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Open Innovation in China's New Energy Vehicle Market: Case Study of BYD Auto Co., Ltd.

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Abstract：

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【Keywords】

1. Introduction

In recent years, the shift from internal combustion engine vehicles such as gasoline-car and diesel-car to electric vehicles (EVs) has been rapidly progressing in the global automobile industry. Among them, the battery electric vehicle (BEV) powered by batteries and motors is in the limelight as the leading role of the new energy vehicle (NEV). In addition, the battery, which is the power source for EVs, is a core technology and is a bottleneck for the spread of EVs. There are great demands for innovation in battery technology. At the current state of the technology, it requires hundreds of kilograms of expensive batteries and still has a short mileage. If the batteries become smaller and cheaper while keeping high performance, EVs will significantly improve in terms of price and usability. It will accelerate the spreading of charging infrastructure. Governments and automobile companies around the world are raising investment greatly in the research and development (R&D) of EVs.

The purpose of this paper is to investigate the accelerating R&D of Chinese automotive companies. The popularization strategies for automotive electrification from the perspective of open innovation are also investigated. It is to clarify whether to create value by developing and commercializing technology by utilizing the knowledge and ideas of universities and research institutes. Here, BYD Auto, which is the largest NEV manufacturer in China, is taken as the analyzing exampling.

2. Literature review

This section achieves the research purpose as follows: First, the background and term of open innovation are illustrated. Second, the previous research on open innovation is reviewed. Finally, the analytical perspective is clarified.

2-1. What is an open innovation

By the middle of the 20th century, many companies had done their R&D to monopolize the results of innovation and prevent the imitation of competitors. They

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were also in charge of basic research that would not produce results within a short period. It is a so-called closed innovation model. However, with the arrival of the IT revolution and the knowledge society from the latter half of the 20th century, it becomes difficult to lock in the results of innovation, the burden, and risk of R&D investment increases, the period during which huge investment can be recovered is shortened. In the process of diversifying the risks faced, the importance of open innovation that practices collaboration through alliance with the outside world is increasing. Open innovation is broadly defined as "accelerating internal innovation by utilizing the inflow and outflow of knowledge to meet the company's purposes, and expanding the market that promotes the external utilization of innovation" (Chesbrough, 2003). Since then, many researchers and practitioners around the world have paid great attention to the paradigm shift from closed to open innovation models.

The concept of open innovation has recently gained widespread attention in the academic and business communities over the past three decades. Open innovation is a concept that involves companies or organizations opening up their innovation process to external sources, such as customers, suppliers, and partners. The term was first coined by Henry Chesbrough in 2003, and it has since gained widespread attention in the business world. One of its most often used definitions is: "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation" (Chesbrough and Crowther, 2006). In 2003, Henry Chesbrough coined the term "open innovation" to create a contrast with the closed innovation strategy, as opposed to its predecessor, where companies generate their innovation ideas (Chesbrough, 2003). The idea behind open innovation is that by tapping into the ideas and expertise of external sources, companies can increase their innovation output and stay ahead of the competition. This can be achieved through a variety of methods, such as crowdsourcing, joint ventures, and partnerships.

There are several benefits to open innovation, including increased efficiency, reduced costs, and improved speed to market. By leveraging the expertise of external sources, companies can reduce their R&D costs and bring products to market more quickly.

However, open innovation also poses some challenges. One of the biggest challenges is managing intellectual property and ensuring that confidential information is protected. Companies must also be careful to control their innovation process and avoid becoming too reliant on external sources.

Overall, open innovation is a powerful tool for companies looking to increase their innovation output and stay ahead of the competition. However, it requires careful planning and execution to ensure that the benefits outweigh the challenges.

2-2. The prior research review on open innovation

Open innovation has been a popular topic in academic research over the past few decades. Here is a brief literature review of some of the key findings and themes in open innovation research.

First, external sources of innovation: One of the primary themes in open innovation research is the importance of external sources of innovation. Studies have found that companies that collaborate with external partners, including customers, suppliers, and universities, are more likely to develop innovative products and services (Drucker, 1985; Dyer, Kole. and Harbir, 2001; Chesbrough, et al, 2006; Rothaermel and Hess, 2010).

Second, intellectual property management: Another key theme in open innovation research is the management of intellectual property (Chesbrough,2003; Milder and Olleros, 2007). Studies have found that companies that are more open with their intellectual property, such as by sharing patents or licensing technology, are more likely to benefit from open innovation.

