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The Behavior of Consumer Buying New Energy Vehicles Based on Stochastic Evolutionary Game

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Abstract. China's current vehicle emissions caused by air pollution problems have become increasingly prominent. How to improve new energy vehicle market share, and effectively guide the consumer buying behavior become a problem, which the government and social have to be solved. In this paper, according to establish the stochastic evolutionary game model between the government and consumers in the car market, introducing of random factors analysis on the impact of evolutionary stability ,will obtain the stable strategy of government and automotive consumers. And on the basis of it, we study the government support, cost of vehicles, the use of cost, the utility of automobile use for the ways of evolutionary stability, with case further illustrates the external disturbance factors on consumer purchase of new energy vehicles in evolutionary game process stability. Studies show that: the increasing government subsidy policy, the reducing life cycle costs of new energy vehicles and the improving effectiveness of new energy vehicles will lead the model's evolution to the orientation of consumer purchasing new energy vehicles.

1. Literature Review

While the transition to a low-carbon economy has become the main trend of world economic development, the utilization level of energy and the ability to protect the environment has also become an important indicator to evaluate a country's economic development level in the future. To guide the consumer behavior converting into green consumption, and to urge enterprise to promote energy conservation and emissions reduction are of great significance for China to move toward green development. Compared with the traditional gasoline cars, new energy vehicles, as a new type of green transport, have lower energy consumption through its whole life circle and have less effect on comprehensive environment. Because of its advantages, many scholars are concerning about the new energy vehicles[1-4]. Christina[5] and her teams have studied the implementation of the "vehicle label plan", which launched by Brazilian government and aimed at improving energy efficiency. The results of the research show that the sales of cars in Brazil are not affected by the plan, and the average fuel consumption is still on the rise. The frequent adjustment of oil prices in recent years adds the cost of operating social economy, and brings deep and lasting influences

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on the rapid development of China's auto market. Sprei[6] found a Sweden's policy aiming at encouraging the use of mixed fuels to reduce the fuel consumption rate. Siskos[7] pointed out that to achieve the 2020 carbon dioxide emissions reduction targets, the EU have implemented the low carbon reduction technology in the auto industry. Recently the Chinese government put forward the plan of developing new energy vehicles to achieve the purpose of energy conservation and emissions reduction. By using the logarithmic curve, Tang and his teams[8] predicted the market share of new energy vehicles and calculated the potential environmental benefits of each car in the next 30 years. The results show that the new energy vehicles will contribute to energy conservation and emissions reduction. Liu[9] summarized the development of China's new energy automotive industry, discussed the role of Chinese government in stimulating the development, and came to the conclusion that the policies introduced by Chinese government can help reduce the consumer prices of new energy vehicles. Zhang[10] also stressed that the government support is crucial for the development of renewable energy. He suggested the government to strengthen the collaborative energy policy and to improve the local policy innovation so that the government can establish a perfect investment and financial system for the energy market. Meanwhile, Siang[11] put forward that because of the integration of alternative resources which was led by the rapid development of new energy vehicles, the government should strive to develop the smart grid. Evolutionary game theory is developed on the basis of game theory. In traditional game theory, the participants must be rational, and in every process of the game, the players should also be rational when making decisions and are not allowed making mistakes. However, when social economy and the problems the players are supposed to solve are complicated, it is easy for people to see the players' rational limitations. Thus one has to analyze the game between limited players. The evolution process of evolutionary game mainly includes two mechanisms: variation mechanism and selection mechanism. Due to its limitations, variation mechanism generally refers to the random changes (excluding the formulation of new policies) of individual strategies in the established strategy space. Kaniovski[12] believed that in evolutionary game the variation mechanism can test the stability of evolutionary equilibrium. Therefore, the modeling of evolution processes mainly depends on the selection of mechanism. And the exploration of the evolutionary game which is conducted between groups is already appeared in some domestic and foreign literatures. Actually, the idea of evolutionary game is originated from biology. In 1973, a thesis named The Logic of Animal Conflict was published in the famous international journal Nature. In the thesis, Smith[13] applied the game theory, proposed the evolutionary stable strategy from the perspective of individual choice when talking about the conflict between animals for limited resources such as foods, domains or spouses, etc. Harper[14], Jacek[15] and other people also explained some biological behaviors on the basis of evolutionary game. Then evolutionary game is widely used in various aspects of economic management. Marcin[16] used evolutionary game theory to explore the cooperation in MANETs. Jin[17] used evolutionary game theory to transform optimization problems into the use of game strategy when researching multi-objective optimization problems, and got the optimize strategy by simulating the dynamic evolution process through the application of adaptability. Liu[18] studied the supervision in China's coal mine safety and built an evolutionary game model between government and coal mining industry. Zhang[19] used evolutionary games to provide solutions for cooperative dilemma in multi-agent system with different memory capacity. Fan[20] used evolutionary game theory to analyze the problems of mobile payment business model by assuming that the mobile operators and the financial institutions in mobile payment industrial chain are limited rational game themes. From above analysis, we can see that the government policies play an important role in guiding consumers to conduct green consumption, and the evolutionary game theory is one of the effective ways to analyze consumer behavior. This paper references above achievements and introduces random variable into "evolutionary stable strategy" and "replicated dynamic equation". In consideration of the factors like "energy conservation and emissions reduction" policy and tax policies of central government and local government, the total life circle cost and oil price fluctuations of new energy vehicles and traditional automobiles, the paper tries to build an evolutionary game model between local government and automobile consumption groups, find out the Evolutionary Equilibrium in the game, analyze the stability conditions of equilibrium solution and finally to determine the final results of the evolution.

