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Research on Decision Optimization of New Energy Automobile Enterprises under the Double Points Policy

Jiawei Liang [1,*], Ziyu Chen [2], Hanyimeng Guo [2], Jiayi Lv [3]

[1] School of International Economics and Trade, Anhui University of Finance and Economics, Bengbu 233030, China.

[2] School of Management Science and Engineering, Anhui University of Finance and Economics, Bengbu 233030, China.

[3] School of Economics, Tianjin University of Finance and Economics, Tianjin 300221, China.

* Corresponding Author

Abstract

The promulgation of the "Double Points Management Measures" not only solves the pollution problem caused by the large-scale production of fuel vehicles, but also encourages the development of the emerging new energy automobile industry and affects the future growth of the entire domestic automobile market. Based on the research background of the double-point policy, this paper uses game theory to analyze, specifically discuss the evolution of the game between auto companies and local governments and the optimal strategies of the two parties in various situations, and put forward relevant policy recommendations.

Keywords

Double points policy; new energy vehicles; evolutionary game; decision optimization.

1. Introduction

In the automobile industry, my country started relatively late compared to the old-fashioned automobile power. Although in recent years, with the support of the government, my country's automobile industry has developed very well, and there have been batches of domestic independent brands, but In many key technologies, my country is still facing the technological blockade of the old car powers. In the production of some parts and precision equipment, it is very dependent on the old car powers. In order to reduce pollution, encourage the development of emerging industries, and surpass Western countries in the new energy vehicle industry, in September 2017, the Ministry of Industry and Information Technology issued the "Administrative Measures for the Parallel Administration of Passenger Vehicle Enterprises' Average Fuel Consumption and New Energy Vehicles". The approach introduced the concept of NEV points for the first time and was implemented in April 2018. The introduction of the double-point policy has, on the one hand, restricted the production and manufacture of highly polluting fuel vehicles and eased my country's pressure on environmental governance. The independent car brand stands on the same starting line with the old car power, and has the opportunity to overtake in the corner.

Double points refer to CAFC (Corporate Average Fuel Consumption) points and NEV (New Energy Vehicle) points respectively. CAFC points and NEV points are calculated in two different ways. The points are calculated mainly through indicators such as the fuel consumption of a single vehicle, the target value of fuel consumption of a single vehicle, sales volume, mileage in pure electric mode, and electric vehicle models. Before March 1 each year, an automobile enterprise submits an annual report on the implementation of the CAFC points and NEV points

of the enterprise in the previous year to the Ministry of Industry and Information Technology. If the points are negative and not paid off within 90 days after the report is issued, companies that do not meet the standards will be subject to strict penalties. Companies with unpaid negative CAFC points will be punished by suspending the declaration of high fuel consumption products and suspending the production of high fuel consumption products. Enterprises whose NEV negative points are not compensated will be punished by suspension of production of high fuel consumption products. Once punished, it will undoubtedly have a huge impact on the economic benefits of automobile companies. Therefore, if a car company with negative points wants not to be punished, it can buy points from a passenger car company with positive points, and offset their negative points in a one-to-one ratio.

In April 2020, the Ministry of Industry and Information Technology announced the CAFC points and NEV points of 146 auto companies. From the results, all domestic auto companies generated NEV positive points of 3,830,900, negative points of 806,900, CAFC positive points of 6,074,300, and negative points of 4,570,800; among them, FAW-Volkswagen ranked at the bottom of the two points, respectively - 549439 points, -145274 points. In order to avoid the penalty, FAW-Volkswagen purchased a large number of points from its peers. For NEV points alone, it would cost an additional 100 million yuan. From this, it is not difficult to see that the introduction of the dual-point policy has a great impact on the development direction of the entire domestic automobile industry. It encourages the development of the new energy automobile industry, but also makes the traditional fuel vehicle brands have to spend a lot of money every year. New energy vehicle companies buy a lot of credits to avoid penalties, inhibiting the development trend of traditional fuel vehicles.