Third, organizational culture and structure: Organizational culture and structure also play a role in open innovation success. Studies have found that companies with a culture of openness and collaboration are more likely to succeed with open innovation (Manabe and Yasumoto, 2010). Additionally, companies with decentralized decision-making structures are more likely to adopt open innovation practices.

Fourth, open innovation in different industries: Open innovation has been studied in a variety of industries,

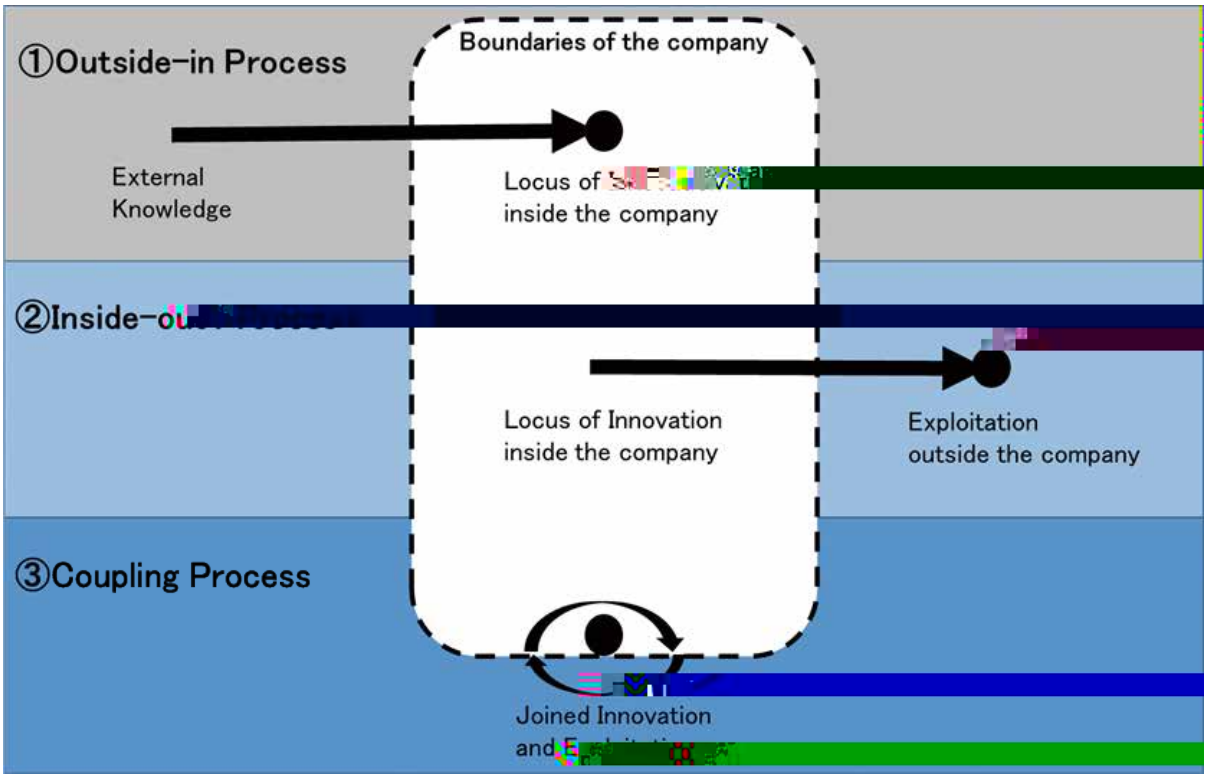

Figure 1.　Three processes of open innovation (Enkel, Gassmann, and Chesbrough, 2009)

including healthcare, software, and manufacturing (Holmberg, 2001; liu and Zhan, 2016; Beaume and Milder, 2009). Each industry has its unique challenges and opportunities for open innovation.

Finally, measurement and evaluation: measuring the success of open innovation initiatives is an important area of research (Yonekura and Shimizu, 2015; Faems, 2010). Studies have proposed various metrics for evaluating the success of open innovation, including the number of partnerships formed, the number of patents filed, and the financial performance of the company.

Overall, open innovation is a complex and multifaceted concept that has been studied extensively in academic research. The findings suggest that open innovation can be a powerful tool for companies looking to innovate more effectively, but it requires careful management of intellectual property, organizational culture, and partnerships with external stakeholders.

