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A Research on Development Strategy of New Energy Vehicle Business in China

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Abstract

Since 1990s, New Energy Vehicles like Hybrid Electric Vehicle, Electric Vehicle and Fuel Cell Vehicle have been emerging with the development of automobile technology, especially in US, Europe, and Japan. As an emerging giant, China is increasingly suffering from the growing demand for oil and especially for imported crude oil due to soaring vehicle sales. And, increasing consumption of oil and rapid industrialization are leading to the heavy pollution and the exhausting of greenhouse gas. Now, China highly expects promising Alternative Fuel Vehicles that can secure national energy supply by reducing the dependency on oil, can promote the environment protection and sustainable development, and also can bring a great opportunity of leaps on technology for domestic automakers. However, New Energy Vehicles are highly diverse in technologies and also characterized by different levels of technology maturity, cost, fuel, cleanness and so on. Furthermore, the commercialization of New Energy Vehicles needs heavy investment on the fuel and infrastructure developments, the market demand extension, the substitution from traditional vehicles and so on. Then, my research objective is to design the reasonable

technological development roadmap and the commercialization strategy for New Energy

Vehicles according to the facts of China and the traits of different New Energy Vehicles technologies.

Concept of New Energy Vehicle

Compared to orthodox car, the new energy vehicle is not only using electricity or alternative fuel on an energy basis, but also is the green product that provides the least impact for ecological environment, the highest utilization rate of resources and the lowest energy consumption on the whole lifecycle. New energy vehicle integrates such new energy, new materials, application electronic, environmental and computer technologies, and reflects the environmental consciousness for impacts and changes of the automotive industry. It is the inevitable product from the state of constant developing of automotive engineering. New energy vehicle has the three characteristics.

1) Can be recovered to use. At the present time, the German government stipulates that automobile manufacturers must establish the waste automotive recycling center.

2) Improve the power source. Electric vehicle is

the highlight of the green car development at present.

3) Reduce the environmental pollution. This is the most essential.

Development of New Energy Vehicle

1) Classification of new energy vehicle

New energy vehicle can fall into six categories by different fuel power. Traditional petroleum fuel, coal-oil fuel, hydrogen and gas fuel, storage battery fuel, solar fuel and biofuel. See the table to compare the advantages and disadvantages of different fuel.

Table 2-1 Classification of green car

	Advantages	Disadvantages
Hybrid vehicle	<ol style="list-style-type: none"> Compared with similar engines, reducing emissions. Improved vehicle's fuel economy. Through reduction in load of engine to reduce noise. 	<ol style="list-style-type: none"> Price of the car is expensive Power is not better than petrol Have a little pollution
Hydrogen and gas fuel	<ol style="list-style-type: none"> Exhaust emissions is water, don't produce any pollutants on driving. Hydrogen is a renewable resource. 	<ol style="list-style-type: none"> High cost of hydrogen fuel cells Extraction of hydrogen needs through brine electrolysis or to use the natural gas, and to consume a lot of resources.
Storage battery fuel	<ol style="list-style-type: none"> Technology is relatively simple, can charge on everywhere. Zero draining, zero pollution, zero noise 	<ol style="list-style-type: none"> Cost of battery is high. Weight and volume of battery is great. Charging speed is slow
Solar fuel	<ol style="list-style-type: none"> can supply electric power on sunny place no pollutant on driving 	<ol style="list-style-type: none"> Need large Solar Panels. Influenced most by weather. Short of power

2) The situation of hybrid vehicle

At present, hybrid vehicle is the mainstream in the market of new energy vehicle. It has become one of the fastest developing and most widely being used new energy vehicles.

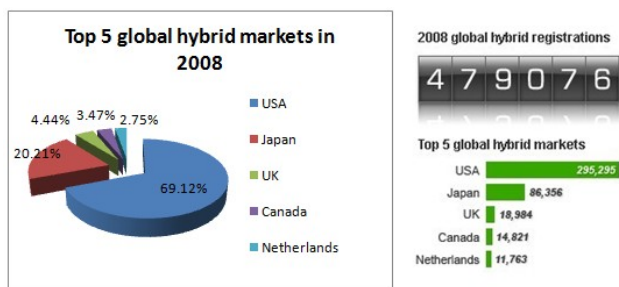


Figure 2.1 Top 5 global hybrid markets in 2008

There are 479,076 hybrid vehicle of the world in 2008. The United States is the country with the biggest number of hybrid vehicle.

