The R&D Direction and Business Strategy: The case study on the cooperation of EV and battery makers

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Abstract

This paper focuses on the R&D direction and the business strategy of EV firms and battery makers with reference to Porter's productive frontier. M. E. Porter (1996) claimed that the productivity frontier represents the maximum value that the organization can deliver at any a given cost, using technologies, skills and purchased inputs. He argued that strategic decisions are ones that are aimed at differentiating an organization from its competitors in a sustainable way in the future. We use the patent information of EV firms (Toyota, Tesla, Volkswagen) and battery makers (Panasonic, CATL, LG Chem) as the cases. We examine our propositions by social network analysis and text mining. The analysis in this paper includes: 1) trying to distinguish between differentiation and cost leadership strategy from R&D direction, and visualizing productivity frontier, 2) making discussing on the inter-organizational relation of EV firms and battery makers. In this paper, we clarify that patterns of cooperation EV firms and battery makers R&D.

Keywords: R&D direction, EV makers, Battery makers, Patent analysis

1. Introduction

EV (Electric Vehicle) is expected to spread as it has the potential to bring about major changes in global energy problems such as global warming countermeasures. The research and development of battery, which is the main component of EV, will be important for the spread of EV.

This paper will focus on the R&D direction and the business strategy of EV firms and battery makers. We use Porter's productivity frontier to discuss these issues. The analysis in this paper includes: 1) visualizing the productivity frontier of battery industry, and distinguishing between differentiation and cost leadership strategy from R&D direction 2) discussing on the inter-organizational relationships of EV firms and battery makers. In this paper, we clarify the patterns of strategic alliance between EV and battery makers.

2. Background

2.1. *Productivity frontier*

M. E. Porter defines the productivity frontier as: the sum of all existing best practices at a given time. And he explains the difference between operational effectiveness and strategic positioning with productivity frontier map [1]. Operational effectiveness (OE) means performing similar activities better than rivals performing them. In contrast, strategic positioning means performing different activities from rivals' or performing similar activities in different ways. (See Figure 1) He points out that constant improvement in operational effectiveness is necessary to achieve superior profitability. However, it is not usually sufficient. Competitive strategy is about being different. It means deliberately choosing a different set of activities such as non-price buyer value delivered or relative cost position to deliver a unique mix of value.

In the case of EV's battery, we focus on the R&D direction of battery makers that choosing from LFP (LiFePo4), NCM (Nickel, Cobalt, Manganese), and Solid-state batteries. First, characteristics of LFP are lower energy density than NMC, quite robust rather than economical (abundant materials, no need of Nickel and particularly Cobalt).Second, characteristics of NMC are higher energy density, shorter lifetime, lower safety margins, and higher price. Finally, solid state batteries where liquid electrolyte and separator are replaced by a solid material, have to solve many issues and the R&D are still on progress and mass production have not started yet.

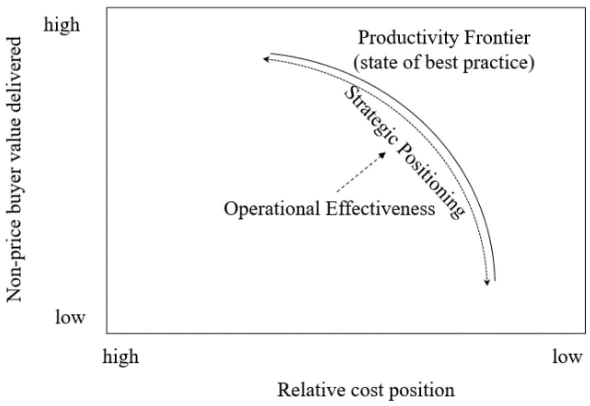

Fig. 1. Operational Effectiveness Versus Strategic Positioning modified by the authors

Table 1. World Plugin Vehicle Sales (2020)