In recent years, open innovation has been one of the major topics in innovation management. The basic condition of open innovation is to clarify the innovation process. In general, the innovation process is defined as "the use of knowledge inflows and outflows, respectively, to accelerate internal innovation and expand the market for the use of external innovation" (Chesbrough et al, 2006). From the perspective of corporate innovation processes, there are three main processes in open innovation (Enkel, Gassmann, and Chesbrough, 2009). ① The external to internal process enhances the knowledge of a firm that brings together the knowledge that comes from customers, suppliers, and competitors. ② The internal-to-external process makes the firm more profitable by coming up with innovative ideas, commercializing intellectual property rights, and expanding technology by interacting with the external environment. Make it expensive. ③ The combination of the above processes is a coupling process in which the process from the outside to the inside and the process from the inside to the outside are applied at the same time. The coupling process can be achieved primarily through the cooperation of complementary partners (joint ventures and alliances) (see Figure 1).

Since it also applies to this study, the coupling process is elaborated here. The coupling process, as shown in the lower part of Figure 1 is collaborative innovation and development in collaboration with com-

plementary partners, from outside to inside and from inside to outside of ideas and knowledge. It is a hybrid model obtained from a combination of flows (Gassmann and Enkel, 2004). These partnerships can be formulated as joint ventures or alliances. Companies build relationships between companies through the coupling process. R&D departments between companies work together to develop complementary technologies. Through inter-organizational collaboration, companies can explore new opportunities and technologies. Innovative networks and R&D alliances are also important components for companies in their attempt to achieve better results in product innovation. R&D alliances are a more effective strategy than mergers and acquisitions in terms of improving a company's innovation performance.

However, despite increased business outcomes, collaboration between firms involves risks such as opportunistic behavior and increases control costs (Faems et al, 2010). Unlike the external-to-internal process, the coupling process requires companies to share the results they obtain with their collaboration partners. Therefore, while collaboration may help companies achieve better results in innovation performance, the process of opening up can diminish the occupancy of management resources. Furthermore, seeking external management resources, especially technology development resources, may reduce the core competencies of the company's long-term R&D (Yonekura and Shimizu, 2015). Therefore, companies need to understand these negative aspects and carefully implement open innovation.

2-3. Analytical perspective

Once open innovation is adopted, the organization's boundaries become permeable, and that allows combining the company resources with external co-operators. Changes in the social environment and competition between companies are accelerating and intensifying at the global level, and collaboration between companies such as joint ventures and alliances is extremely important for innovation, organizations, and new forms of competition, as companies survive (Reuer et al, 2010). Dyer, Kale, and Harbir (2001) argue that many companies use the collaboration paradigm to identify, improve, and ensure sustainable competitive advantage, and to develop new strategies. Partnerships can also be effectively used as a solid learning tool. Especially when elemental technologies with uncertainty are occurring, or when many different systems need to be coordinated with each other, learning tools are primarily "collaborators on issues defined in the process of collaborative work". Focuses on "exploratory partnerships to generate collaborative knowledge in which collaboration with" (Aggeri, Elmquist, and Pohl, 2009). In addition, strategic partnerships are increasing in terms of number and importance. With the globalization of economic activity today, strategic partnerships and networks of partnerships have changed the competition paradigm from companies to networks. In the value creation process, companies devise strategic alliances with other companies and new approaches to gain a great competitive advantage.

3. Methodology

3-1. The case method

The case study approach allows in-depth, multi-faceted explorations of complex issues in their real-life settings. The value of the case study approach is well-recognized in the fields of business, law, and policy. Keil (2006) argues that adopting the explanation of a phenomenon provides flexibility in construing, interpreting, and gaining insight. This paper uses an in-depth case study method to investigate how firms in the Chinese automotive market and the case of BYD Auto.

The case BYD Auto was selected due to the following reasons: First, the automotive industry in China has experienced rapid growth in the past two decades. Second, as a relatively young company, BYD Auto emerged as one of the top three China brand car manufacturers in just ten years since its formation. Third, BYD is recognized as an innovative company in the world. In 2010, BusinessWeek ranked BYD the 8th most innovative company in the world, ahead of Ford, Volkswagen, and BMW (Einhorn and Arndt, 2010). Fourth, as a private firm (instead of a state-owned enterprise), BYD represents an emerging force of innovation growing in China in the recent decade. Last, it is worth mentioning that BYD is not just an automotive compa-

Table 1. Profile of BYD Auto

Company name	BYD Auto Co., Ltd.
Predecessor	Xi'an Qinchuan Automobile Co., Ltd.
Founded	January 2003
Headquarters	Xi'an, Shanxi, China Shenzhen, Guangdong, China
Founder	Wang Chuanfu
Parent	BYD Company Limited (99%)
Subsidiaries	Denza (90%) Yangwang Fangchengbao BYD Toyota EV Technology (50%) Guangzhou GAC&BYD New Energy (50%)
Business details	・passenger battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) ・electric buses and trucks

ny. It first started as a battery manufacturer, then expanded into the field of mobile phone manufacturing, then became a rising star in the automotive industry. This seemingly unique development path also represents a common scene of diversification that can be observed among many Chinese firms.