2. Model Construction and Model Analysis

2.1. Model Construction

In the market of automobile purchases, consumers will choose new energy vehicles or traditional energy vehicles according to the factors such as car utility and the strength of policies, which were made by central government and local government. Consumers have bounded rationality for decision-making, and in the process of buying every consumer owns a certain ability to learn and imitate, thus they can determine which buying strategy is the better one. Meanwhile, the government will decide whether to adopt the supportive policy, in order to achieve the maximization of the whole social benefits. So there is a game between the government and the consumers , the establishment and the study of this game model can reflect the evolution of consumer buying behavior and the adjustment of government's policy. Thereby this paper set up a game matrix between government and consumers, as shown in table 1.

Table 1: Payoff matrix of stochastic evolutionary game influenced by government's policy

Consumers(A)	Local Government(B)	
-	Support(y)	Not support(1-y)
Buying new energy vehicles(x)	$(U_1 - C_1 + S_C + S_1, G_1 - S_1)$	$(U_1 - C_1 + S_C, G_1)$
Buying traditional energy vehicles(1-x)	$(U_2 - C_2, G_2)$	$(U_2 - C_2, G_2)$

In table 1, everyone in the automobile consumption group has two kinds of purchase strategies: buying new energy vehicles or buying traditional energy vehicles. Local government use the "support" or "not support" strategy to influence the behavior. The utility and the cost are the major influential factors on buying behavior preference of consumers. Suppose the utility brought by buying new energy vehicles is U_1, and the utility brought by buying traditional energy vehicles is U_2 And consumers need to consider the purchase, operation and maintenance costs when buying the car. In this paper, if consumers were to buy new energy vehicles, the costs of its overall life cycle is C_1 ; otherwise the costs is C_1.

Currently, our governments at all levels implement preferential policies for new energy vehicles, it can be considered that the discount got by consumers is the sum of the support policies of both sides. The game strategies of local government are divided into "support" and "not support". Suppose the support of central government of buying new energy vehicles is S_c , and the support of local governments is S_l , and the two sides will not take a specific policy to support the consumers who have choose the traditional energy vehicles. When consumers buy the new energy vehicles, the total social utility that the local government can get is G_1 , and the total social utility is $G_2$when consumers buy traditional energy vehicles.