At present, many scholars at home and abroad have conducted research on the new energy vehicle industry. Most scholars affirmed the role of the double-point policy in promoting the development of the new energy vehicle industry, and discussed the policy design and policy evaluation from the perspectives of policy design and policy evaluation. Impact of the Double Points Policy. Based on the research background of double integral policy, this paper uses static game and evolutionary game methods to analyze, specifically discusses the evolution process of the game between auto companies and local governments and the optimal strategies of both parties in various situations, and proposes related policy suggestion.

2. Static game analysis between new energy vehicle companies and the government under the dual-point policy

2.1. Premise assumptions

1. Assume that the main players on both sides of the game are local governments and auto companies, and the behaviors of the two players are completely rational. These two players constitute the game combination A={a,b}, where the participant a represents the Local government, participant b represents an auto company. In any case, the decisions made by the two actors are completely based on the maximization of their own utility.

2. Assume that both the local government and the auto company have two decisions to choose from. The decision set of the local government is B1={subsidy, no subsidy}. The subsidy refers to the local government's decision to develop new energy vehicles for auto companies or to reduce energy consumption. If the technology is not subsidized, the local government does not encourage such behaviors of automobile enterprises, and will not provide any financial assistance to the research and development of automobile enterprises. The decision set of auto companies is B2={R&D, no R&D}. In order to maximize their own utility, auto companies will maintain existing production, pay fines for negative credits, and draw a lot of money to develop new energy vehicles. Choose the one that best suits your interests.

3. The influencing factors and variables are set as follows:

The financial subsidy provided by the local government for the research and development of automobile enterprises is denoted by C1;

The time, capital and other costs that automobile companies spend on developing new technologies and products are represented by C2;

The opportunity cost of an automobile company to develop new technologies and products is represented by W1 (that is, if the auto company does not use funds to develop new products or technologies, but the income obtained from operating other businesses is represented by W1);

The income obtained by automobile companies when they successfully develop new products or technologies is represented by W2 (W2>W1; W2>C2);

Resources other than government subsidies, such as technical support and assistance policies, obtained by auto companies in the process of developing new products or technologies are represented by I;

When the local government encourages auto companies to develop new products or technologies, the local government is supported by national finance or policy, which is represented by R;

When an automobile enterprise succeeds in developing new products or technologies, it brings more employment opportunities and other resources to the local government, and the realized benefits are represented by V;

When an auto company obtains financial subsidies from the local government but does not conduct any R&D activities and defrauds the funds, the local government is notified by the state, and the income that the financial support obtained is reduced is represented by P.

4. Regardless of the order of actions of local governments and enterprises, the game result matrix of both parties is shown in the following table:

When auto companies choose R&D and succeed:

		Decisions of auto companies	
		research	no research
local government decisions	subsidy	R+V-C1,W2+I-W1-C2	R-C1-P,W1
	not subsidized	0,W2-C2-W1	0,W1

Figure 1 Static game matrix of complete information between local governments and auto companies under the condition of successful R&D

When auto companies choose R&D but have not made technological progress:

		Decisions of auto companies	
		research	no research
local government decisions	subsidy	R+V-C1,W2+I-W1-C2	R-C1-P,W1
	not subsidized	0,-C2-W1	0,W1

Figure 2 The static game matrix of complete information between local governments and auto companies in the case of R&D failure

2.2. Game Analysis of R&D Behavior of Automobile Enterprises

According to the premise of the game model and the game analysis profit matrix, the profit situation of both sides of the game under static game conditions is analyzed. The details are as follows:

When car companies make progress in developing new products or technologies and satisfy the situation of $W_2 > 2W_1 + C_2$ car companies will have an optimistic attitude towards expected earnings, and they will choose to develop new products. Auto companies have not made any progress in researching and developing new products or technologies. Only when $I > 2W_1 +$

C_2 is satisfied, auto companies will choose to conduct research and development. From the perspective of the local government, the local government subsidizes the R&D activities of auto companies as C1. If the R&D of the auto company is successful, the local government will receive more resources V such as national policy support R and employment opportunities brought by the auto company. In this case, if $R > C_1$, the optimal decision of the local government is subsidy. If $R + V < C_1$, the optimal decision of the local government is not to subsidize.