3-2. Data collection

The data used for this work comes from face-to-face interviews and secondary sources. The case analysis is based on in-depth interviews with senior managers of BYD Auto on August 28, 2019. Besides, we have also obtained information on BYD from other sources such as websites, newspapers, magazines, and other research reports.

4. Case study

4-1. Overview of BYD Auto Co., Ltd.

Headquartered in Shenzhen, Guangdong province, BYD Co., Ltd. (BYD) is a battery and automobile manufacturer founded in 1995 by the founder Wang. The company name BYD bears the full name "Build Your Dreams" which symbolizes a commitment to creating a better future. In less than 30 years, BYD has developed from a small battery enterprise with an investment of RMB 2.5 million and 20 employees to a world-class high-tech enterprise that owns more than about 220,000 employees and 9 production bases across China. It also has subsidiaries or offices in the United States, Europe, Japan, South Korea, India, Taiwan, and other countries and regions, covering four industrial clusters including IT, automobile, new energy, and urban transportation (www.bydglobal.com).

BYD Auto Co., Ltd. (BYD Auto), which is responsible for BYD's automobile business, was established in 2003 as a subsidiary of BYD and is a young automobile manufacturer headquartered in Shenzhen, Guangdong Province. The predecessor of the company was established in January 2003 as a new company by acquiring the state-owned company Xi'an Qinchun Automobile Co., Ltd. and changing the company name to BYD Auto (see Table 1).

BYD has also entered the automobile business by utilizing its know-how in the battery business and has begun to produce gasoline-powered vehicles while imitating it. In June 2006, the BEV "F3e" was launched on the market based on the gasoline-powered "Flyer 3", and in December 2008, the world's first mass-produced plug-in hybrid vehicle (PHEV) "F3DM" is now on sale. After that, riding on the NEV boom in China, BYD auto started full-scale production of NEV models that made use of the strengths of its own battery business. Currently, it is centered on the Chinese dynasty series "Qing" "Tang" "Song" and "Yuan" of PHEV, and "e6" of

BEV. Since its establishment in 2003, BYD Auto has been actively engaged in R&D related to NEV by making the best use of its battery strength. BYD Auto, which began entering the NEV market in June 2006, is renowned as the top runner of NEV in China. In the NEV market, BYD Auto has held the world's top position for four consecutive years from 2015 to 2018, overtaking rivals such as Tesla in the United States and Beijing New Energy Automobile.

BYD Auto, with only 20 years of history since it entered into the automobile market in 2003 as mentioned above, has mobilized all internal and external resources. In particular, it has taken advantage of its battery strength to produce NEV. Sales got off to a good start and rapidly grew and developed. In the next section, how BYD Auto has grown in the NEV market is described in detail.

4-2. Strategic shift from battery maker to automobile maker (2003-2009)

BYD focused on nickel-cadmium batteries, which were being abandoned in developed countries at that time, and steadily increased its business performance in the battery field, becoming the number one battery manufacturer in China in 2008. The founder, Wang Chuanfu, was looking for a new source of growth with a sense of crisis that the growth of batteries alone would eventually reach its bottleneck. At that time, he was considering entering the real estate, IT, finance, and home appliance industry, but decided to use the existing battery business in the automobile industry. BYD has steadily made careful preparations to enter the automobile industry. For example, since a huge amount of operating funds are required to produce automobiles, the company was listed on the Hong Kong Stock Exchange in July 2002 to raise operating funds. In the same year, BYD acquired Beijing Jichi Mold Engineering Co., Ltd., which is under the umbrella of Beijing Automotive Group, and established BYD Company. This company is responsible for the development and production of molds for BYD Auto's flagship F3. With a loan from the listing on the Hong Kong Stock Exchange and a small amount of money from the battery business, obtaining a license for automobile production, BYD acquired Qinchun Automobile Co., Ltd which is a small state-owned company in Xi'an on January 23, 2003. At that time, Qinchun Automobile Co., Ltd. had a press line provided by FAGOR in Spain, a press mold and welding production line provided by Ogiwara Company in Japan, a welding line manufactured by DURR in Germany, and a complete supply provided by BENZAI Company in Japan. It already had four advanced assembly lines for the production of finished vehicles, such as a vehicle inspection line.