Because of their different preference for new energy vehicles and for traditional energy vehicles, the members of automobile consumption group, who may influenced by government consumption policy and consumer behavior of others, tend to buy the new energy vehicles with a certain probability. Assume at any time (t) the probability for the members in automobile consumption group to buy the new energy vehicles is $x_(t)$, and the probability for the local government to support consumer behavior of buying car is $0 < x_(t), y_(t) < 1$ and the corresponding probability of buying traditional energy vehicles is $1 - x_(t)$ the probability for the local government to choose not-support policy is $1 - y_(t)$.

On the basis of above analysis, it can be concluded that the profits of consumers can get through buying new energy vehicles is $E_{11} = y(U_1 - C_1 + S_c + S_l) + (1 - y)(U_1 - C_1 + S_c)$, the profits which is got by buying traditional vehicles is $E_{12} = y(U_2 - C_2) + (1 - y)(U_2 - C_2)$, the average expected income of consumers is $E_A = xE_{11} + (1-x)E_{12}$, and the expected income of the government is $E_B = yE_{21} + (1-y)E_{22}$. Considering the expected incomes of buying new energy vehicles, the choice for consumption groups to buy new energy vehicles or not in support of local government policy at t, and the choice for the government to apply the support policy or not, let the stochastic evolutionary game replicated dynamic equation of the two sides' strategic behavior be:

$$dx_{(t)} = x_{(t)}(1 - x_{(t)})(S_c + yS_l + U_1 - U_2 + C_2 - C_1 + 1)dt \tag{1}$$

$$dy = y(1-y)(1 = xS_l) \tag{2}$$

In order to see the difference between the expected income of buying new energy vehicles and of buying traditional energy vehicles clearly, the formula (1) can be rewritten as:

$$dx_{(t)} = x_{(t)}(S_c + yS_l + U_1 - U_2 + C_2 - C_1 + 1)dt \tag{3}$$

Formula (3) shows that if the expected income of buying new energy vehicles as greater than that of buying traditional energy vehicles, would increase; otherwise $x_{(t)}$ would decrease.

2.2. The Introduction of Random Variable

The parameters in the formula (3)–S_c, S_l,U_1,U_2,C_1andC_2, andC_2–are always affected by internal and external environment change and continue to fluctuate, which influences the whole evolutionary game. Referring to above assumptions, the supporting policies of central government and local government and the volatility of consumer utility are relatively stable (ignoring the parameters which fluctuate less than C_1andC_2 . The fluctuation of $C_2$is often affected by the change of oil price, and in real life the fluctuation of oil price is the most important variable which influences $x_{(t)}$,Other parameters in the model is often change along with the change of oil price directly or indirectly. To discuss the evolution of the game under the random fluctuations of internal and external environment, the paper introduced stochastic dynamic equation into formula (3) and amends it as follows:

$$dx_{(t)} = [x_{(t)}(S_c + yS_l + U_1 - U_2 + C_2 - C_1 + 1)]dt + \sqrt{x_{(t)}(1-x_{(t)})}d\omega_{(t)} \tag{4}$$

The introduction has improved formula $\sqrt{x_{(t)}(1-x_{(t)})}dw_{(t)}$ by bringing the uncertainty of external environment change (especially the change of oil price) into the evolution of the model. The $w_{(t)}$ is a one-dimensional standard Brownian motion which describes the rise and fall of oil prices and shows random factors' influence on the stability of constructed model. In addition, if the time (t) was given, $w_{(t)}$ obeys normal distribution N(0, t), $w_{(t)}$ obeys the normal distribution N(0, $\triangle$t) thus $w_{(t)}$ can also become a random process.

