)\cdot(1-X^*)=(p_b-c)\left(\frac{2-a-b}{2}-\frac{p_a-p_b}{2t(a-b)}\right) \quad (7)$$

The first-order conditions of the optimal price function are:

$$p_a = c + t(b-a)(\frac{1}{2}+\frac{2b+a}{3}) \quad (8)$$

$$p_b = c + t(b-a)(1+\frac{b-a}{3}) \quad (9)$$

Put the equation (6) into the equation (2), we can get the inverse demand function of goods a as follow:

$$p_a = c - 2t(b-a)X^* + t(b-a)(1-\frac{2b+4a}{3}) \quad (10)$$

If there are exogenous factors that make goods a's sales prices decline, for example, to promote production and application of goods a, government implement financial subsidies or tax cuts, and then the cost of goods a will decline. The demand function of goods a will decline, and the market equilibrium position will move right from X^* to $X^{*'}$. This indicates that the goods a's market share expands, as the following equation show:

$$p_a - \Delta T = c - 2t(b-a)X^{*'} + t(b-a)(1-\frac{2b+4a}{3}) \quad (11)$$

Put the equation (5) into the equation (8), we can get equation as follow:

$$2t(b-a)X^* = 2t(b-a)(\frac{1}{4}-\frac{4b+5a}{6}) - \Delta T \quad (12)$$

Order $2t(b-a)(\frac{1}{4}-\frac{4b+5a}{6})=M$. Take logarithm on both sides of equation (9), after processing, we can get equation as follow:

$$\ln X^{*'} = -\ln 2t + \ln(M-\Delta T) - \ln(b-a) \quad (13)$$

This shows, when other conditions remain unchanged, the changing of goods a's market share relate to government tax incentives and the position of a goods and b goods.

4.2. Data selection and description

China's vehicle market can be approximated as only supply two products, namely new energy vehicles and conventional vehicles. Assuming that they are located at point a and point b. The demand curves of the two goods are different. The intersection of the two curves locate at point X^*, of which represents the market share of two goods when market in equilibrium. X^* represents the new energy vehicles market share, and 1- X^* represents the conventional vehicles market share. Because the new energy vehicles have positive external effects, production costs and selling prices higher than conventional cars, thence $X^* \le 1-X^*$. In order to support the development of new energy vehicles, China's government implement acquisition tax incentives. And then new energy vehicles sales price fall, demand curve downward, market share expands to $X^{*'}$. b-a represents the different degree between the new energy vehicles and conventional vehicles. When other factors remain unchanged, the new energy vehicles market share will be determined by the degree of government support and the different degree between new energy vehicles and conventional vehicles.

In terms of data selection, this paper selects the annual data on sales quantities, purchase allowance and the convenience degree of new energy vehicles of 9 typical models of the new energy vehicle demonstration and extension project to form panel sample data set. The annual data collected from the period of 2001-2012. The 9 typical models are IEV, BYD E6, the Roewe 550, BYD QCJ7100, Changan SC7005, Beijing BJ7000B3D, Chinese sy7150, Zotye JN7000 and Futian BJ6438. The data of sales quantities are obtained from "Yearbook of Energy-saving and New Energy Vehicle" (2012, 2013, 2014). The data of purchase allowance are calculated according to the parameters of the vehicle and the national subsidy standard. The vehicle's parameters come from the Ministry of Industry and Information Technology of China. The convenience degree of new energy vehicles mainly assesses the difference of continued driving ability between new energy vehicles and conventional vehicles, and the data are obtained from the Ministry of Industry and Information Technology of China.

4.3 Regression Analysis

Based on the above analysis of model and data, this paper uses EViews7.2 software to do regression analysis. The results of regression analysis are shown in Table1.

Table 1. Results of estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	14.8672	1.294629	11.48375***	0.0000
ΔT	1.220313	0.358208	3.406721***	0.0023
b-a	-1.224487	0.160367	-7.635554***	0.0000

Note: ***indicate significant at 0.01 level.

According to the results, we can get the equation as follow:

$$\ln X^* = 14.87 + 1.22\ln(\Delta T) - 1.22\ln(b-a) \quad (14)$$

By the equation (14), we can see that fiscal subsidy (ΔT) has significant effect to the sales quantities (Q) of new energy vehicle. A unit increase of ΔT drives the growth

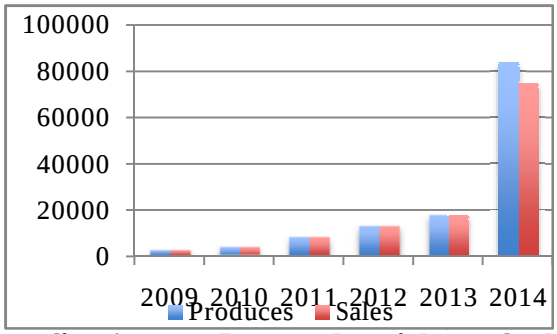
of Q up about 1.22 units. The convenience degree of new energy vehicles than the traditional car (a-b) has also significant effect to the sales quantities of new energy vehicle. In the equation (14), the coefficient of the convenience degree of new energy vehicles than the traditional car is negative. When the mileage of new energy vehicles increases and the gap between the traditional car shrinkages, the factors that hinder the sale of new energy vehicles will be reduced. A unit increases of the convenience degree of new energy vehicles will makes the impact of factors that hinder the sale of new energy vehicles down about 1.22 units. That is to say, the sales of new energy vehicles will increase accordingly. Visibly, fiscal subsidies and improving the technical level of new energy vehicles (battery ability) have an important role in promoting the sales of new energy vehicles. Accordingly, the market share of new energy vehicles will increase.