4-3. Investment in R&D

At the time of its founding, BYD Auto launched "Flyer", a model that the former Qinchun Automobile developed its own body based on Suzuki's former Alto. However, BYD Auto, which had little experience in producing automobiles because it was not successful because it was notorious for being a copycat, established the BYD Auto Research Institute in Shanghai in 2003. Worked on R&D in the engine and gearbox. In addition, the EV division was established by integrating the original battery technology and the automobile business. BYD Auto used the "reverse engineering" method to accelerate in-house R&D. "Reverse engineering" refers to learning first from the mature and successful products of the market. Disassemble, scan, digitize, copy, or modify (if patented) the benchmarked vehicle (mainly Toyota). The F3, which imitated the Corolla of Toyota, was very similar except for the details such as the front and rear lights, so the shape of the tail light and the four doors perfectly matched the Corolla, yet the price of the F3 was just half that of the Corolla. The F3 quickly hit the market and became the fastest domestic car with total sales of 1 million units, bringing a lot of profit and confidence. BYD Auto continued to imitate and develop many products such as F0, F2, F3, F6, M6 after F3. For example, the F6 is similar to the Camry of Toyota, the F0 is similar to the Aygo, and the M6 is similar to the Previa. BYD Auto admits that the intermediate sedan F6 is a joint development with the Chinese design company Shanghai Tongji University Technology co., Ltd. (described later) and that Japanese automobile industry officials are participating in the development. In addition, F3 was developed by absorbing the technologies of Japan (Corolla of Toyota) and South Korea. As for the engine,

the F6 is equipped with the company's engine (2.4L), and the F2 and F3 are equipped with the Shenyang Aerospace Mitsubishi engine (1.6L, 1.3L) (Li, 2006a; 2006b).

Only two years after entering the automobile market, the new model F3, which started mass production in 2005 and reached 100,000 units in 2007, was announced. Like battery production, BYD Auto relies on its production network, except for some parts such as tires and glass. On April 1, 2010, it acquired the Tatebayashi factory of Japanese mold maker Ogihara. BYD Auto had the advantage of being able to put high-quality molds produced in Japan into its production line.

4-4. Evolution to NEV maker (2010～)

Two factors cause BYD Auto to enter the NEV market. First, the internal factor is that BYD Auto has an advantage in the R&D and production of batteries, which is the power source for the electrification of automobiles and is also the core technology of EVs. External factors include the preferential policies of NEV subsidies by the central government and local governments and the continued growth of the NEV market in China.

BYD Auto's many R&D activities focus on the combination of EV and in-vehicle battery businesses. Since 2003, having acquired Qinchun Automobile, BYD Auto has gathered about 500 engineers and invested RMB 1 billion to start the development of in-vehicle batteries. At the same time, BYD auto launched EV development projects such as the BEV "e6". Compared with lithium-ion batteries, the newly developed iron phosphate (Li-FePO4) battery offers the advantages of cost, capacity and safety. It can be fully charged from a regular outlet in 9 hours and be charged up to 80% in 15 minutes using industrial charging equipment, and the life cycle of the battery pack reaches 2,000 times, over 600,000 km range, or up to 10 yfb □
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Table 2. BYD Auto's major collaborations

Partner	Type of partnership	Investment Relationship	Scope of collaboration
Shanghai Tongji University Technology	R&D	Non-capital relationship	Development and design of vehicle body
Shenzhen Bus Group China Southern Power Network	client Power Infrastructure	Joint Venture (55：33.75：11.25)	・BYD Auto - Provision of BEV "e6" ・Shenzhen Bus - Taxi company operation ・China Southern Power Network - Installation of charging poles
Daimler (German)	Development and manufacturing of NEVs	Joint Venture (50：50)	・Daimler's Body Development, Design and Production Technology ・BYD Auto's battery, electric motor, and electronic control technology ・Production and sales of the new brand "DENZA"
Changan Auto	R&D for automotive batteries	Joint Venture (50：50)	・Production and sales of batteries for NEVs ・Collaboration on the design, assembly, testing, and production of electric drive components for NEVs.
Toyota Motor (Japan)	Development and Production of BEV	Joint Venture (50：50)	・BYD Auto's competitiveness and development capabilities in the EV market, Toyota's quality and safety ・Production and sales of Toyota brand BEVs

is 18.4kWh, which has the highest output and voltage so far. It uses a new storage battery model with specifications. Second, three power sources. It is equipped with one direct-injection 2.0L turbo engine to be combined with BYD Auto's own "6H DT45" transmission and two drive motors (maximum output 110kW per unit) mounted on the front and rear axles. Therefore, high output / high rotation speed / high-efficiency power is realized. Third, a four-wheel drive system. The electronically controlled four-wheel drive (4WD) system structure is even easier to drive because it automatically switches between 4WD and two-wheel drive (2WD) electronically depending on the road surface conditions.