After improved, the formula (4) has a richer meaning: it brings the random factors which influence the stability of the game into the evolutionary game process between the local government and consumers. These factors will work together to keep the stability of the game. Meanwhile, $\sqrt{x_{(t)}(1-x_{(t)})} \leq \frac{1}{2}$, if and only if $x_{(t)} = 1 - x_{(t)}$ will at the maximum, namely the disturbance influence is at the maximum. This reflects the fact that when the proportions of consumers of two kinds of cars are corresponding, the game tend to be the most unstable and even a slight interference can cause the change of game equilibrium; conversely, when the proportions differ considerably, the change of external factors has a smaller influence on game equilibrium.

2.3. Model Analysis

2.3.1. The Existence of Equilibrium Solution

Suppose $x_{(t)}$ is an initial value in an initial time, $x_{(t)} = 0$. Thus we can see from the formula (4) that: $0(S_c + yS_l + U_1 - U_2 + C_2 - C_1 + 1) = 0)$ and $\sqrt{(1-0)0} = 0$ That is to say, the system is stable when it is in the initial state without external interference. The zero solution is the equilibrium solution of the equation and shows that originally there was no one buying new energy vehicles. If the external environment was not to change, or its change had a weak interference of the system, consumers would not to buy new energy vehicles. However, this ideal state is difficult to achieve, the consumer behavior will more or less be affected by uncertain outside factors. Therefore it is necessary to discuss the disturbance's impact on the stability of the equilibrium.

2.3.2. The Equilibrium Analysis of Consumer Buying Behavior

According to the stochastic differential equation:

$$dx(t) = f(t, x(t)) + g(t, x(t))d\omega_{(t)}, x(t(0)) = x_0 \tag{5}$$

So:

(1) When $S_c + yS_l + U_1 - U_2 + C_2 - C_1 + 1 < 0$, the zero solution expectation moment of formula (4) is stable.

(2) When $S_c + yS_l + U_1 - U_2 + C_2 - C_1 + 1 > 0$, the zero solution expectation moment of formula is unstable. Since the costs and utility of buying car and the government support value are relatively much greater than "1", the "1" of above formula can be neglected. And if the terms of the two judge formulas were transposed, a formula with more realistic significance could be introduced. Such as the following two cases:

(3) When $S_c + yS_l + U_1 - C_2 < U_2 - C_2$, namely the sum of the subsidies of two levels government and the utility of buying new energy vehicles is smaller than the difference between utility of buying traditional energy vehicles and total cost including the variable cost caused by oil price (rise), the equilibrium point of evolutionary game is a fact that consumers finally choose to buy traditional energy vehicles. As is shown in Figure 1(a).

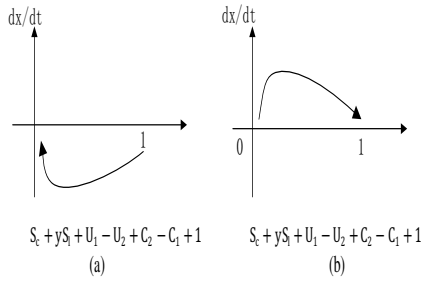

Fig. 1 The replication dynamic phase diagram of the automobile consumption group influenced by the government's supporting policies

(4) When, $S_c + yS_l + U_1 - C_2 > U_2 - C_2$, namely the sum of the subsidies of two levels government and the utility of buying new energy vehicles is greater than the difference between utility of buying traditional energy vehicles and total cost including the variable cost caused by oil price (rise), the equilibrium point of evolutionary game is a fact that consumers finally choose to buy new energy vehicles. As is shown in Figure 1(b).

2.3.3. Equilibrium Analysis of Government Supporting Policies

When the central government supporting policies of new energy vehicles are established, the support policy of a local government will be influenced by the support policy of other local governments, and at the same time, it is also affected by the automobile consumer buying behavior. According to the formula (2),

(1) When $x_{(t)} = 0$, y (the probability for local government to choose support strategies) is in a stable state. However, this situation is of little practical significance, for no matter the local government choose what kind of support policies, consumers won't buy the new energy vehicles. So a local government with bounded rationality will choose not-support policies.