Japan is the country with the highest production of hybrid vehicle. Next chart is hybrid vehicle sales in China, Japan and USA from 2005 to 2009.

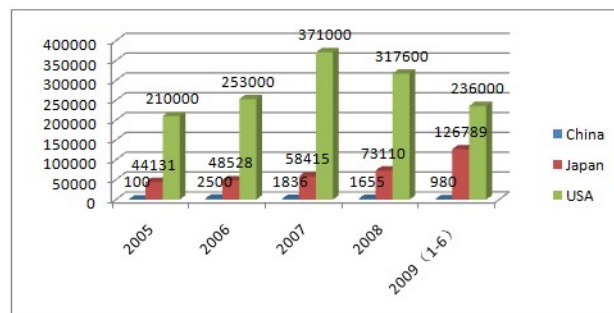


Figure 2.2 hybrid vehicle sales in China, Japan and USA

Dual-mode is the most advanced technology in hybrid vehicle. Only three companies have this technology in the world. They are BYD, Toyota and GM. Make comparisons among them.

Table 2-2 Comparison among three main companies

	China BYD dual-mode electric vehicle	Toyota dual-mode electric vehicle	GM dual-mode electric vehicle
Name	BYD F3DM	Plug-in Prius	Chevrolet Volt
Time To Market	2008.12	2010~	2010~
Battery Type	iron battery	lithium battery	lithium battery
Battery Manufacturers	BYD	Panasonic	LG Chemical
On Pure Electric	100km	30km	64km
Charge Time	9h	7h	6h
100km/L	4L	3.6L	2.35L
Price	2.10M JYN	4.59M JYN	3.90M JYN

We can see from this diagram, BYD is more economical and practical, Toyota and GM are more luxury and high-grade.

Core technology of hybrid vehicle is battery. BYD F3dm is using iron battery. Plug-In Prius and Volt use lithium battery. Next we compare between BYD iron battery and lithium battery.

Table 2-3 Comparison between two main batteries

	BYD iron battery	Lithium battery
Voltage	3.3V	3.6V
Capacity	1000kwh	1200kwh
Weight	30kg	26kg
Cycles	2000 times	1000times
Cost	0.57M JYN	1.00M JYN
Safety	safe	Have risk
Charge time	9h	7h
Environmental protection	pollution-free	Recovery of lithium to consider

We can see from above data, both of them are nearly the same in many properties. But BYD iron battery is cheaper, safer and more durable than lithium battery. While lithium battery has been used widely at present.

The Development Strategy in new energy vehicles business in China

In general, the development strategy of new energy vehicle business in China can be divided into three parts: green manufacturing strategy, product R&D strategy and the new energy vehicle marketing strategy.

Green Manufacturing Strategy of New Energy Vehicles Business in China. The issue of resource and environment related to sustainable development strategy is the great challenge for human society in 21st century. Presently, China central government put forwards energy saving & emission reducing strategy by considering the situation to ensure fast and healthy development of national economy. Automotive industry as one of the national pillar industries consumes a lot of resources and brings measurable environmental influence. Green manufacturing is a modern manufacturing mode, integrating all the issues of manufacturing and its ultimate goal is to reduce and minimize environmental impact and resource consumption during product life cycle that includes the design, production, packaging, transportation, use and disposal. Applying Green manufacture technology applied to automotive industry is one of the key technologies of green manufacturing, in which environmental impact and resource consumption issues are considered synthetically

and by which the optimal process project can be drawn up with the goal of guaranteeing machining duality, minimizing machining cost, minimizing machining time, minimizing environmental negative impact and maximizing resource utilization efficiency. The new energy vehicles always have the large basic cost. Actualizing green manufacturing strategy can reduce resource consumption and save cost in production and sales, and thereby reduce the price of new energy vehicle, increase competitiveness.

This paper divides the green manufacturing strategy into fourth parts: green design, green production, green market and green recovery.

Green Design. In order to fundamentally prevent pollution, and conserve resources, starting point depends on your design. During the design phase will be put the environmental factors and pollution preventive measures into product design. It means “Strive to make products the smallest impact on the environment”. In terms of industrial design, the core of green design is 3R: Reduce, Recycle and Reuse.