4-6. Collaboration with companies in the NEV field

BYD Auto is a latecomer, who lacked knowledge of automobiles when entering the automobile industry, and it was able to grow by accumulating limited technology by starting with imitation rather than true innovation. But BYD Auto still needs to learn knowledge from external. As shown in Table 2, BYD Auto is actively working to collaborate with organizations such as universities, customers, suppliers, and competitors across national borders and industries to succeed in the automobile business.

4-6-1. Industry-academia Joint development with Shanghai Tongji University Technology Co., Ltd.

Shanghai Tongji University Technology Co., Ltd., a private automobile design company under the umbrella of Tongji University, is an important player in independent development in China. In 1999, Professor Rai Yucheng (Chairman of the Board of Directors) of Tongji University Automobile College and 11 colleagues including faculty members and graduate students invested RMB 1.2 million to establish the compa-

ny. The company transferred a 15% stake to Tongji University Automotive College, thereby acquiring the right to use the college's laboratory. Rai Yucheng is an expert in 3D CAD development and has worked with UGS in the United States to develop modular software for automotive design for GM (Li, 2006b). BYD Auto, which was established by acquiring Xi'An Qinchuan Automobile. In 2003, initially entrusted the development of many car bodies to Shanghai Tongji Technology Co., Ltd. while establishing BYD Automobile Research Institute in Shanghai. The result was the announcement of the intermediate sedan F6 in June 2004 in collaboration with Shanghai Tongji Technology Co., Ltd. Amid fierce competition for human resources in the Chinese automobile industry, Lian Yuebo, one of the founders of BYD Auto Technology Co., Ltd., transferred to BYD Auto in February 2004 with more than 30 engineers and became the director of BYD Auto Research Institute. As a result, BYD Auto's development capabilities have been further enhanced. After that, BYD Auto announced the F series such as F0, F2, and F3 one after another.

4-6-2. Creation of a demonstration experiment site: operation of a taxi company

On February 26, 2010, Shenzhen Bus Group, BYD Auto, and China Southern Power Network Co., Ltd., jointly established Shenzhen Pengchen Electric Vehicle Taxi Co., Ltd. (Pengchen EV Taxi). The capital is RMB 20 million, and the investment ratios are 55%, 33.75%, and 11.25%, respectively. Pengchen EV Taxi owns about 50 BYD Auto's "e6". In this new business alliance, Shenzhen Bus Group conducts the daily business operations of Pengchen EV Taxi. BYD Auto provides its BEV "e6" as a taxi and technical support. In addition, the role of the Southern Power Network is to cooperate in the construction of charging stations and to verify energy management related to optimal operation and charging in driving.

BYD Auto introduced 40 BEV "e6" as taxis on a trial basis in 2010 with the cooperation of Shenzhen City, which is trying to become a pilot city of NEV. A demonstration experiment on public roads has started in Shenzhen city. At the end of February 2012, BYD Auto and Shenzhen City announced that they would further expand this demonstration experiment. As a result, they decided to introduce an additional 1,500 units in Shenzhen City, including the EV bus "k9" and the EV taxi "e6". In addition, BYD Auto has partnered with a taxi company to allow taxi licenses to be used to purchase cars without a down payment using a bank loan. The full amount can be repaid within 4 years. BYD Auto received financial support of 30 billion yuan from the China Development Bank under this mechanism. In 2016, Shenzhen City had 3,000 EV buses, 800 EV taxis, 200 EV public vehicles, and 500 EV police vehicles. As infrastructure developed, 80 fast charging stations and 3,000 charging spots were installed.

BYD Auto adopted its own BEV vehicle as a taxi with the cooperation of Shenzhen Bus Group, China Southern Power Network, China Development Bank, etc. when NEV was not widely accepted by general users. They provided users (passengers) with the opportunity to experience BYD Auto's BEV and enhanced the BYD brand. Furthermore, by analyzing the enormous amount of driving data collected by operating BEVs such as taxis "e6" and buses "k9", the experience and satisfaction of users (taxi carriers and passengers) can be accurately collected. At the same time, BYD Auto has accumulated technology and knowledge regarding battery performance (charging/mileage), drivability/safety, and vehicle body design in EVs. It will be useful for better EV R&D and improvement in the future.

4-6-3. A joint venture between BYD Auto and Daimler

On March 1, 2010, BYD Auto and Daimler signed an agreement to launch a new brand and jointly develop, manufacture, and sell a new EV only for the Chinese market. The agreement on this technical partnership aims to combine the know-how of Daimler's EV architecture with the excellence of BYD's battery technology system. Immediately, a work team consisting of engineers, designers, and executives from both companies was set up, and the concept creation of the new EV was started.