(2) When $x_{(t)} \neq 0$, $S_l = 0$, namely the local government choose not-support policy, and in this case y is zero. The practical significance of this situation is that if a certain proportion of consumers chose to buy new energy vehicles but the local governments were not to support that behavior, consumers' strategy selection would be determined by the sequential order of the factors excluding local government's support policy, and local governments would keep selecting not-support policy.

(3) When $x_{(t)} \neq 0$, $S_l > 0$, $y = 0$ is the only stable point for local government to choose, namely local government don't have to select a corresponding support policy.

2.3.4. The Analysis on Evolutionary Equilibrium

In order to discuss the stochastic disturbing factors' influence on model stability, one should figure out what y is when $S_c + yS_l + U_1 - U_2 + C_2 - C_1 = 0$, Transposing the terms, y $= \frac{U_2-C_2-U_1+C_1-S_C}{S_l}$.Suppose $\frac{U_2-C_2-U_1+C_1-S_C}{S_l}$ = k, then the value of k can be divided into the following three kinds:

(1) When k£0, namely $U_2 - C_2 < U_1 - C_1 + S_l$, $S_l \geq 0$, this infers that no matter what the probability of local government's support is , the value of y will always greater than k when the difference of the cost and utility of consumers' buying of traditional energy vehicles is smaller than the difference between the utility of buying new energy and the cost of central government's support. That situation meet the condition of formula (4) in which the zero solution expectation moment of formula (4) is unstable, and the evolutionary game of the system finally tends to the only stable point (1, 0). The corresponding stochastic evolutionary game of groups is shown in Figure 2.

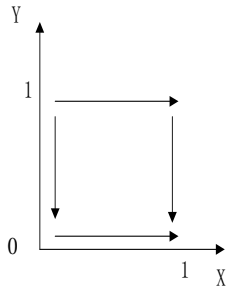

Fig. 2 Trends for system stochastic evolutionary game

Conclusion 1: When the government support was considered, the fluctuation of oil price have already made the total life cycle cost difference of purchasing traditional vehicles and new energy vehicles greater than the utility difference between traditional car and new energy vehicles. Thus regardless of the magnitude of local government's supporting policies, the consumers of auto market tend to buy new energy vehicles.

(2) When $0 < k \leq 1$, $U_1 + S_c - C_1 < U_2 - C_2 \leq U_1 + S_c + S_l - C_1$,At this point, if the local governments were to apply some supporting policies, the expected income of automobile consumption group members of buying new energy vehicles would greater than the expected income of buying traditional vehicles. What's more, when the probability of the local government to implement supporting policies meet the assumption y£k, it can be seen through judge (4) that the zero solution expectation moment of formula (4) is unstable, and the proportion of automobile consumer who choose to buy new energy vehicles is evolving to the condition $x_{(t)} = 0$. If the local governments were not to implement supporting policies, or the governments have already applied supporting policies while y£k, the practical meaning is that the automobile consumption groups' expected profit of buying new energy vehicles will less than that of buying traditional vehicles. According to judge (3), it can be inferred that the zero solution expectation moment of formula (4) is stable, and the proportion of consumers who choose to buy new energy vehicles tends to be zero ($x_{(t)} = 0$), the system evolution tends to stable at the point (0, 0). The corresponding stochastic evolutionary game of groups can be seen in Figure 3.