There are three methods of R&D of green design.

- (1) Life Cycle Design. The core is a process which includes the production, using, scraping, recycling and regeneration.
- (2) Innovative Design. According to the customer demand, to develop the new car is different from improving existing product.
- (3) Concurrent Engineering Design. The main concern is type of organization of integration and concurrency. The core is through team work to complete the design task.

This article based on these three methods proposes the synthetic method of green design. Use a graph showing as follows:

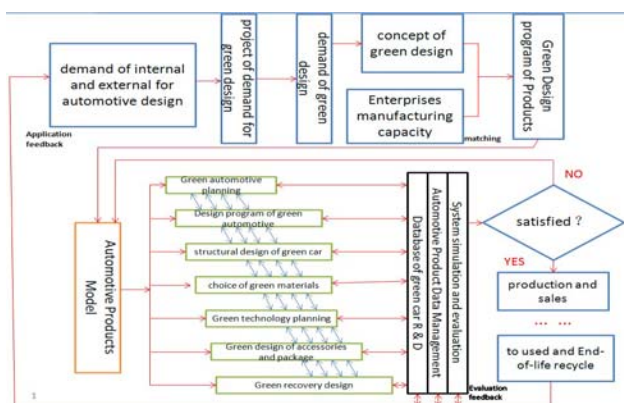


Figure 3.1 Green design

Automobile manufacturing enterprises form a set of design requirements by collecting internal and external demand information through the green automotive design engineering. According to these requirements, the design department can largely determine the design concept. At the same time, it investigates the production capacity of enterprises. On the basis of products model of the car, Design department can make product planning. After the assessment, if satisfactory, go ahead to produce, and if not, back to redefine the model.

Green Production. Changes in the traditional automotive production, were just only for improving quality, lowering costs, and shortening delivery time, but didn't consider environmental factors. All links and factors in green production have close connection with environment and resource. It is not just a mode of production, even more importantly is an idea of environmental protection. Modern automobile production has changed from “linear” to “cyclical” model. It embodied in Figure 3.2.

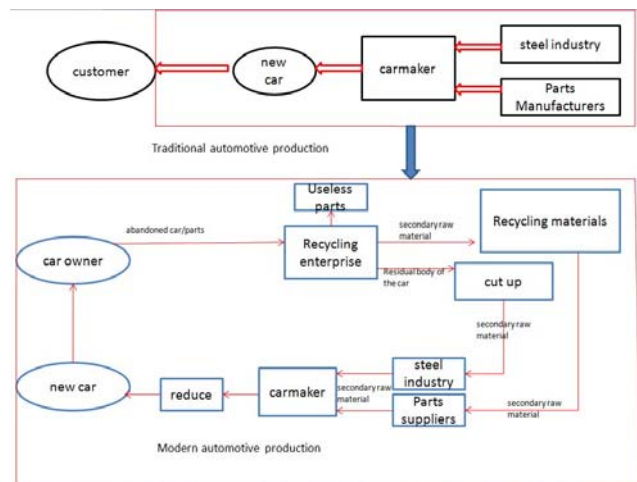


Figure 3.2 Shift of automobile production

Green Marketing. Green marketing also called as eco-marketing, environment marketing or harmony marketing, is to strive for unification for consumer, enterprise and society. Not only fully satisfy the consumer demand, achieve enterprise profit target, but also pay attention to the natural ecological balance. Green marketing mainly includes green package, green transport and green consumption. As shown in Figure 3.3.

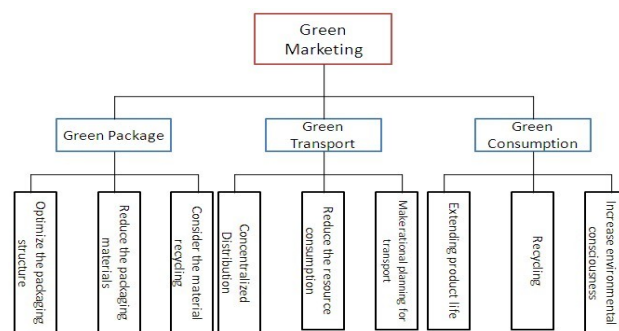


Figure 3.3 Green marketing

Green Recovery. The recovery of the products can be divided into three levels: production level, part level and material layer. As shown in Graph 3-4.

