

Catching Up in a Bidirectional Way: Evidence from Chinese Electric Automotive Industry Leader BYD

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Abstract--To catch up with leaders, whether latecomers should follow an “imitation to innovation” path or an “innovating to leapfrog” path is still not quite clear. To shine some light on this issue, we focus on the case of BYD, a latecomer growing from nobody to the pioneer of Chinese electric automotive industry and the champion in world electric vehicle sales in a dozen years. We find that BYD catches up in a bidirectional way by which it has kept doing imitation and innovation from the start and made them well balanced to achieve the best of cost performance. This is different from the unidirectional view that a latecomers’ catching-up either starts from a reverse innovation way like “from imitation to innovation”, or from a leapfrogging way that requires “science-technology-innovation”. Evidence is also found that technology accumulation affects BYD’s selection between imitation and innovation. This paper helps latecomers to make a better decision for their catching-up.

I. INTRODUCTION

This paper focuses on the relationship between innovation and reverse innovation in a latecomer firm’s catching up process. A latecomer firm is a resource-poor late entrant to an industry, not by choice but by historical necessity [1]. Scholars have found that different from firms in developed countries that usually do innovation in a “Science – Technology – Innovation” way, latecomer firms usually do innovation in a reverse innovation way like “Acquisition – Assimilation – Improvement”, which doesn’t require R&D work in early stages [2, 3]. Scholars have also found that latecomer firms can catch up in a leapfrogging way, especially the path-creating way which suggests latecomer firms entering new technological trajectory as soon as possible to gain advantages [4, 5]. In the path-creating catching-up, no matter how much technological capabilities latecomer firms have accumulated, they have to do R&D and innovate since there is little for them to imitate.

Therefore, latecomer firms have at least two ways to catch up. One way is reverse innovation, starting with imitation, following a “imitation to innovation” path to gradually reduce the gap between latecomer firms and firms in developed countries [6]. The other way is innovation to leapfrog, paying more attention to R&D work to take advantages of technological change to significantly reduce the gap with firms in developed countries or even overtake them and become leaders of the new technology [7].

Little attention has been paid to whether latecomer firms can start to catch up by using both strategy at the same time, which may imply a latecomer firm use only one way to catch up. This weakens the explanatory power of existing theories

for industrial practice, as some latecomer firms do use both ways to catch up at the same time. One important reason for this gap between theory and practice is that the technology a latecomer firm needs for catching up at a certain stage is usually treated as a whole. In fact, the technology consists of different parts, a latecomer firm may be weak in most of the technology that it needs to learn from imitation, but it may be relatively strong in a certain technology that it can do R&D and innovate. In other words, latecomer firms may not catch up in a unidirectional way, either imitation or innovation, but in a bidirectional way that they do imitation and innovation at the same time.

To get a better understanding of this issue, this paper focuses on the case of BYD, a Chinese electric vehicle (EV) player. EV technology can simply be taken as the combination of automotive technology and battery technology. While most of giants in automotive industry have little accumulation in battery industry, BYD is a latecomer in automotive industry with battery experience. It only takes BYD 12 years to become the champion of world EV sales. BYD’s catching-up practice provides an interesting example about how latecomers with knowledge accumulation can successfully catch up in one of the most established industries [8].

This paper is organized in the following manner. The next section presents a review of the literature forming the basis of this case analysis. This is followed by a section explains why case study is used and how the case is selected. Then comes a section elaborating on BYD case. After that the discussions and conclusions of the study are presented.

II. LITERATURE REVIEW

Latecomer firms are faced with two kinds of disadvantages. One is that latecomers are poor in technology accumulation and have limited access to advanced technology and a healthy surrounding national system of innovation. The other is they confront underdeveloped and unsophisticated users instead of demanding users who are very important for firms’ innovation [9, 10].

Therefore, in contrast with the R&D and design-led strategies typical of leaders and followers, latecomers began with acquiring outside mature technology and making incremental improvements to manufacturing processes [11]. They concern on output capabilities which describe firms’ technologies and skills relating directly to the currently observable product, and show little interest in the ability to enhance or develop the product [12]. After they accumulate

basic technology, they start to do some product development to make the product introduced from leading markets to better fit less developed domestic market that they are more familiar with. After they have accumulated certain knowledge in engineering and development, they start to do some research to innovate. And when they finish all steps above, they can start from more advanced technologies instead of mature technology, and continue to follow Acquisition – Assimilation – Improvement process to catch up [6]. This process is opposite to the AU model illustrating how product innovation and process innovation change in developed countries [13].

The key to succeed in catching-up is to use less money and time to master the technology and make similar products in lower cost. In this way, a latecomer's catching up is a learning process focusing on imitation instead of doing R&D to innovate [14].