Model	Brands	Battery Maker	2020H1Sales	2021H1Sales	Y-O-Y
Tesla Model 3	Tesla	CATL, LG, Panasonic	142,346	243,753	71.20%
Wuling HongGuang Mini EV	SAIC	CATL, Gotion High-tech	- - -	181,810	- - -
Tesla Model Y	Tesla	LG, Panasonic	13,415	138,401	931.70%
BYD Han EV	BYD	BYD	- - -	38,667	- - -
Volkswagen ID.4	Volkswagen	CATL, LG, Samsung SDI, Gotion High-tech	- - -	38,499	- - -
GW ORA Black Cat	GWM	SVOLT,CATL	- - -	32,013	- - -
Renault Zoe	Renault	LG,AESC	37,154	31,426	-15.40%
Hyundai Kona EV	Hyundai	SK Innovation	19,286	31,233	61.90%
Volkswagen ID.3	Volkswagen	CATL, LG, Samsung SDI, Gotion High-tech	- - -	31,079	- - -
GAC Aion S	GAC	CALB, CATL	14,516	30,456	109.80%
Li Xiang One EREV	Li Auto	CATL	- - -	30,154	- - -
Nissan Leaf	Nissan	AESC	23,867	29,372	23.10%
Changan Benni EV		Gotion High-tech, CATL, CALB, BYD	- - -	29,178	- - -
Kia Niro EV	Kia	SK Innovation	12,157	27,395	125.30%
Chery eQ	Chery Auto	CATL, Gotion High-tech, Farasis Energy	- - -	27,136	- - -
Volvo XC40 PHEV	Volvo Cars	CATL, LG	- - -	26,839	- - -
Audi e-tron	Audi	LG, BYD	17,592	25,758	46.40%
Toyota RAV4 PHEV	Toyota	Panasonic, CATL, BYD	- - -	25,279	- - -
BMW 530e/Le	BMW	CATL, Samsung SDI	20,586	24,985	21.40%
Ford Escape/Kuga PHEV	Ford	Samsung SDI,BYD,SK Innovation	- - -	24,763	- - -

Source: Inside of EVs Website

Table 2. Global EV Battery Deployment

Source: SNE Research

2.2. *The overview of EV and battery industry*

After a decade of rapid growth, in 2020 the global electric car stock hit the 10 million mark, a 43% increase over 2019, and representing a 1% stock share. Battery electric vehicles (BEVs) accounted for two-thirds of new electric car registrations and two-thirds of the stock in 2020 [2].

As they are key players in this market, this paper will focus on the EV firms such as Tesla, Volkswagen and Toyota, and battery makers such as Panasonic, CATL and LG Chem. (See Table 1 and Table 2)

3. Methodology and data

In the following sections, the R&D direction and business strategy of each EV firms and battery makers is analyzed with social network analysis, which can visualize the features of R&D patterns using archived patent information.

We selected patent documents archived in patent database service by Patent Integration Co.. All patents are classified according to the worldwide standard classification codes IPC (International Patent Classification). This paper utilizes all patents of EV firms and battery makers since 2000, including USA and WIPO (World Intellectual Property Organization). We extract related patents such as "Battery (H1), Charging (H2)", and then collect patents which are applied by each company. (See Table 3)

Table 3. IPC code on battery

H01M50/00	Constructional details or processes of manufacture of the non-active parts of electrochemical cells other than fuel cells, e.g. hybrid cells
H01M6/00	Primary cells; Manufacture thereof; In this group, primary cells are electrochemical generators in which the cell energy is present in chemical form and is not regenerated.
H01M8/00	Fuel cells; Manufacture thereof; In this group, the following expression is used with the meaning indicated: "Fuel cell" means an electrochemical generator wherein the reactants are supplied from outside.
H01M10/00	Secondary cells; Manufacture thereof; In this group, secondary cells are accumulators receiving and supplying electrical energy by means of reversible electrochemical reactions.
H01M12/00	Hybrid cells; Manufacture there of (hybrid capacitors H01G11/00); Note. This group does not cover hybrid cells comprising capacitor electrodes and battery electrodes, which are covered by group H01G11/00. In this group, hybrid cells are electrochemical generators having two different types of half-cells, the half-cell being an electrode-electrolyte combination of either a primary, a secondary or a fuel cell.
H02J7/00	Circuit arrangements for charging or depolarising batteries or for supplying loads from batteries

Source: Japan Patent Office

3.1. *An approach based on the number of patent publications*

In the case of EV firms, Toyota has more control over its rivals such as Tesla and Volkswagen, lead in patents, but its sales are unmatched by Tesla. In the case of Battery makers, Panasonic and LG Chem have more control over CATL, lead in Patent, but the sale of CATL is the highest in this industry. (See Table 2, Fig. 2 and Fig. 3)