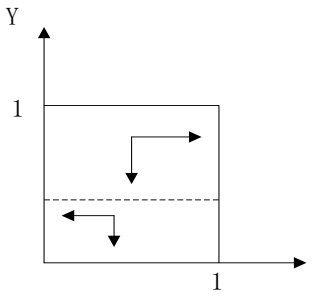

Fig. 3 Trends for system stochastic evolutionary game

Conclusion 2: when $C_1 - C_2$, namely the total life cycle cost difference caused by the fluctuation of oil prices between buying traditional energy vehicles and new energy vehicles is combined with central government's support, the cost difference will smaller than the utility difference between two kinds of vehicle; and when the cost difference is combined with both the central government's support and the local government's support, it will greater than the utility difference. That is to say, the support of local governments is play an important role in the evolution of consumer buying behavior, and the automobile consumption groups under this state are policy oriented consumers. In other words, if local governments were to take certain supporting policies to guide the consumer buying behavior, the automobile consumption groups would evolve to buy new energy vehicles.

(3) When k£1, $U_2 - C_2 > U_1 + S_c + S_l - C_1$ which means that when the difference between utility and cost of buying traditional energy vehicles is greater than the difference between the cost and the summation of utility and support of buying new energy vehicles. In this case, because $y \leq 1 < k$, judge (3) will always be true, namely the zero solution expectation moment of formula (4) will keep stable, so the consumers are finally tend to buy traditional vehicles. Thus $x_{(t)} = 0$, the system will keep stable at the point (0, 0), the corresponding stochastic evolutionary game of groups can be seen in Figure 4.

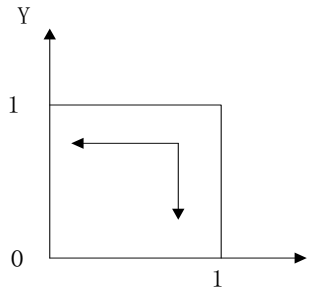

Fig. 4 Trends for system stochastic evolutionary game

Conclusion 3, when the summation of the supporting policies both implemented by central government and local governments (even if the probability of local government to apply supporting policies is 100 percent, namely y=1) and $C_1 - C_2$ is still smaller than the utility difference between traditional energy vehicles and new energy vehicles, it can be inferred that the support of the government cannot make up for the cost gap between the two kinds of vehicles which was caused by oil prices' fluctuation. Under the constrains of the fact that the utility of new energy vehicles is still not comparable with traditional energy vehicles, the automobile consumption groups tend to buy traditional energy vehicles and at that moment, the supporting policies of the government is useless.

3. Case study

Among the large number of automobile enterprises in China, the most representative new energy automobile manufacture is BYD; among all the new energy vehicles BYD has produced, BYD e6is the first pure electric vehicles. The most attractive characteristics of e6 are its electric drive, good safety performance, fast charging and convenient usage. In order to avoid the influence of car brand on consumer buying behavior, this paper selected the traditional energy vehicles which have the highest similarity of comprehensive performance with e6 as a subject of comparison. To find out the traditional energy car, the author has investigated the most representative regional 4s shops of each area, collected and verified data, and made full use of statistical methods[21]. On this basis, the utility of buying e6 and buying the traditional energy vehicles is approximately the same. Then the focuses can be converted to the comparison of the whole life cycle cost to the vehicles.

(1) Questionnaires and Interview

The surveys are conducted in four Chinese cities of different economic development level, respectively Shenzhen, Beijing, Wuhan and Lanzhou. The author chose the BYD 4s shop of those cities for the professionals of the 4s shop must have a better understanding of different car's performance. The respondents of the survey are the workers in those 4s shop, and the sites of the survey are BYD 4S shops in the four cities. The surveys were conducted from November 2012 to April 2013 with the method of random sampling and interview. 300 questionnaires were given while 207 of them are available, the effective rate is 69.1.

In order to choose a traditional energy vehicle of BYD which is similar to e6, the responders are supposed to mark the traditional vehicles respectively from 1-5 according to their similarity to e6, for which 1 represents the lowest similarity and 5 represents the highest similarity. After counting and analyzing the statistics which were collected by the questionnaires, it can be seen that the Nextway of BYD has the highest similarity of e6. Therefore, in the existing traditional BYD autos, the utility of Nextway is more close to the utility of e6. By using the SPSS17.0 to test the reliability of the 207 questionnaires, it can be seen that the Cronback's reliability coefficient is 0.743, this stands for the credibility of the investigation results.