However, by a reverse innovation way shown above, latecomers can reduce the gap between leaders, but they are hardly able to become leaders, since they have to imitate leaders' products. Those who would like to overtake leaders have to do R&D and make something different [15, 16].

Technological change is often seen as a chance for latecomers [5, 7, 17, 18]. When a new technological regime comes, leaders are usually reluctantly to change to the new regime since they have made huge amount of investment in old regime and they are not sure whether the new technology will prosper or die out. They continue to invest in old technology to compete against the new one, as a result, it is often too late to enter and lead in the new regime. In addition, leaders of old technology don't have much accumulation in the new regime and entry barriers are low [5, 17, 19]. Therefore, when a new technological regime occurs, latecomers should enter the new regime and start to do R&D to develop their own technology and product and win in the new technological regime.

Another chance for latecomers lies in the fact that they are more familiar with domestic market than leaders, and some latecomers do have some technology accumulation [16, 20]. They can develop their own products according to domestic customers' taste. Although products developed by leaders are likely to have a better overall performance, latecomers' products can still enjoy a certain market since products for developed market may not meet the need of customers in emerging economies. Only latecomers doing R&D instead of imitating can develop a more domestic product [21]. Cases from Chinese DVD industry even implies that the earlier latecomers start R&D work, the high chance for success it enjoys [22].

To date, there are two ways for latecomers to catch up, holding an opposite view of when and how should latecomers start to do R&D and innovate. The majority believes latecomer firms should first imitate then innovate, gradually improve their R&D capability through learning [23]. Others argue that latecomer firms should start to innovate from the start and be prepared for possible technological leapfrogging

[22]. Little research has been done on whether latecomers can start their catching up by both imitation and innovation, and how to balance them.

In addition, most existing research on latecomers' innovation practice are based on evidence from East Asian economies which have a relatively small domestic market and rely on overseas market. However, China is large economy providing a big domestic market for its latecomer firms. Since Chinese latecomer firms don't have to compete in high-standard international market at their early time and can first develop their capabilities in domestic market, they may choose catch up strategies different from that of firms in small economies.

III. RESEARCH METHOD

This research is a theory building research focusing on "how" questions, the behavior of those involved in the study can't be manipulated. A single-case study provides richer details for us to look into the case and learn better about how latecomer firms catch up [24, 25].

We relied on both primary and secondary data for our study. Primary data comes from interviews and observation. We visited BYD for two days, interviewed six senior engineers and managers for one and a half days. Besides respondents from BYD, five engineers and four professors in automotive field are interviewed, and each interview last one hour to two hours. Secondary data comes from diverse sources such as official website, annual reports, business magazines, web content, BYD BBS, and Wikipedia. These resources provide reliable data on both BYD innovation strategy and details during its development.

BYD is a latecomer in automotive industry with battery background. It was set up in 1995 by a battery researcher, Chuanfu Wang, with RMB 2.5 million and 20 members in Shenzhen, China. It engaged in rechargeable battery business, mobile phone components and assembly. Taking advantages of world battery industry transfer, BYD enjoyed a fast growth: it took BYD 7 years to become the 2nd world largest nickel-cadmium batteries manufacturer. BYD also became the first Chinese lithium ion battery supplier of MOTOROLA in 2000 and the first Chinese supplier of NOKIA in 2002. To search further growth, Wang set up his mind to enter automotive industry in 2003 by acquiring Qinchuan Automotive Limit, a going-bankrupt manufacturer with poor technology accumulation.

After the acquisition, BYD continued to developing gasoline vehicles inherited from Qinchuan, at the same time it set up a research center for EV, trying to take advantages of its battery background. 12 years later, BYD has made much progress in automotive business, it even becomes the champion of world EV sales during Jan 2015 to Nov 2015. Its automotive sales and EV sales are shown as Figure 1 and Figure 2. In contrast, most other Chinese firms entered automotive industry the same time with BYD ended up failed.

