The Research of Electric Vehicles Industry Based on Business Model

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Abstract. With the accelerated process of industrialization, problems of climate change and global shortage of resources are increasing, which make alternative power concept becoming more and more important. This paper is based on business model theory, using system dynamics approach to explore the development of the electric vehicles industry, and seek the development tactics of electric vehicle industry.

Introduction

With the accelerated process of industrialization, emissions of harmful gas and depletion of resources continue to increase. Among them, the rapid growth of conventional cars brings serious environmental pollution and a large number of crude oil consumption. Relative to conventional cars, electric vehicles have obvious advantages in energy saving and environmental protection. Many countries, governments and enterprises have developed various programs, and invested huge sums of money to develop the electric vehicles industry.

In terms of the development of electric vehicles, the present study mainly include the development routes of electric vehicles in the developed countries, the support of policies and constructions of infrastructure. In the business model of electric vehicles, the study mainly include energy supply mode, select and operation of charging mode, and business model framework and models of electric vehicles. Existing studies have focused on static business model of electric vehicles, did not consider changes in the dynamic market environment. The paper is based on the business model theory, using system dynamics method to study the development of electric vehicles, to seek the development tactics of electric vehicle industry.

Literature Review

Business Model Definitions and Components

No generally accepted definition of the term “business model” has emerged. Linder(2000) thought business model is the logic relationship for organization or business system to creat value[1]. Amit and Zott(2007) described business model as a system of interdependent activities that transcends the focal firm and spans its boundaries[2]. Teece(2010) thought business model is capable of forming a good value proposition to achieve a favorable cost structure and risk[3]. Due to the diversity of business model definitions, the division of business model components present a height difference. Yunus(2010) divided business model into three components—value proposition, value constellation and profit equation, in which value proposition and value constellation interact with each other, and both have impact on profit equation[4]. Casadesus(2012) thought business model include choices and results, using causal loop diagrams to represent the business model[5].

System Dynamics in Electric Vehicles Research

Electric vehicles is a product with strong network externalities, which is different with general merchandise. System dynamics is a better solution to solve problems of electric vehicles. Struben (2008) established a system dynamics model, to explore the mechanism that switch conventional cars to new energy vehicles. The model contained multiple feedback mechanism between vehicle and fuel.
facilities, between producers and consumers, internal manufacturers (research and development, learning and scale effects). Meyer (2009) built system dynamics model based on the interaction of hydrogen cars and fuel facilities, and results showed that: the relationship between hydrogen cars and fuel facilities can be expressed as four scenarios, and identified policies to promote reinforcing mutually. Ehsan (2012) proposed a hybrid simulation model, that combined system dynamics with agent-based simulation, to study the transition of traditional vehicles to new energy vehicles. The model included the main parties system, car manufacturers, car dealers, customers, energy delivery systems, fuel stations and government, which was more accurate and efficient.

Model

The paper choose the structure of Yunus, Moingeon & Lehman as basic framework, using Casadesus-Masanell’s method that showing business model by causal map, to refine the framework of electric vehicles. Because this study put the industry in the dynamic market environment, the market and personal factors will impact options.

![Figure 1. Structure of business model.](image)

Causal Diagram

The key of system dynamics to study is self-feedback mechanism in system. In order to analyze the various of feedback system structure, the first thing need to do is to analyze the overall system and factors, and the structure levels between factors and factors, to clear the hierarchy and pursue mutual causality. Then according to causal factors, re-grouping configuration to form circuit. In the system dynamics, causal loop diagram is the most simple and intuitive way, shown in Figure 2.

![Figure 2. Causal diagram of electric vehicle industry.](image)

System Flow Diagram

According to the causal diagram, in order to further prove the relationship between the internal structure and system variables, it needs to refine system flow chart, shown in Figure 3. System flow diagram can be more clearly describe the transfer direction of information flow, material flow and
energy flow, as well as complete feedback loops within the overall system. It can also easily identify the relationship between each factor with other factors. These are all to ensure the reliability of the system dynamics model.

![System flow diagram of electric vehicle industry.](image)

**Equation**

1. \[ \text{car ownership} = \text{INTGE}(\text{change}, \text{initial value}) \]  
2. \[ \text{change}_t = \text{car ownership}_{t-1} \times \text{growth rate} \]  
3. \[ \text{market demand of electric vehicle} = \text{market demand} \times \text{market share of electric vehicles} \]  
4. \[ \text{sales of electric vehicle} = \text{market demand of electric vehicle} \times \text{willingness-to-pay} \]  
5. \[ \text{willingness-to-pay} = \text{purchase intention} + \text{infrastructure} + \text{image} \]  
6. \[ \text{image} = \text{energy} + \text{environmental} + \text{policy} \]

**Simulation**

**Inspection**

In Vensim modeling software running process, using the checking function in software to test the correctness of model equations, whether the basic form of the model fit requirements of system dynamics modeling and Vensim software. If the model is proper, the detection result is displayed as "Models are A.O.K.", which means that the model has no problem.