In the case of $W_2 + I < 2W_1 + C_2$, auto companies will choose not to carry out R&D after a trade-off between spending a lot of money to develop new energy vehicles or paying fines. Because if there is no progress in research and development, the auto company will directly lose $W_1 + C_2$, and will continue to buy points later, a lot of investment, and no output is obviously an irrational decision. If the subsidy behavior of the local government to the automobile enterprises has applied for the financial and policy support of the state, then when $R > C_1 + P$, the decision of the local government with the greatest utility is the subsidy. If an auto company does not conduct R&D and fraudulently obtains funds, in the case of $R < C_1 + P$, the local government will give up subsidies and policy support for the R&D behavior of auto companies.

To sum up, whether local governments support auto companies depends on whether the state's financial or policy support to local governments can compensate for the R&D expenditures of auto companies. In the case of $R < C_1 + P$, local governments will hold a relatively conservative attitude, and auto companies will determine their own R&D behaviors based on the possibility of R&D success and expected benefits. In the case of $W_2 > 2W_1 + C_2$, the equilibrium decision is (no subsidies, research and development); when $W_2 < 2W_1 + C_2$, the equilibrium decision is (no subsidies, no research and development). In the case of $R > C_1 + P$, the local government will show a supportive attitude to auto companies. When $W_2 > 2W_1 + C_2$ or $I > 2W_1 + C_2$, the equilibrium decision is (subsidy, R&D).

On the basis of the above research, a dual-matrix game model is established, assuming that the possibility that the local government will subsidize the participation of auto companies in R&D is x (0≤x≤1), and the possibility that it will not be subsidized is 1-x; The possibility of auto companies participating in R&D is y (0≤y≤1), and the possibility of not participating in R&D is 1-y. The game model can be represented in the following form:

When auto companies choose R&D and succeed, the game model is shown in the following figure:

		Decisions of auto companies	
local government decisions		research (y)	no research (1-y)
	subsidy (x)	R+V-C1,W2+I-W1-C2	R-C1-P,W1
	not subsidized (1-x)	0,W2-C2-W1	0,W1

Figure 3 The static game model of local government and enterprises under mixed strategy (success)

Therefore, the expected payment cost of local governments to support auto companies is:

$$E_1 = xy(V + P) + X(R - C_1 - P) \tag{1}$$

When the first derivative of the revenue expectation function is 0, the local government's support for the R&D behavior of automobile companies can achieve the maximum revenue:

$$\partial E_1/\partial x = y(V + P) + (R - C_1 - P) = 0 \tag{2}$$

The optimal improvement probability of the local government is:

$$y' = (R + C_1 - R)/(V + P) \tag{3}$$

In this case, the optimal profit of the automobile company is:

$$E_2 = xyI + y(W_2 - 2W_1 - C_2) + W_1 \tag{4}$$

When the first derivative of the revenue expectation function is 0, the revenue obtained by the automobile company reaches the maximum:

$$\partial E_2/\partial y = Ix + (W_2 - 2W_1 - C_2) = 0 \tag{5}$$

The probability that the auto company gets the maximum benefit is:

$$x' = (2W_1 + C_2 - W_2)/I \tag{6}$$

When an automobile company chooses to research and development but fails to achieve success, the game model is shown in the following figure:

		Decisions of auto companies	
local government decisions		research (y)	no research (1-y)
	subsidy (x)	R+V-C1,W2+I-W1-C2	R-C1-P,W1
	not subsidized (1-x)	0,W2-C2-W1	0,W1

Figure 4. Static game model of local government and enterprises under mixed strategy (unsuccessful)

When auto companies choose R&D but have not made progress, the maximum profit probabilities of local governments and auto companies are:

$$y' = (P + C_1 - R)/P \tag{7}$$

$$x' = (2W_1 + 2C_2)/I \tag{8}$$

To sum up, the Nash equilibrium of the mixed strategy of local governments and auto companies is (x', y'). From the perspective of local governments, when auto companies choose the possibility of R&D y $> y''$, the decision of the local government with the greatest utility is subsidies; when the possibility of auto companies choose R&D y $= y'$, The probability of local government support should be $y = (P + C_1 - R)/P$; when auto companies choose the possibility of R&D y $< y'$, the decision of the local government with the greatest utility is not to subsidize.

