Business Value Evaluation of Electric Vehicle Charging Network-based Internet of Vehicles

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Abstract. Electric vehicle charging network develops rapidly, but now there is still lack of research about business value evaluation of electric vehicle charging network. This paper discusses the business value of electric vehicle charging network based on Internet of vehicles. By analyzing the business evaluation index, a three-dimensional value index system of the two business segments is set up from the aspects of economy, society and environmental benefits, which aimed at improving the business value of electric vehicle charging network.

1. Introduction
In recent years, electric vehicle users were explosive growing. Chinese government has introduced a series of policies to promote development of electric vehicle industry. As supporting facilities, charging network develops as well [1-2]. However, problems like single mode of the charging network, not interconnected of information and improper scheduling of management hinder the development of charging network market. To solve the problems above, the concept of Internet of vehicles emerges. Internet of vehicles, according to a variety of information sensing equipment, access technology and network services support technology, achieve to extract, use and provide integrated services in the information network platform for all vehicle [3]. In 2015, the State Grid Corporation started smart Internet of vehicles platform on line. Up to now, the number of charging pile is more than 16.7 million, and daily charge amount is more than 100 million kwh, which means it has become the world's most extensive coverage, most access equipment and highest level of skill Internet of vehicles. Internet of vehicles and its carrying intelligent traffic, as an intelligent information network service system, has brought historical opportunity of evolution and integration for the electric vehicle industry [4]. Since charging network based on Internet of vehicles is still emerging business [5], this paper starts from the current state of charging network, through the analysis of business evaluation indicators, builds integrated business value model combining three-dimensional value index system and two business plates, and has important guiding significance for development of electric vehicle industry [6].

2. Research status of electric vehicle charging network

2.1. Research status of electric vehicle based on Internet of vehicle
In the context of the development of Internet of vehicle and electric vehicle, in the area of business mode of Internet of vehicle and electric vehicle, some scholars start from the relationship between Internet of vehicle and charging network, and come up with the charging mode of electric vehicle based on Internet of vehicle [7]. Some scholars envisioned the electric vehicle - Internet of vehicle business mode, in which relevant parties can achieve optimal integration of resources and benefits [8-9]. In terms of specific applications, there are two kinds of user-based association methods to optimize the content sharing service of electric vehicles under the Internet of vehicle [10]. In summary, most of the research is from macro point of view, and rarely from business value evaluation.

2.2. Research state of business value
At present, there is a lack of research on business value of electric vehicle charging network at home and abroad. Among studies at abroad, there are methods of resource-centered and contingency-based, by using linear and non-linear means to analyze business value [11]. Among studies at home, a comprehensive evaluation method including value engineering, life cycle and index system is brought up [12], which can study the cost and economic benefits of business [13], market life [14] and comprehensive evaluation [15].

3. Business scope of electric vehicle charging network
Charging network business includes the basic interconnection of electric vehicle and power grid and Internet. This article divides electric vehicle charging network business into charging business and extra business. Learning from business model of Internet of vehicles, emerging business like route planning, intelligent charge and discharge are brought forward.

3.1. Charging business
With large-scale development of electric vehicle, charging demand gradually expands and charging business deepens. Electric vehicle charging network needs intelligent and interactive development to enhance service efficiency.

- Charging service: provide charging platform for electric vehicle
- Cost settlement: according to different regions and periods, provide charging price for charging facilities, calculate charging cost for electric vehicle, provide charging network data for operator to clear settlement

3.2. Extra business
Extra business is emerging business of electric vehicle charging network. As an important business plate, it includes charging and discharging, message pushing, statistical analysis, consumption drainage, information release, grid interaction, clean benefit analysis and etc.

- General: intelligent charging strategy, management of charge pile, route planning, safety monitoring, remote diagnosis, traffic data recording
- For individual: entertainment, electric vehicle rental
- For enterprise: vehicle information management, charging network platform operation
- For third party: user preferences mining, vehicle data analysis, traffic information statistics, highway tolls, electric vehicle cleaning efficiency analysis, charging load statistics and forecast, related business promotion

4. Integrated business value model of electric vehicle charging network
Since the value compositions of charging network business are complicated, in order to understand it better, this paper starts at the characteristics of the electric vehicle charging network business, sets economic, social and environmental benefits as indicators, builds two business evaluation index system respectively, and finally forms the integrated business value model of electric vehicle charging network through the comprehensive weight coefficient.
4.1. Establishment thoughts of evaluation index

In China, electric vehicle development considers not only economic benefits, but also social and environmental benefits. Among them, economic benefits are concerned to promote the upgrading of China's auto industry and cultivate new economic growth point. Social benefits are concerned to improve travel conditions and public satisfaction. Environmental benefits are mainly concerned to promote alternative energy, help transformation of energy consumption structure, reduce vehicle exhaust pollution emissions and ease the increasingly serious environmental problems.

Electric vehicle charging network business is the derivatives of electric vehicle industry. Since the two have inextricably connection, this article analyses electric vehicle charging network business value from economic, social and environmental value three aspects as well.

4.2. Establish of business value model

4.2.1. Establish basis of business value indicators. The business value of electric vehicle charging network is mainly reflected in its effectiveness. In general, benefits are beneficial effects of a particular activity, which also can be seemed as effectiveness and interests.

- Economic benefit analysis
  With the reason of charging business features, the performance of economic benefits is mainly affected by profitability and consumption of service. The indicators under profitability are used to evaluate business operation effects. The indicators under consumption consider cost and fixed assets turnover.
  Economic benefits of extra business are composed of cost and income. Cost concludes data mining analysis and so on. Income concludes electric vehicle rental, operating network platform and etc.