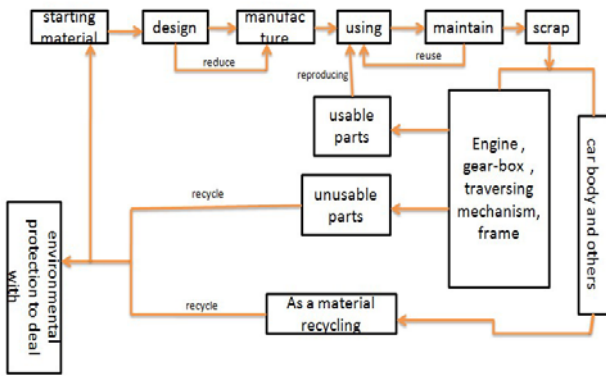


Figure 3.4 Green Recovery

Improving the repeated utilization ratio will reduce the loss, save resources, and thus seek to achieve environmental protection.

Real Options Analysis of New Product R&D

Value assessment of new product R&D is a typical application of real options. Table 3.1 shows that variables in different conditions of new product R&D and financial option.

Table 3.1 variables in different conditions of new product R&D and financial option.

New product development	variables	Financial Option
PV of expect cash flow	S	stock price
cost of investments	X	strike price
risk-free rate of interest	r	risk-free rate of interest
development time	T	maturity time
fluctuation ratio of return of expect cash flow	σ	fluctuation ratio of stock

New product R&D is a continuity and phased investment, in each stage of the investment, determine the next stage investment whether to continue. This flexibility of decision can be considered that the investment of each stage get an investment opportunity (option) for next time. Usually new energy vehicle companies develop new products needing some months or some years to complete. During this time, due to the uncertainties of market technology, industrial policy and consumer environmental can bring

some new information to affect the value of new product development projects, so we need reappraise this project. Have a project development plan, it is equivalent to have an opportunity or right to choose: When we find the investment of next stage hasn't the profits, we should withdraw investment to avoid the greater loss; when we find the investment of next stage has some potential profits, we should make the investment of previous stage as a option for the next stage. In a similar way, each stage of new energy vehicle product R&D can be seen a call option for next stage. The value of a project not only depends on the cash flow from initial investment, but also rests with the value of investment opportunity from follow-up stage. Even when you use method of traditional NPV to assess the value of a new product project, maybe it is negative, after you add the flexible value into this assessment, the whole project's value maybe can become plus.

The Characteristic of Compound Real Option in New Product R&D. (1) Compound option

A compound option is simply an option on an option. Since Geske (1979) an analytical formula for the price of compound options was worked out within the Black-Scholes framework. Basically, the procedure consists of the following two steps: at first the underlying option is priced according to the Black-Scholes method; then, the compound option is priced as an option on the security whose value has already been found in the first step. The exercise payoff of a compound option involves the value of another option. A compound option then has two expiration dates and two strike prices. Take the example of a European style

call on a call. On the first expiration date T_1 , the holder has the right to buy a new call using the strike price X_1 . The new call has expiration date T_2 and strike price X_2 . Let the current time be time 0, S be the underlying asset price and $c(S, \tau; X)$ denote the value of a call with time to expiry τ and strike price X . Let C_{call} denote the value of the call on a call at the current time. On the first expiration date T_1 , the value of the call on a call is given by

$$C_{call} = \max[X_1, c(S, T_2 - T_1; X_2)].$$

Let S^* be the critical asset price such that $c(S, T_2 - T_1; X_2) = X_1$. When $S > S^*$, we have $c(S, T_2 - T_1; X_2) > X_1$, and accordingly, the holder should exercise the call at T_1 . The value of the call on a call at the current time depends on the joint probability that the asset price is above S^* at T_1 and above X_2 at T_2 . Under the lognormal assumption of the underlying asset price process, the price formula for C_{call} is given by

$$C_{call} = Se^{-qT_2} N_2(a_+, b_+; \sqrt{T_1/T_2}) - X_2 e^{-qT_2} N_2(a_-, b_-; \sqrt{T_1/T_2}) - X_1 e^{-rT_1} N(a_+),$$

where

$$a_+ = \frac{\ln(S/S^*) + (r - q + \sigma^2/2)T_1}{\sigma\sqrt{T_1}}, \quad a_- = a_+ - \sigma\sqrt{T_1},$$

$$b_+ = \frac{\ln(S/X_2) + (r - q + \sigma^2/2)T_2}{\sigma\sqrt{T_2}}, \quad b_- = b_+ - \sigma\sqrt{T_2}.$$

