Technological Discontinuities and the R&D Strategy of Automobile Companies

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Abstract

This paper focuses on patterns of technological changes and the R&D strategy of automobile companies. Tushman and Anderson (1986) pointed out that there are two types of technological changes. One is incremental technological change which is often generated by existing companies, and the other one is radical technological change which makes great extension in business environment and destroys the order of existing companies. We use the patent information of three automobile companies (Toyota, BYD, Tesla) as the cases on these changes. And we examine our propositions by text analysis and social network analysis. The analyses in this paper include the followings: 1) To distinguish between the radical and incremental technological changes from R&D projects, and create heat-maps to visualize these changes, 2) To discuss on technological discontinuities and the R&D strategy of automobile companies. In this paper we suppose that patterns of corporate R&D strategy cope with the threat of radical technological changes.

Keywords: technological discontinuities, radical technological change, R&D strategy of automobile companies, patent analysis,

1. Introduction

This paper focuses on patterns of technological changes and the impact of technological breakthroughs on environmental conditions. Tushman and Anderson (1986) point out that there are two types of technological changes [1]. One is incremental technological change which is often generated by existing companies, and the other one is radical technological change which makes great extension in business environment and destroys the order of existing companies.

Nowadays, traditional automobile industry is faced with new challenges due to radical technological change such as the development of electric vehicle. New entrants, such as Tesla and BYD, are competing with existing companies in research development. We suppose that

some features of R&D management help these entrants to keep their competitive advantage.

In this paper, we use the patent information of three automobile companies (Toyota, BYD, Tesla) as the cases on these changes. And we examine our propositions by text analysis and social network analysis. The analyses in this paper include the following: 1) To distinguish between the radical(product) and incremental(process) technological changes from R&D projects, and create heat-maps to visualize these changes, 2) To discuss on technological discontinuities and the R&D strategy of automobile companies. In this paper we suppose that patterns of corporate R&D strategy cope with the threat of radical technological changes.

2. Background

2.1Technological discontinuities

Abernathy(1978) described that a dynamic model of innovation includes a pattern of sequential and cross-sectoral change in product innovation, process innovation, and organizational structure. Firms that are new to a product area will exhibit a fluid pattern of innovation and structure. As the market develops, a transitional pattern will emerge. Finally, the market stabilizes, fostering a specific pattern of behavior. [1].

Tushman and Anderson(1986) demonstrate that technology evolves through periods of incremental change punctuated by technological breakthroughs which enhance or destroy the competence of firms in an industry. These breakthroughs, or technological discontinuities, significantly increase environmental uncertainty and munificence. They point out that while competence-destroying discontinuities are initiated by new firms and are associated with increased environmental turbulence, competence-enhancing discontinuities are initiated by existing firms and are associated with decreased environmental turbulence. Therefore, a radical innovation that can create new businesses and transform or destroy existing ones [2].

Anderson and Tushman(1990) suggest that the key punctuation points are technological discontinuities and dominant designs; these delimit eras of ferment and eras of incremental change [3]. Firms must develop diverse competences both to shape and deal with technological evolution.

2.2 The overview of automobile industry

Table 1 Market value of world top automobile companies

Company	Stock price	Market Cap
Toyota	$52	172.1billion
Daimler AG	$73	78.3billion
Tesla Inc	$364	59.7billion
BMW	$94	56.8billion
SAIC Motor Corp	$5	53.2billion
General Motors	$34	51.9billion
Honda	$28	50.3billion
Volkswagen	$154	45.5billion
Ford	$11	43.3billion

Source: Factset (Jun 2017)

Although as a new entrant, Tesla gives confidence and expectation to investors. Table 1 shows the market value of world top automobile companies. From this table, we can see that Tesla in the United States is valued higher in corporate value than GM in the stock market in 2017. In addition, China's BYD has attracted attention for the global production of electric vehicles.

In this paper we discuss the patterns of R&D strategies of Toyota, Tesla and BYD. Because the advent of electric vehicles in the automobile industry may be product innovation and is also possible to become technological innovation of competence-destroying discontinuities to existing firms like Toyota. To test this hypothesis, we make a comparison among R&D strategies of Toyota, BYD and Tesla by social network analysis.