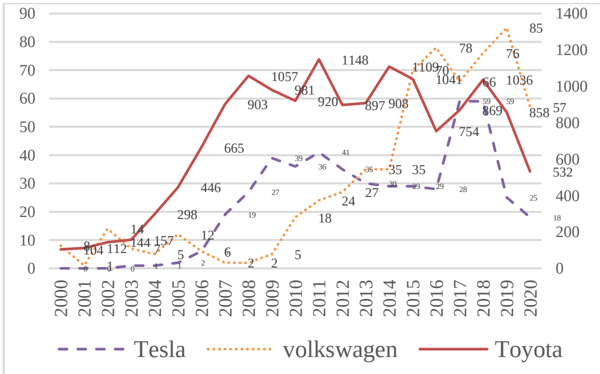

Fig. 2. Status of battery patents (by EV firms)

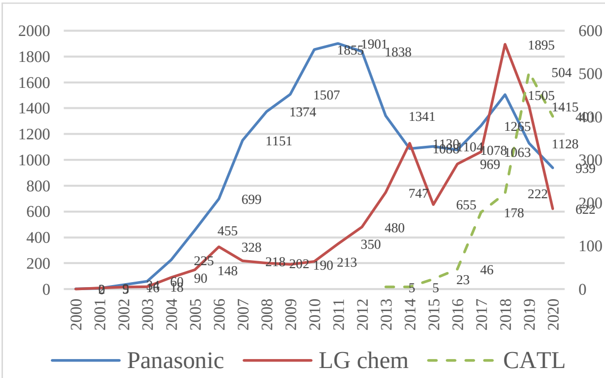

Fig. 3. Status of battery patents (by Battery Makers)

3.2. *An approach by social network analysis*

Fig. 4 shows the R&D direction and business strategy of each EV firms and battery makers with social network analysis with transaction and patent data. (See Table 2, Fig. 2 and Fig. 3) Toyota, Panasonic and LG Chem have more power than Volkswagen, Tesla and CATL in patent, but Tesla and CATL have better position than their rivals

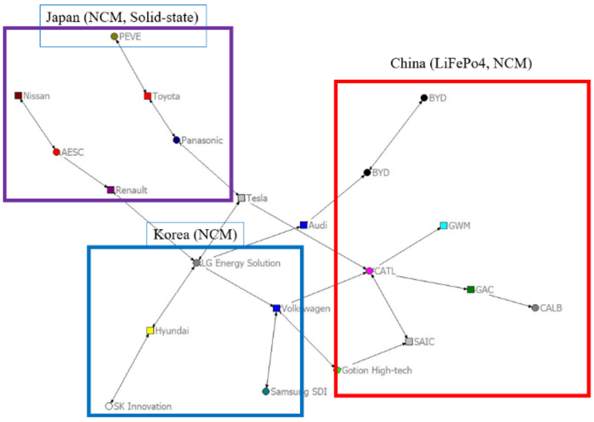

Figure 3. The relation between EV firms and battery makers by social network analysis

at the business level. Because they are center position in value network.

4. Discussion and conclusions

We have discussed the patterns of cooperative relationship between EV firms and battery makers under the impact of radical technological changes [3]. In our analysis, Tesla has good position which can use both low cost (LFP) and difference (NCM) in productive frontier. In Japanese firm's case, Panasonic have continued to grow in importance. Because they have cooperative relationship with Tesla and Toyota. Moreover, we find the similarities and differences in the R&D direction from EV firms and battery makers. In the future study, we will discuss how these companies have taken different R&D strategies?

Acknowledgements

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References

1. M. E. Porter, *On Competition, Updated and Expanded Edition*, Harvard Business Review Press (2008)
2. IEA Global EV outlook 2021: Trends and developments in electric vehicle markets (2021).
3. Y. Park and I. Nakaoka, Y. Chen,, "The R&D Strategy of Automobile Companies in Radical Innovation" *Journal of Robotics, Networking and Artificial Life*, Vol.7, No.3, pp. 184-189 (2020)

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