- Social benefit analysis
  The social benefits of electric vehicle charging network mainly consider effects in public and industry. In the part of public, except the shared user satisfaction, charging business concerns more about network construction, that is, the ratio of car and charging pile. Extra business is biased to measure service progress, and here it includes improve the reliability of the grid and digital process. And because measurement of industrial value is no different in the two, this paper selects advancement in technology and industrial agglomeration strength as its three level indicators.

- Environment benefit analysis
  Charging network business will have a certain impact on the environment, mainly in energy conservation and alternative. Since the electric vehicle has significant effects on environment. The larger number it is, the larger effects it applies on energy conservation. Electric vehicles replace traditional fuel with power. In this way, it promotes alternative energy and changes energy structure towards electrification.

4.2.2. Establishment of evaluation index system for charging business. According to benefit analysis, economic, social and environmental benefits are set as the first level indicators. Business operation results, consumption proportion and so on are the second level indicators. Business profit rate, cost profit rate and so on are the third indicators. All the factors comprise value indicators of electric vehicle charging business. As shown in Table 1:

| Serial number | First level indicators                      | Second level indicators         | Third level indicators     | Type    | Unit |
|---------------|--------------------------------------------|---------------------------------|----------------------------|---------|------|
| 1             | Economic benefit                           | Business operation results      | Business profit margin     | Numerical | %    |
2. Total rate of return on assets Numerical %
3. Cost profit margin Numerical %
4. Fixed asset turnover rate Numerical %
5. Degree of customer satisfaction Numerical High/medium/low
6. Ratio of car and charging pile Numerical %
7. Advancement in technology Logical Yes/no
8. Advancement in industrial agglomeration strength Logical Yes/no
9. Unit mileage CO\textsubscript{2} emission reduction Numerical g/km
10. Unit mileage NO\textsubscript{x} emission reduction Numerical g/km
11. Unit mileage SO\textsubscript{2} emission reduction Numerical g/km
12. Electricity consumption proportion of charging network Numerical %

4.2.3. Establishment of evaluation index system for extra business. According to benefit analysis, economic, social and environmental benefits are set as the first level indicators. Cost, income and so on are the second level indicators. Data mining analysing cost and interactive mechanism research cost and so on are three indicators. All the factors comprise value indicators of electric vehicle extra business. As shown in Table 2:

Table 2. Value indicators of extra business

| Serial number | First level indicators | Second level indicators | Third level indicators | Type | Unit |
|---------------|------------------------|-------------------------|------------------------|------|------|
| 1             | Economic benefit       | Business cost           | Data mining and analysing cost | Numerical | ¥    |
| 2             |                        |                         | Interactive mechanism research cost | Numerical | ¥    |
| 3             |                        | Economic benefit        | Clean benefit analysis cost | Numerical | ¥    |
| 4             |                        | Business income         | Information service income | Numerical | ¥    |
| 5             |                        |                         | Financial business income | Numerical | ¥    |
| 6             |                        |                         | Operating network platform income | Numerical | ¥    |
| 7             |                        |                         | Electric vehicle rental income | Numerical | ¥    |
| 8             | Public value           |                         | Degree of customer satisfaction | Numerical | High/medium/low |
| 9             | Social benefit         |                         | Improve grid reliability | Logical | Yes/no |
| 10            |                        |                         | Improve the digital process | Logical | Yes/no |
| 11            | Industry value         |                         | Advancement in technology | Logical | Yes/no |
| 12            |                        |                         | Advancement in industrial agglomeration strength | Logical | Yes/no |
4.3. Integrated business value model

Electric vehicle charging network business consists of charging business and extra business. Taking into account the difference between business positioning, the two plates should be distributed by weight when determining the integrated value of business plates. In addition, when deciding the weight of two services in integrated value, it is necessary to consider the degree of business development, and the most significant one among which is the user proportion of extra business. Extra business is the main part of integrated business value model.

This paper takes the comprehensive proportion to determine the value of business weight. According to company's internal judgments, quantify the impact of business positioning and get business positioning weight. According to the forecast data of network charging business, business development weight is determined by extra business proportion. Take the average of the two as comprehensive weight. According to above analysis, the establishment steps of integrated business value model of electric vehicle charging network are as follows:

4.3.1. Determine business position weight. Consult relevant departments of electric vehicle, and collect the position score of business. In this way, the original score of business position forms. Take the equalization ratio of business (charging business: extra business = M11: M12) as the business position weight.

4.3.2. Determine business development weight. According to the forecast data of business, take the proportion of extra business as extra business weight M22. On this basis, the charging business weight M21 = 1-M22. At last, ratio of the two is business development weight.

4.3.3. Determine business comprehensive weight. Take the average of business position weight and business development weight, recorded as M1: M2.

4.3.4. Establish integrated business value model. Record the value model of charging business as $f_1(x)$, the value model of extra business as $f_2(x)$. So the integrated business value model of electric vehicle charging network $f(x)$ is:

$$f(x) = M_1f_1(x) + M_2f_2(x)$$

5. Conclusion

This paper combines with the development state of electric vehicle charging network, and explores business value of electric vehicle charging network based on Internet of vehicles. First, through the comprehensive index analysis method, set economic, social and environmental benefits as three-dimensional value indicators. Then divide electric vehicle business into charging business and extra business, and build different business value index system respectively. Finally, according to business comprehensive weight consisting of business position weight and business development weight, combine two index systems, and form the integrated business value model of two business plates with three-dimensional value index. This paper provides a meaningful reference for the development of electric vehicles.

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