BYD Auto and Daimler have jointly established a joint venture called "BYD Daimler New Technology (BDNT)" with a 50% stake in each On May 27, 2010.

The registered capital of BDNT is RMB 600 million, and the two companies will jointly establish and own a new brand "DENZA" to sell the new EV. At this time, BYD Auto provided excellent lithium iron phosphate battery technology and electric drive system, and Daimler provided knowledge and know-how on the architecture and safety of luxury cars such as Mercedes-Benz. This has made it possible to develop the luxury EV market, which is a new field for BYD Auto. So BYD Auto set a new step in its business and can reinforce its external capabilities in areas that are still internal weaknesses. On December 8, 2016, the company name was changed to Shenzhen DENZA New Energy Automobile Co., Ltd.

Rise Automobile officially released a high-end BEV of the new brand "DENZA" series in March 2014. "DENZA" is a luxury EV brand consisting of R&D, products, sales, and brands. It is operated independently from its parent companies BYD Auto and Daimler. The overall battery technology of the vehicle is provided by BYD Auto and the car manufacturing process is controlled by Daimler. The "NENZA 500", debuted on March 26, 2018, is a compact BEV that uses a Mercedes-Benz B-class platform. The battery protected by a strong aluminum case is housed in a long wheelbase equivalent to the E class, and its cruising range reaches 451 km. The local price is RMB 449,800, Considering the national and local government subsidies of RMB 120,000, the actual price is about RMB 329,800 (DENZA Automobile News: www. denza.com/news/576.html, March 18, 2018)

On April 19, 2017, it was announced that both sides would increase their capital of RMB 430 million. The capital increase was used mainly for manual labor to expand the rising dealer network and improve branded products. It also changed a part of Rise Automobile's original sales system. "DENZA" has joined Daimler's luxury car Mercedes-Benz sales and service network and after-service, and is offered to 13 Mercedes-Benz dealers in Beijing, Shanghai, Shenzhen, Guangzhou, Tianjin, Hangzhou, etc. On November 26, 2019, DENZA Automobile began to develop and produce a new SUV "DENZA X" by sharing resources ("Tang" technology) between Mercedes-Benz and BYD Auto.

4-6-4. External sales of core battery parts-Strategic alliance with Changan Automobile

Automotive batteries are known as the core component of NEVs and hold the key to the popularization of NEVs. BYD Auto has been involved in the R&D, design, and manufacture of in-vehicle batteries since its establishment in 2003, and has a wealth of knowledge and experience in core technologies. In addition, to respond to the in-vehicle battery market where competition has exacerbated in recent years, BYD Auto breaks through the closed model of self-production and self-consumption of in-vehicle batteries and aims to gain more market share. On July 5, 2018, BYD Auto and Changan Auto signed a strategic alliance agreement to establish a joint venture to develop, produce, and sell in-vehicle batteries for NEV. As part of the alliance, Changan Auto and BYD Auto will collaborate on the design, assembly, testing, and production of electrically driven integrated parts for NEV. The joint venture's 10GWh production capacity will be gradually increased, reaching 5-6GWh in the first stage and 4-5GWh in the second stage. The developed parts are planned to be installed in the Changan Auto model in 2019. Changan Auto can leverage its strengths by focusing on the development and production of vehicles, relying on BYD Auto's superiority in NEV's in-vehicle batteries. BYD Auto aims to meet Changan Auto's demand for in-vehicle batteries and stabilize the positioning of domestic in-vehicle battery supply. This strategic alliance is the first step in the external supply of BYD Auto's in-vehicle batteries, and the development of BYD Auto's in-vehicle battery supply system is accelerating.

quality and safety in the automobile market. We aim to provide EVs that meet the needs of the market and our customers can be pleased as soon as possible" (BYD Auto, Press Release, November 7, 2019).

Since signing a contract to establish a joint venture for EV R&D on November 7, 2019, the two companies have been preparing. On April 2, 2020, BYD Auto and Toyota invested 50% each with a registered capital of RMB 345 million in Shenzhen City, Guangdong Province. The joint venture is called BYD Toyota Electric Vehicle Technology Co., Ltd. At the new company, Toyota Motor Corporation's Hironao Kishi has been appointed as chairman of the board of directors, and BYD Auto's Zhao Bingen has been appointed as president. The number of employees will be 300. The business content is the design and development of EVs, their platforms, and related parts.