3. Methodology and data

In the following sections, the trends of R&D strategies of automobile companies are analyzed. Patent documents are archived in Patent integration. All patents are classified according to three kinds of classification codes, IPC (International Patent Classification), FI (File Index) and F-term (File Forming Term). FI and F-term are classification codes for segmentalizing IPC in Japan. IPC codes in table 2 are the most frequently used in electric vehicle. This paper utilizes all patents (Japan, America, China, and WIPO) of automobile companies and we pay special attention to their IPC which is related to electric vehicle described in “IPC B60L”. Patents which are based on F-term and IPC related to electric vehicle and published by each company are extracted and collected

Table 2 IPC of patents related to electric vehicle

IPC codes	Contents
B60L	PROPULSION OF ELECTRICALLY-PROPELLED VEHICLES
B60L1/00-3/12	Supplying electric power to auxiliary equipment of electrically-propelled vehicles
B60L7/00-13/00	Electrodynamic brake systems for vehicles in general
B60L15/00-15/42	Methods, circuits or devices for controlling the propulsion of electrically-propelled vehicles

(Source) World Intellectual Property Organization

from the patent information. In order to examine target companies' R&D strategies and the change of core researchers in their R&D organizations, we visualize their patent information in 3 steps, and then diagrams can be created by these analyses.

First, count the number of patent publications related to electric vehicle of each target company. Second, conduct social network analysis and calculate network centrality. Third, create heat maps of core member in R&D projects.

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

Fig. 1 shows that Toyota is overwhelmingly more than other two companies in the number of patent applications. The reason is that the R&D investment amount of Toyota is as 10 times as the other two.

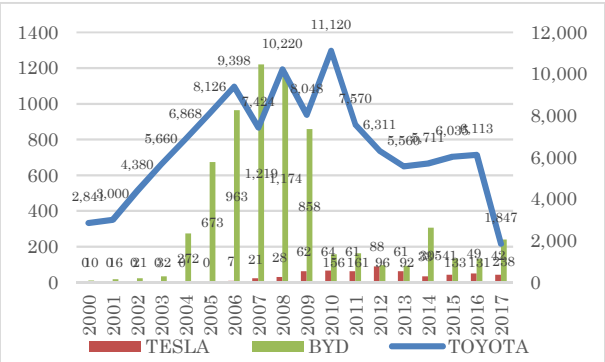


Fig. 1 The number of patents applications of the three companies

3.2. *An approach by the text analysis.*

We visualize their R&D strategies associated with co-applicant of patent publication by social network analysis and calculate network centrality (degree, betweenness, closeness). Fig 2, 3, 4 show the network of patent co-applicant of Toyota, BYD and Tesla in 2016.

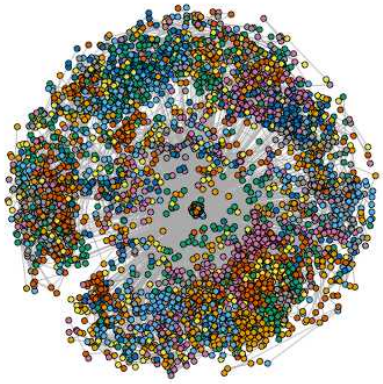
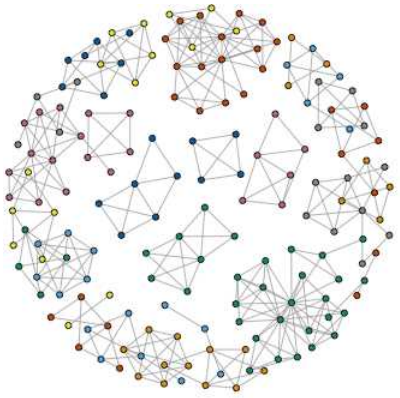


Fig.2 Network of patent applicant of Toyota



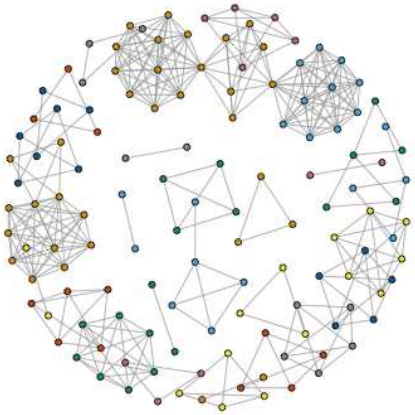


Fig. 3 Network of patent applicant of BYD
Fig. 4 Network of patent applicant of Tesla