Based on the historical data of US auto market, determining the basic parameters of the model. After running the simulation, comparing the simulation results with actual data, to verify degree of error, and make judge on reliability and accuracy of the model simulation. The degree of error within 1% is highly reliable, within 10% is basically reliable. The result is that degree of error is less than 10%, so the model simulation is basically reliable.

**Analysis**

According to simulation results of US electric vehicle market development in 2001 - 2030 years, combined with economic development and policy changes in the United States, we can predict the development of electric vehicle industry.
In 2001-2007, due to the energy crisis and environmental pollution problems have become increasingly serious, the US government enhanced the development of electric vehicles into the national strategic level, and supported in policies. At the same time, people's awareness of environmental protection and energy-saving was also rising. So the electric vehicle industry accelerated the pace of development, and sales continued to rise, but which were mainly hybrid vehicles. After 2010, the plug-in hybrid and pure electric vehicles were imported into the market, and the deductible promotions further increased, so more and more consumers started to buy electric cars, which made sales begin to rise fast. When the market was gradually improving, the government began to reduce policy support. As technology continued to accelerate innovation, sales of electric vehicles rose substantially in the state, but the speed began to slow down.

In the early, because of technical obstacles, the cost of electric vehicles was very high, and growth of electric vehicle industry profit was small. But with accelerating technological breakthroughs and innovation, electric cars began to decrease costs, and profits rose increasingly. When the market is fully developed, government intervention will weaken, and competition in the market begin to accelerate. It is important to continue to adjust the structure. But overall, profits rise will decrease, and finally reach a stable state. Based on the analysis above, the paper divides the development of US electric vehicle industry into three stages: the initial stage, growth stage and mature stage.

Tactics

As an emerging industry, the commercialize promote of electric vehicles not only have to rely on technological progress and product innovation, but also need government intervention. Electric cars and conventional cars have different power sources, which lead to different consumer costs, user habits, stakeholder structure and profit sources. The paper provides three tactics to improve the development of electric vehicles:

1. cutting prices
2. increasing R&D funding
3. increasing government subsidies

After simulation of the three tactics in the model, we can get the results:
According to the figure, it is found the comparison of results under three tactics to promote the development of electric vehicle industry. First of all the government should increase the tax credits, accelerating to promotion of use; followed, enterprises need to increase R&D investment by accelerating technology innovation and enhancing product competitiveness fundamentally; and finally, enterprises should reduce the price to a price war, invest in the construction of charging infrastructure, and solve driving range and energy supply problems.

In the early development of electric vehicles, the number of firms, sales and profits are low; high cost; lack of infrastructure; lack of industry technical standards. The major products are hybrid electric; market competition is not fierce. After importing into market, new products will face technical problems to be solved, and consumers are not likely to change behavioral patterns of traditional fuel vehicles. Manufacturers have risk and high cost entering the market at the early time, and cannot compete with conventional cars on price, and technical progress is slow. From national environmental protection and energy security strategy, we recommend the government to increase tax credits, to make electric cars narrow the price gap with conventional vehicles, and maintain its sales and profits.

In the growing state, electric car sales growing rapidly, which mainly are hybrid vehicles. Pure electric vehicles carry out large-scale demonstration; technical standards become mature. Government begin to be appropriate to reduce or cancel its purchase subsidies, so the industry focus on the mass production process innovation. with reduce of cost by the amount of production, consumer willingness to buy increase, and corporate profits begin to rise rapidly. With corporate earnings rise, they can further increase R&D investment. In addition to continuing to improve the production process, they can also put money into the technological innovation of pure electric vehicles and fuel cell vehicles.

In the mature stage, electric vehicles overall sales growth rate will continue rapid growth. But with the growing of electric car market, the market is becoming more competitive, and pattern of industry profits constantly change. Profits begin to decline overall. On the one hand, corporates need to maintain sales volume, and can take price-cutting; on the other hand, gradually corporates should reduce costs, such as management costs, R&D investment and factory equipment.

Summary

The paper based on the business model theory, summarizes the research results systemly, using system dynamics method to study the future development of the electric vehicle industry, compared different tactics to promote the electric vehicle industry, and achieves results of the following aspects:

1) summarized the research of methods on the business model theory, and according to the characteristics of the electric vehicle industry, chose the fit business model theory.

2) Based on data published by the United States departments, collected and collated the data to predict changes in sales volume and profit, and select the best tactics.

References