Here, r is the interest rate, q is the dividend yield, σ is the volatility, and $N_2(x, y; \rho)$ is the two-dimensional cumulative normal distribution function with correlation coefficient ρ . For overlapping Brownian increments, the correlation coefficient is seen to be $\sqrt{T_1/T_2}$.

The first term in the price formula for C_{call} gives the risk neutral expectation of the asset value conditional on $S > S^*$ at T_1 and $S > X_2$ at T_2 , the second term give the expected cash payment upon exercising at T_2 and the last term is the expected cash payment upon exercising at

T_1 .

Other examples of compound options are call on a put, put on a call and put on a put. Their respective price formulas are given by

$$C_{put} = X_2 e^{-rT_2} N_2(-a_-, -b_-; \sqrt{T_1/T_2}) - Se^{-qT_2} N_2(-a_+, -b_+; \sqrt{T_1/T_2}) - X_1 e^{-rT_1} N(-a_-)$$

$$P_{call} = X_2 e^{-rT_2} N_2(-a_-, b_-; -\sqrt{T_1/T_2}) - Se^{-qT_2} N_2(-a_+, b_+; -\sqrt{T_1/T_2}) + X_1 e^{-rT_1} N(-a_-)$$

$$P_{put} = Se^{-qT_2} N_2(a_+, -b_+; -\sqrt{T_1/T_2}) - X_2 e^{-rT_2} N_2(a_-, -b_-; -\sqrt{T_1/T_2}) + X_1 e^{-rT_1} N(a_+).$$

(2)Compound Option in New Energy Vehicle Product R&D

Generally speaking, new product R&D has three stages: technology development stage, product development stage and market development stage.

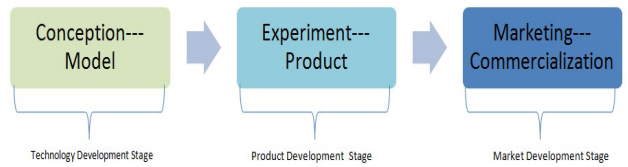


Figure 3.5 Process of new product R&D

In the process of new product R&D, have a compound option---an option on an option. R&D of new energy vehicle has the characteristic of compound option, so the value assessment problem of new product turns into the pricing problem of compound option.

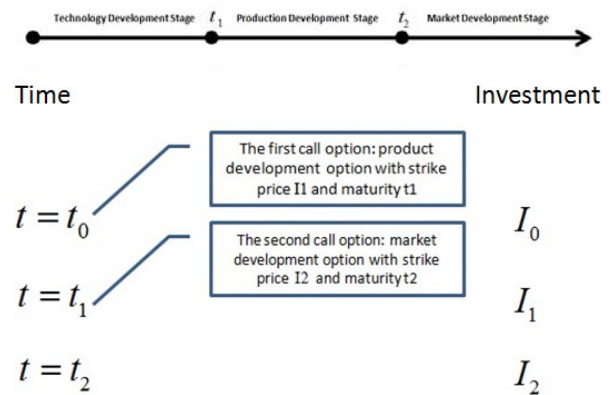


Figure 3.6 Two options in the new product R&D

At $t = t_0$ the investment of technological development is I_0 , it will get a chance for produce development stage, so form the first call option at $t = t_0$. If succeed, it will get a chance for market development stage, so form the second call option at $t = t_1$. Only if the value of second option bigger than strike price of first option, compound option can be exercised.

According to this analysis, to set up the model:

Real Option Theory has been widely used in the R & D project evaluation. New energy vehicle product R&D often has a continuity of time, so the most effective method to evaluate this problem is Geske model.