3.3. *An approach by core rigidities.*

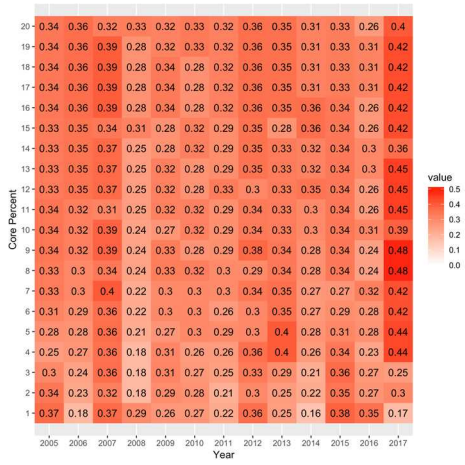


Fig. 5 Core rigidities of Toyota

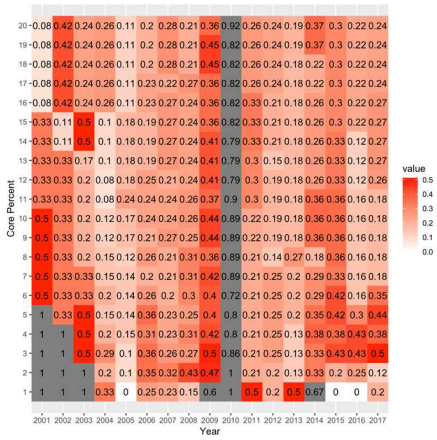


Fig. 6 Core rigidities of BYD

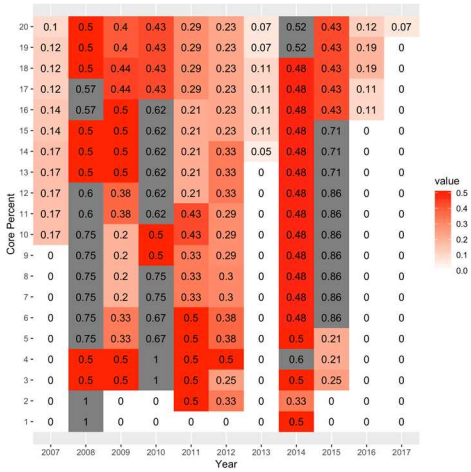


Fig. 7 Core rigidities of Tesla

Fig. 5, 6, 7 illustrate the core rigidities of these three companies. The score of core rigidities means that core members have been continuously active in R&D projects. In pattern of heat maps, we find that Toyota has exploited core member every year and taken an improvement of R&D capabilities. BYD and Tesla have changed core member per 2-3 years and taken an exploration of R&D capabilities.

4. Conclusions

We discuss that patterns of corporate R&D strategy cope with the threat of radical technological changes such as electric vehicle. We find the similarities and differences in the R&D strategies of three companies. Why has each company taken different R&D strategies? For Toyota, whose core product has been gasoline engine, has adopted R&D strategy that leveraged this. BYD whose core competence has been battery technology, developed FHV of world in 2009. Recently BYD has focused on the development of EV. Tesla may have been reorganized R&D strategy by mass production of Model X since 2014 and development of Model S as a new car.

Therefore, the hypotheses on R&D strategy of each firms seem to be related to their business domain and core competence. In the case of business domain, we think that the decision of vertical integration or horizontal specialization affects a firm's profit and competitive advantage. The analyses we have made on Chinese ICT companies, prove our hypotheses [4]. For automobile companies, we should also pay attention to the decision of vertical integration or horizontal specialization.

References

1. W. J. Abernarthy, *The productivity dilemma*, Baltimore, MD: Johns Hopkins University Press (1978).
2. M. L. Tushman and P. Anderson, "Technological Discontinuities and Organizational Environments" *Administrative Science Quarterly*, 31, pp. 439-465 (1986).
3. P. Anderson and M. L. Tushman, "Technological discontinuities and dominant designs: A cyclical model of technological change" *Administrative Science Quarterly*, 35, pp. 604-633 (1990).
4. Y. Chen, Y. Park and I. Nakaoka "A Comparison Study on the Vertical Integration and Horizontal Specialization of Chinese ICT Companies" *Journal of Robotics, Networking and Artificial Life*, Vol.4, No.4, pp. 317-321 (2018)