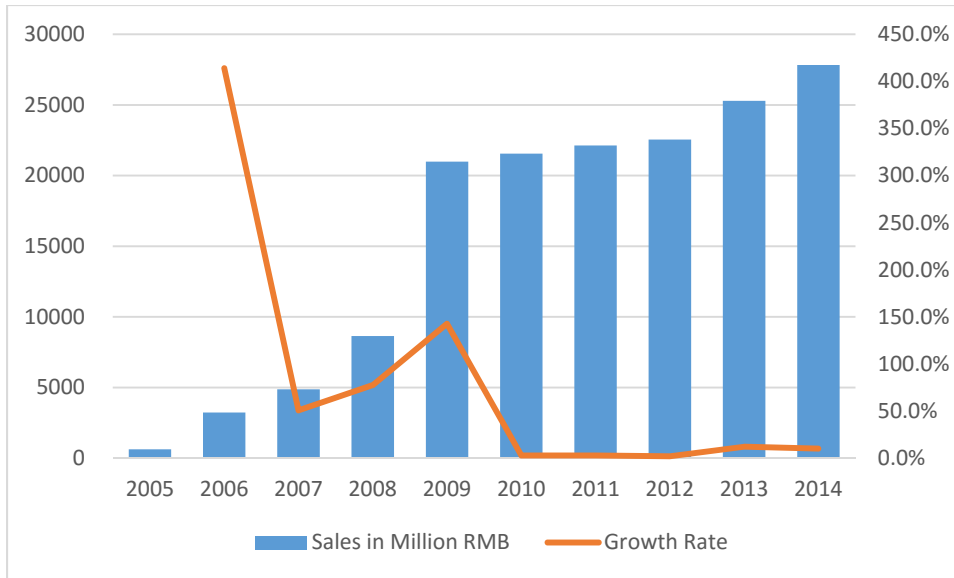


Figure 1 BYD's Automotive Sales 2005 - 2014
Source: data collected from annual report 2006 - 2015.

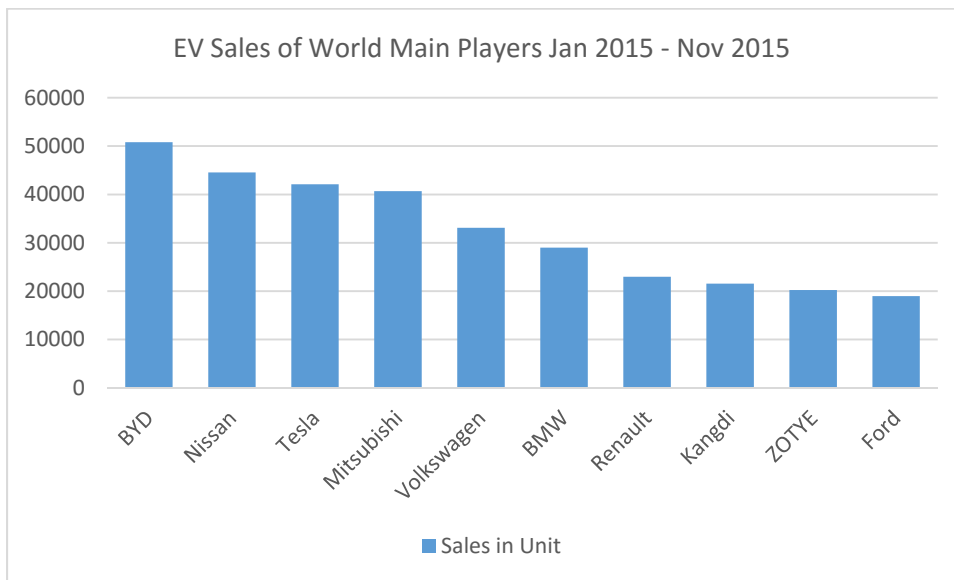


Figure 2 World Main Players EV Sales Jan 2015 - Nov 2015
Source: data collected from auto gasgoo.com.

IV. BYD'S CATCHING-UP PRACTICE

A. Reverse innovation practice

BYD didn't decide to focus on imitation at the beginning. Since it had become the second largest nickel-cadmium batteries manufacturer, it believed it can develop a good product by itself even it had limited technology accumulation. It developed an all-BYD car, BYD F2, a year after the acquisition. When BYD invited its dealers to promote it, none of them were satisfied with the ugly model and expensive price, some immediately went away and some even asked BYD to cancel their contracts. Not until that time did BYD admitted it too hard to develop a car with little accumulations,

and set up its mind to do imitations.

Considering the poor technology accumulation, BYD spent millions of dollars to purchase the latest models of other car makers, including Honda, Toyota, Mercedes, and BMW. Its employees were asked to disassemble these cars and write reports to learn from these outside products. In the beginning some young technical staff hesitated to disassemble these cars, especially luxury ones like Porsche, Mercedes and BMW. The time Wang knew this, he scratched his Mercedes with his key and said: "Go ahead and disassemble it now." In this way, BYD got a better understanding of cars, enhanced its technological ability, and selected which product to imitate.

Then BYD start with a duplicated imitation [6](Kim, 1997), tried its best to copy. Its first product put into market, BYD F3, was so similar to Toyota Corolla that its four doors matched Corolla perfectly, and the price of F3 is only half the price of Corolla. This product soon proved itself in the market, it was the quickest domestic car to reach a total sale of 1,000,000 units, bringing in much revenue and confidence for BYD to continue imitation. After F3, BYD developed many products with obvious imitation trace. For example, BYD F6 is similar to Toyota Camry, BYD F0 is similar to Toyota Aygo, BYD S6 and its first hybrid SUV, and BYD M6 is similar to Toyota Previa, etc. BYD's EV products also benefited from imitation, since many are developed based on those gasoline products¹.