5. Conclusions and Suggestions

According to policy analysis and empirical testing, we can draw the conclusions as following:

(1) The fiscal policies of fiscal subsidies, which reduce the sales price of new energy vehicles, have significant effect to promote the development of new energy vehicles industry. The fiscal policies of fiscal subsidies and tax cuts reduce the sales price of new energy vehicles and narrow the price gap between new energy vehicles with conventional vehicles. This will greatly increase consumer's demand for new energy vehicles. By the equation (14), we can see that fiscal subsidies and sales quantities of new energy vehicles are positively correlated, and a unit increase of fiscal subsidies drives the growth of the sales quantities up about 1.22 units. In recent years, the sales quantities of new energy vehicles in China continue to rise. And this also proves the positive effect of fiscal policy from practice (as shown in Figure 2). In 2009, the production and sales of new energy vehicle in China were 2500 and 2560 respectively. The number of production and marketing are very small. With the increasing government support, the production and sales of new energy vehicle increased continuously. By 2014, the production and sales of China's new energy vehicles reached to 83900 and 74800 respectively, which increased 3.8 times and 3.2 times respectively than 2013, and increased 32.6 times and 28.2 times respectively than 2009. This shows that fiscal policy has played an important role in promoting new energy vehicles industry development.

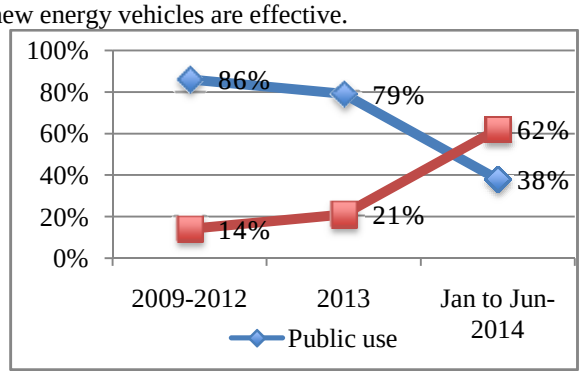
(2) The convenience degree of new energy vehicles has some effect to the sales quantities. The smaller convenience degree gap between new energy vehicles and conventional vehicles is, the more likely promote the sales of new energy vehicles. A unit down of the gap of the convenience degree drives the growth of sales quantities up about 1.22 units. It suggests that, improving the technical level of new energy vehicles (battery ability) have an important role in promoting the sales of new energy vehicles.



Source: China Automotive Engineering Research Institute Co., Ltd.; China Association of Automobile Manufacturers.

Figure 2. China new energy vehicles production and sales

(3) The demonstration effect of the public sector is very obvious. In the case of low penetration of new energy vehicles, the fiscal policy that government procures and uses new energy vehicles firstly in the public sector has a strong demonstration effect. This can enhance customer's awareness on new energy vehicles and encourage customer to purchase new energy vehicles. Procuring and using new energy vehicles in public sector promote the infrastructure construction, and also drive private to purchase new energy vehicles. In terms of application area, the public transport sector's application accounts for the major part and private use accounts for very little at first. However, in 2014, the proportion of the private purchasing and using new energy vehicles increased rapidly and exceeded the public sector. This indicates that the fiscal policies that government encourages private to purchase new energy vehicles are effective.



Source: China Automotive Engineering Research Institute Co., Ltd.

Figure 3. Applications field of China new energy vehicles (2009 - first half of 2014)

Overall, China's fiscal policy has played a positive role in promoting the development of new energy vehicle industry. In order to further improve the efficiency of fiscal policy, combined with the research conclusions, this paper puts forward policy recommendations as follow: First of all, the government should continue to play the role of

economic leverage of fiscal policy. In promoting the development of new energy vehicles, financial policies and other economic means have played an important role. The fiscal policies of tax cuts and fiscal subsidies, of which can reduce the sales price of new energy vehicles and narrow the price gap with conventional cars, are very effective in the promotion of new energy vehicles sales. So, China should further increase the subsidies and tax cuts for new energy vehicles, and expand the application and popularization of new energy vehicles. Secondly, the government should increase financial support to new energy vehicle technology research. Advanced new energy vehicle technology is very important to promote industry development. Government should subsidize the technology research, and promote new energy vehicle technology development. Thirdly, the government should support infrastructure construction of new energy vehicle industry. The more perfect the infrastructure of the new energy automotive industry is, the more conducive to the application and promotion of new energy vehicles. Government should increase investment in infrastructure construction and guide private capital investment into this industry through financial subsidies. Fourthly, the government should improve the efficiency of fiscal policy. Government should strength the financial capital budget management and auditing to improve the efficiency.

6. Acknowledgement

Supported by PhD Innovative Practice Project of China University of Political Science and Law (No. 2014BSCX33).

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