(2) Case Study

Considering the 1.5TID luxury Nextway is the most representative type of Nextway and has a closest performance to e6, the paper will analyze the difference between the cost of new energy vehicles (represented by e6) and traditional energy vehicles (represented by Nextway). The parameters in table 2 are subject to Beijing. The cost shown in the table has already considered government's policies on tax and subsidy for automobile consumers. The cost structure mainly includes the fixed cost and the variable cost. Considering the factors in fixed cost like registration fees, insurance, parking fee, etc. Have many similarities, the paper will ignore those factors.

Table 2: The parameters associated with cost

type	driving mode	fixed cost(yuan/year)			variable cost		Government	
		price (yuan)	Mainten -ance cost	Vehicle and vessel tax	energy con -sumption per hundred km	price of oil/electri -city (yuan)	central govern -ment	local govern -ment
E6	pure	369800	19500	none	15000 watt	0.4883	60000	60000
Nextwa	gasline	92900	1500	420	6.5L	7.41	subsid -ies	subsid -ies

On the basis of existing petrol and electricity prices, the present social discount rate (7) and the average running kilometers of vehicles (12000), this paper uses the cost discounting value formula, introduces the cost of different period to the formula, and finally figures out that C_1 =1.0339 million yuan and C_2 =446 thousand yuan. Put C_1 and C_2 into $y = k = \frac{U_2 - U_2 - C_2 + C_1 - S_c}{S_l}$, then $k = \frac{0+103.3926-44.59912-6}{6} = 8.7989 > 1$.

According to the conclusion (3) it can be inferred that presently the difference between the cost and the utility for BYD consumers from buying traditional energy vehicles is greater than the difference between the summation of utility and supporting policies and the cost. That is to say, currently the strength of local

governments' supporting policies is too weak to attract consumers to buy e6, the new energy vehicles. Consumers under the supporting policies will gradually and eventually tend to a stable strategy, namely buying traditional energy vehicles. It can also be inferred from the stability of local governments' supporting policies in the model that no matter what x0, the proportion of the consumers in initial state choose to buy new energy vehicles is, the only stable point local governments' policies can choose is y=0. At this point, the corresponding group game phase diagram will finally tends to (0, 0), namely all consumers are tend to buy traditional vehicles and the government with bounded rationality will not support the consumer behavior.

The oil price or the electricity price is an important factors which affects consumer buying behavior. The results of the interview show that generally consumers are sensitive to the fluctuation of oil price which is caused by the change of external environment, while the electricity price is relatively stable. Hang and Tu [22] studied the relationship between energy price and energy intensity and pointed out that the relation between supply and demand in global crude oil trade market and the price fluctuation of coal and electricity will affect the trend of oil price. Zhang et al. [23] suggested that the long-term events, including war and global economic recession will have an influence on oil price. Their opinions provide the theory support for simulating the change of oil prices. In the long run, the fluctuation of oil prices will lead to the change of the use cost of traditional vehicles and result in the variation of the difference between the use cost of traditional vehicles and the use cost of new energy vehicles. So whether the oil prices were to change or not would has an impact on the stability of the conclusions based on the analysis of cases. The author used the mathematical software Matlab to do a numerical simulation of formula (4) in hope of finding concealed regulations through the change of data. Combined with the data mentioned above, t=0 in the initial state, let y=1, means local government choose to support consumer buying behavior completely, and the probability for consumers of buying new energy vehicles alters as 1, 1.5 or 1, $S_c = 6$, $S_l = 6$, then

$$dx_{(t)} = (-45.79348)x_{(t)}dt + \sqrt{x_{(t)}(1 - x_{(t)})d\omega_{(t)}} \tag{6}$$

To draw a figure according to formula (6), let the random item dw(t) be a random number, and the simulation result made by Matlab is shown in Figure 5.