From the perspective of auto companies, when the local government chooses the possibility of subsidy x $> x'$, the most useful decision of the auto company is R&D; when the possibility of the local government subsidizes R&D x $= x'$, the probability of an automobile enterprise choosing to start a business should be $x = (2W_1 + 2C_2)/I$; when the possibility of an automobile enterprise choosing R&D x $< x'$, the decision with the greatest utility of an automobile enterprise is no R&D.

It can be seen that under the condition of static game, because it may be affected by factors such as national policies, the uncertainty of R&D results, and the level of local government's investment in the R&D behavior of automobile companies, the optimal decision made by the two subjects and The equilibrium outcome is not unique, therefore, the use of evolutionary game models may be a better solution to this problem.

3. Evolutionary Game Analysis of New Energy Vehicle Enterprises and Government under Double Points Policy

Under static conditions, local governments and auto companies can adjust their decisions through changes in Nash equilibrium variables due to information symmetry and rational choices. However, in reality, the information between local governments and auto companies is asymmetric, and the decisions of local governments and auto companies are affected by various factors, so it is difficult to ensure that all decisions are rational. The government and auto companies will repeat the game of R&D behavior. Therefore, it is difficult to fully display the game process between local governments and auto companies in the real world by means of static games, and it is necessary to further explore by means of evolutionary game methods.

On the basis of the premise of the static game assumption in the previous part, an evolutionary game model is established. Assuming that the ratio of each local government to subsidize local auto companies is x (0≤x≤1), and the ratio of each auto company to choose to develop new products or technologies is y (0≤y≤1). In the game between auto companies and local governments, if the adaptability of the decisions of both parties is higher than the average adaptability of the group, the decision will dominate the development direction. Therefore, the replicator dynamic equations under this game are:

$$\begin{cases} x'' = x(1-x)[y(V+P)+(R-P-C_1)] \\ y'' = y(1-y)[xI+(W_2-2W_1-C_2)] \end{cases} \tag{9}$$

$$\begin{cases} x'' = x(1-x)[yP+(R-P-C_1)] \\ y'' = y(1-y)[xI+(-2W_1-2C_2)] \end{cases} \tag{10}$$

According to the above replicator dynamic equations, the evolution path of the game is analyzed from the perspective of two participating subjects:

3.1. The evolution path of local government

If the auto company successfully develops new energy vehicles, when $y=(P+C_1+R)/(V+P)$, $x''=0$; if the auto company fails to successfully develop new energy vehicles, when $y=(P+C_1+R)/P$, $x''=0$. In this case, when the ratio of auto companies to develop new energy vehicles is $(P+C_1+R)/(V+P)$ or $(P+C_1+R)/P$, whether the local government The benefits of subsidizing R&D activities are the same, and the results of these two decisions are the same.

If an auto company successfully develops a new energy vehicle, $x''=0$ when $y\neq(P+C_1+R)/(V+P)$; $y\neq(P+C_1+R)/P$, when $x=0$ and $x=1$, $x''=0$. Therefore, when x stays at 2 points, it is the equilibrium point of the local government's choice. At this time, according to the size of y, if $y>(P+C_1+R)/P$时, $x''=0$, then the local government's income is greater than the average expectation. Therefore, at the equilibrium point of $x=0$, if the local government can subsidize and guide the R&D of auto companies, and obtain good returns, it will trigger replication dynamics and drive local governments in other regions to subsidize local auto companies. , which is also the decision of the local government to maximize the utility.

When $y<(P+C_1-R)/(V+P)$, $x''=0$, then the local government's income is lower than the average expectation. Therefore, at the equilibrium point of $x=1$, if the local government can subsidize and guide the R&D of auto companies without any progress, it will also have an impact on the subsidies provided by local governments in other regions to local auto companies, which in turn will affect the local auto companies. Raises replication dynamics for $x=0$.

In summary, the success of R&D ($y = (P + C_1 - R)/(V + P)$) and the failure to develop a new energy vehicle ($y = (P + C_1 + R)/P$) are the watershed between two evolutionary game decisions with $x = 0$ and $x = 1$ Subsidies from local governments to auto companies, local governments receive state funding, and auto companies have slowed their R&D progress after being subsidized or the local governments have been notified due to lack of research and development.