In establishing the company, Zhao Bingen said, "At the new company, we will bring in technologies and know-how from BYD auto and Toyota and pursue high-quality technology to make EVs that are more environmentally friendly, safe, comfortable to ride, and smart. Our vision is to achieve both convenience and environmental protection for a customer-centered future mobility society." (TOYOTA Global Newsroom, April 2, 2020). BYD Toyota Electric Vehicle Technology Co., Ltd. started its business in earnest in May 2020, and in 2025, Toyota brand sedan and SUV "C-HR" and "Izoa" EV models will be launched in the Chinese market.

5. Discussion

According to Francis and Bessant (2005), product innovation and process innovation are two of four categories of innovation. The former is related to changes in the products offered by the company, and the latter is related to changes in the

so, BYD Auto will be able to successfully combine its growth strategy with the ideas of its collaborators. Innovative battery technology and supply (Changan Auto) and important innovations in design and manufacturing processes (Daimler, Toyota, etc.), have made great achievements through these strategic alliances. BYD Auto applies a coupling innovation process by building multiple partnerships. This is clarified by BYD Auto's observation of innovations such as battery technology, body design, production technology, and drivability/safety. Through these partnerships, BYD Auto has acquired new production plans, financing, and future sources of revenue.

Finally, according to Dess and Lumpkin (2005), as products and markets mature, companies can update their technology and product portfolios through entrepreneurship. Because of this idea, BYD Auto's strategic alliance with Toyota and Daimler is a good example. Both companies have been successful in the traditional car market but wanted to expand in the emerging NEV market. In the joint venture with Daimler in May 2010, BYD Auto was able to expand sales of its batteries and absorb production technology and management know-how from Daimler to enter the luxury EV market. In addition, BYD Auto's joint venture with Toyota in April 2020 is considered to be one of the strategies for BYD Auto to consolidate large battery customers and acquire attractive EV development and design. Thus BYD Auto achieved its growth goals by establishing alliances with them to update its technology and product portfolio. At the same time, BYD Auto gained valuable knowledge and know-how from partner companies.

However, according to Yonekura and Shimizu (2015), collaboration with R&D organizations involves some risks. The possible advantages of the alliance for technological achievement may not exaggerate the potential disadvantages. BYD Auto must pay attention to its current partners, especially Daimler and Changan Automobile, as they may become BYD Auto's rivals in the future in the Chinese NEV market.

6. Conclusions and limitations

In this article, the data about BYD Auto have been analyzed. Based on the discussions, the following conclusions are summarized.

First, BYD Auto started by acquiring an automobile production license and technology in a short time through the acquisition of a state-owned automobile company. BYD Auto's strategy is to apply product innovation by establishing an in-house automobile design using a "reverse development" method, and also adopt process innovation by combining multiple technologies and know-how obtained from different companies. Therefore, BYD Auto can be regarded as an innovative company.

BYD Auto is also adopting open innovation and its combined process by establishing R&D cooperation with major automobile companies. In that way, innovative technologies can be further developed. In the open innovation activities carried out by BYD Auto, there are various partners, such as domestic and overseas, inter-industry, academic, and government agencies, according to their respective purposes. Since open innovation creates new value, it extends beyond product development to sales, services, and distribution. The key to BYD Auto's success is its top-down open innovation. In other words, in line with the company-wide strategy, the management (founder) has strategically decided to focus on the priority fields from the top down. This makes it possible to promote open innovation as a whole company.

Furthermore, in the highly competitive global market, it is very difficult for start-up companies to enter the market. Investing in a whole new car maker requires a huge cost of capital and product knowledge. In particular, NEV manufacturers need to invest in infrastructure projects to provide the proper functionality of the NEV network (battery charging, battery replacement). Therefore, close cooperation with other companies to share technology and know-how is indispensable for the spread of EVs. BYD Auto has begun planning in that direction by cooperating with many partners. To further develop the strategic alliance network, BYD Auto is actively building R&D alliances with OEM, a supplier that helped itself in various fields.

Although many advantages of open innovation have been focused on, relevant risks must also be recognized. Hidden costs, opportunistic behavior, and finan-

cial difficulties faced by one of many partners in the vast supplier chain that produces and sells NEVs can impact the outcome of cooperation. It is said that many NEV companies have gone bankrupt due to the abolition or reduction of preferential policies such as support measures and subsidies of the Chinese government. There is a serious risk in the current Chinese NEV market. Therefore, BYD Auto needs to pay attention to the implementation of the open innovation process. Strategic alliances must be carefully selected to ensure that understands their role and has a clear understanding of common goals and objectives.

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