First, according to Black-Sholes equation, at $t = t_1$, option of market development stage is

$$I_1 = S_c N(d_1) - I_2 e^{-r(t_2-t_1)} N(d_2) \quad 3-1$$

Where

$$d_1 = \frac{\ln \frac{S_c}{I_2} + \left(r + \frac{\sigma^2}{2}\right)(t_2 - t_1)}{\sigma \sqrt{t_2 - t_1}} \quad d_2 = d_1 - \sigma \sqrt{t_2 - t_1}$$

Then, from the equation 3-1, we can get the value S_c of this project at t_1 :

$$S_c = \frac{I_1 + I_2 e^{-r(t_2-t_1)} N(d_2)}{N(d_1)}$$

Second, at $t=0$, use the Geske compound option equation. The whole development project option value is C:

$$C = S e^{-r t_2} M(a_1, b_1; \rho) - I_2 e^{-r t_2} M(a_1 - \sigma \sqrt{t_1}, b_1 - \sigma \sqrt{t_1}; \rho) - I_1 e^{-r t_1} N(a_1 - \sigma \sqrt{t_1})$$

Where

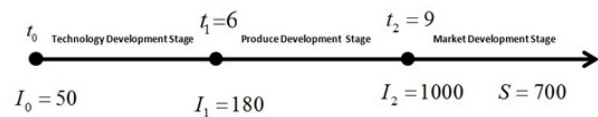
$$a_1 = \frac{\ln(S / S_c) + \frac{1}{2} \sigma^2 t_1}{\sigma \sqrt{t_1}} \quad b_1 = \frac{\ln(S / I_2) + \frac{1}{2} \sigma^2 t_2}{\sigma \sqrt{t_2}} \quad \rho = \sqrt{\frac{t_1}{t_2}}$$

$M(a, b; \rho)$: two-dimensional cumulative normal distribution function with correlation coefficient ρ .
 $N(\cdot)$: single argument cumulative standardized normal distribution function
 S : present value of cash flow at t_2
 I_1 : investment of production development stage
 I_2 : investment of market development stage
 t_1 : maturity of the first option
 t_2 : maturity of the compound option
 σ : fluctuation ratio of R&D project nondeterminacy
 r : risk-free rate of interest

Third, The value of new product R&D : $V = C - I_0$. If $V > 0$, this project can be executed, if not we must give up it.

Example:

An automobile manufacturer wants to develop a new energy vehicle. The first stage needed invested in 50 million for the research of new energy vehicle technology. If this stage succeeds, the company will have an option: can choose to invest 180 million for product development stage in last year. If this option is executed, the company has a second option, can choose to invest 1000 million for marketing development stage. Two options constitute a compound option. Use the Geske model to evaluate this new energy vehicles R & D project. Market fluctuation ratio is 30%, risk-free interest rate is 5%.



To use the above assumptions, if we use the traditional method NPV to calculate the value of this project, the result is negative. So we must give up this project.

$$NPV = S - I_0 - \frac{I_1}{e^{r t_1}} - \frac{I_2}{e^{r t_2}} = 700 - 50 - \frac{180}{e^{0.05 \times 6}} - \frac{1000}{e^{0.05 \times 9}} = -120.3$$

Then, use real options to calculate the value of this project. According to B-S, $S_c = 574.34$,

use Geske equation to work out the value of compound option. $C=228.88$. Because initial outlay is 50 million, so the value of this project is $V=C-I=178.88$. So this project can be executed.

Conclusion

Development of Green Car is now only at a preliminary stage. Still need further research and development. Development trend of green car in the future will follow the stage of power frugal, pollution-free, safety and recycling. China will be not only a big market but also a one of pioneering drive forces at advanced green technology at future vehicles development. Especially, such a radical change of power mechanism and its production system is a big chance for emerging companies like BYD rather than existing competitive company like Japanese or European car makers.

This paper is an applied research in new energy vehicle industry. Through the analysis of development status in China's new energy vehicle industry, found out the problems in development. Then according to these problems, propose the development strategies that including green manufacturing strategy, product R&D strategy and the new energy vehicle marketing strategy for China's new energy vehicle industry. Through green manufacturing strategy to reduce production cost, enhance competitiveness of new energy vehicle products and thereby protect the environment. Because of the indeterminacy of Chinese new energy vehicle market, according to flexible value of real option, use the compound option and binomial option to make the investment decision for new energy vehicle products.

About future's research, I will continue to research the real option, game theory and option-games in-depth. I wish to add some uncertain factors in the option model. And use the option-games to make the investment decision in competitions of Monopoly and joint venture.

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Biography

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