3.2. The evolution path of automobile enterprises

If an auto company successfully develops a new energy vehicle, when $x = (2W_1 + C_2 - W_2)/I$, $y'' = 0$; if an auto company fails to successfully develop a new energy vehicle, when $x = (2W_1 + 2C_2)/I, y'' = 0$. In this case, when the local government chooses to subsidize the R&D ratio of automobile enterprises to new energy vehicles, whether it is $(2W_1 + C_2 - W_2)/I$ or $(2W_1 + 2C_2)/I$ whether the local government has any effect on the R&D behavior of automobile enterprises The benefits of subsidizing are the same, and the results of both decisions are the same.

If an auto company successfully develops a new energy vehicle, when $x \neq (2W_1 + C_2 - W_2)/I$, $y'' = 0$; if an auto company fails to develop a new energy vehicle, when $x \neq (2W_1 + 2C_2)/I$, when y^=0 and y=1, $y'' = 0$ Therefore, when y stays at 2 points, it is the equilibrium point of the car company's choice. At this time, according to the size of x, if $x > (2W_1 + C_2 - W_2)/I, y'' > 0$, then the profit of car companies choosing to carry out research and development is greater than the average expectation. Therefore, at the equilibrium point of $y = 1$, when the ratio of the local government to subsidize the R&D of automobile enterprises is greater than $(2W_1 + C_2 - W_2)/I$, if the R&D of new energy vehicles of the automobile enterprises is successful and obtains good income, And regardless of whether the R&D is successful or not, it can be subsidized by the government, and more and more auto companies will join the ranks of R&D.

If $x < (2W_1 + 2C_2)/I, y'' < 0$, then the profit of auto companies choosing to carry out R&D is lower than the average expectation. Therefore, under the replication dynamics of $y = 0$, when the ratio of the local government to subsidize the R&D of automobile enterprises is lower than $(2W_1 + 2C_2)/I$, the automobile enterprises will give up R&D because there is no subsidy and worry about taking too many risks. new energy vehicles.

In summary, the success of R&D ($x = (2W_1 + C_2 - W_2)/I$) and the failure to develop new energy vehicles ($x = (2W_1 + 2C_2)/I$)are $y = 0$ and $y = 1$两 A watershed in two evolutionary game decisions. When auto companies choose to develop new energy vehicles to obtain higher returns, and they no longer need to purchase credits in order to avoid penalties, the willingness of auto companies to choose to conduct research and development will be higher. And the more sufficient the state grants and policy guarantees to local governments, the more willing local governments will be to subsidize auto companies, thereby driving auto companies' R&D willingness.

4. Conclusion and recommendations

According to the analysis of the static game and evolutionary game above, it can be concluded that factors such as the R&D willingness of automobile enterprises, their attitude towards the risks arising from R&D, and the support and subsidy policies of local governments will affect the final behavioral decision of automobile enterprises. Although local governments also attach great importance to the risks and rewards of subsidy support, relatively speaking, local governments tend to adopt policies that support subsidies. From the perspective of the main body involved in research and development, if auto companies do not have enough willingness to develop new energy vehicles, even if the local government provides sufficient subsidies and policy support, it will be futile. Therefore, the key to the game is whether it can enhance the

R&D willingness of auto companies. If local governments want to maximize their utility, they must adopt effective and reasonable policies to increase the willingness of auto companies to develop new energy vehicles.

Local governments should establish sound assistance and subsidy policies. Not only financial subsidies, but also some support policies should be introduced to guide the research and development of automobile enterprises. On the one hand, local governments can establish new energy vehicle industrial parks and use policy advantages to attract a number of upstream and downstream industries of new energy vehicles to settle in, thereby reducing the cost of R&D and transformation for auto companies. On the other hand, local governments can organize some competitions or industry forums to attract local or other domestic and foreign related enterprises to participate, and provide a platform for automobile enterprises to communicate and cooperate. Local governments should give full play to their role as leaders. According to the problems faced by various auto companies, they should provide in-depth guidance in all directions and from multiple perspectives. Only then can the assistance and subsidy policies play a better role.

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