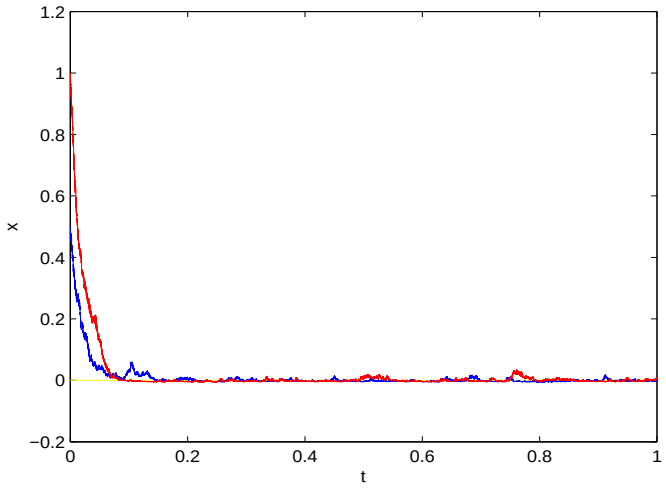

Fig. 5 Numerical simulation of Matlab

It can be seen from the Figure 5 that since the initial point 0, the value of decreases from the initial value 0.5 when x=0.5 or x=1 with the extension of time. Although the value of will fluctuate later, it ranges around

zero. When x=0, the value of remains at 0. This shows that the probability for consumers of buying new energy vehicles will eventually tend to 0 infinitely no matter what the probability is in initial state. From the simulation graph, it is clearly that currently the utility difference between the new energy vehicles, which is supported by the government, and the traditional vehicles. In the long-term game between the government and the automobile consumers, the equilibrium of the game will tend to the fact that consumers will not choose to buy new energy vehicles and this fact will finally become stable. Based on the above research, this paper argues that:

(1) In the short time, the high price of new energy vehicles sets a high threshold for people to buy the vehicles and constrains people's wills of buying them. To apply the supporting policy such as offering subsidies can ease the embarrassing situation of the gap between attitude and action and make more consumers buy new energy vehicles. Considering the statistics above, it can be inferred that currently the strength of central government's policies is not enough to stimulate consumers to buy new energy vehicles. Local government support is uneven, and policy stability is also inadequate, those make it hard to stabilize the equilibrium of consumer stochastic evolutionary game at an ideal state. The consumers of bounded rationality are more sensitive about use cost than about energy conservation and emissions reduction. In order to increase the utility of buying new energy vehicles by subsidizing the use cost, the government not only give consumers a one-time subsidy£but also should adjust consumers sensibility of the difference between electricity price and oil price.

(2) In the long term, Car companies to reduce production costs through technological innovation, optimize the use of various performance indicators to improve consumer utility, consumer behavior would be to buy new energy vehicles[24].

4. Conclusion

Based on the consideration of automobile's total life cycle cost, this paper constructs and analyzes the evolutionary game model between the consumer behavior of buying new energy vehicles and the behavior of buying traditional vehicles in support of the government's policies, introduces the perturbation of model stability brought by random factors which are represented by oil price to the evolutionary equation on the basis of the game model, and analyzes the stability of the equilibrium solution of the model through the stochastic differential equation and the judgment got by the equation. Case study shows that the current governments at all levels support policy and efforts for new energy vehicles are still insufficient, car buyers get subsidies cannot satisfy compared with traditional cars on their cost and effectiveness, In the long term, to improve the new energy vehicle performance and reduce purchase threshold is the fundamental way out for the development of new energy vehicles.

This paper adopted an approximately equal method to deal with vehicle utility. However, in real life, the influence from utility difference between new energy vehicles and traditional vehicles is greater than differences in the cost, so in the future research, the quantification of the utility will be a focus.

The second section

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