BYD is an expert in imitation, it does so much imitation without patent infringement. When asked about whether BYD would be sued by Toyota for patent infringement, Yubo Lian, vice president of BYD, said:

"We have prepared for a lawsuit, and we are 100% sure that the opponents can't win."

BYD was not boasting to make that announcement. In fact, BYD is very careful and pays great attention to avoid patent infringement in its reverse innovation². BYD has a legal department of intellectual property with 200 employees. It is their duty to do research on opponent's patent barriers and keep other department informed of how to break the barriers and which technology should avoid. The way to break opponent's patent barriers is clear, to analyze the opponent's patent one by one. If a patent is expired, then just use it, if not, try to make any improvement or change based on the original patent. BYD's CEO, Wang, once said:

"Each car appearance patent has five photos – front, back, side, upward and obliquely upward. If your design is exactly the same with these five photos, it is likely to be patent infringement. However, as long as there is one photo with totally different style, even the others are exactly the same, it is not patent infringement."

Therefore, BYD can enjoyed low risk, low cost and high efficiency brought by imitation without patent infringement against opponents, which was very important for its further development.

B. Innovation practice

Though doing a lot of imitation, BYD has kept doing R&D to innovate the moment it entered automotive industry. Since it had technology accumulation in battery field, it developed its own automotive batteries and tried to combine its battery technology and automotive business. BYD showed

great enthusiasm in EV, it set up its EV department the year entering automotive industry and exhibited two EV models in the next year, when Chinese major players showed little interest in EV.

Four years later, BYD introduced Chinese first dual model EV, BYD F3DM, which could work as a battery EV and a plug-in one. F3DM is also the first lithium ion battery EV that was free of professional charging station and can be charged by home charger. In November 2012, BYD iron battery production base obtained ISO/TS16949: 2009 certification, which is the first electric vehicle battery ISO/TS16949 certification in Chinese EV industry. BYD introduced a 300km range EV, BYD e6, in 2010, while Nissan and GM's 300km range EV hasn't come to market till 2015, when BYD has increased its EV to a 400km range. These mark BYD's leading position in Chinese EV batteries.

Besides innovating in EV, BYD also innovates in traditional auto technology based on what it learned from imitation. it has developed a series of its own engines and gearboxes, which are considered as two core technologies in auto manufacture. Even many big Chinese auto manufacturers with plenty resources fail to develop their own engines and gearboxes, relying on their joint venture partners' products.

As its automotive technology accumulation grows, BYD also applies its IT technology to auto product to make competitive innovations. For example, BYD put its remote control technology into market in 2012. With nobody inside a car, the car can be started and stopped, driven backwards and forwards and turned left and right. The air conditioner can also be started for the interior to be preheated or cooled before entry. Though this technology requires the driver to be within 10 m from the car, it is perfect for squeezing into tight parking spaces, help green hands park, and make the car more comfortable when people get in. BYD also innovated smart watch key (a kind of keyless enter system), car pad (similar to the pad in Tesla), green net technology (reduce PM 2.5 in cars)³, etc. To one's surprise, these technologies can be found in a product less than USD 15000. As a comparison, not until three years later did Daimler and BMW announced their remote control technology which can only be found in much more expensive products like Mercedes E series and BMW 7 series.

Now BYD has more than 6000 people to do R&D in automotive field. Every one of its executives must be an expert in technology, no matter what kind of business he is in charge of, and Wang often asks questions requiring technological details. In recent years, BYD holds a technology illustrate conference each year to announce its latest technology. It also invites medium and users to visit its factory to make itself better understood by the public.

1. BYD's first EV is F3DM is based on F3, its EV bestsellers Qin is based on BYD Suri, and Tang is based on BYD S7. F3, Suri and S7 are all gasoline products with imitation trace.
2. In fact, BYD won a patent lawsuit against Sony in Japanese court, 2005. BYD's reverse innovation is heritage from its battery business, not invented for auto business.

3. Smart watch key is an intelligent keyless entry system, by which drivers can use their watches as keys to their cars. Car pad is similar to the pad in Tesla, but smaller. BYD's Green Net Technology can reduce PM2.5 index in a car from 500 to 12 in 5 minutes, this helps a lot in cities with air pollution.

TABLE 1 BYD'S CATCHING-UP PRACTICE

Ways of catching-up	What to catch up	When to start	Why this way	Results
Reverse innovation	Automotive technology	A year after entering automotive industry, when its first self-designed product failed	Poor technology accumulation	Produced several imitated bestsellers
Innovation	Battery technology, IT-related automotive technology	From the begin, more to follow after knowing better of automotive	Rich technology accumulation	Developed its own technology and be recognized by others

BYD catches up in automotive industry with both reverse innovation practice and innovation practice. It stopped innovating and started to do imitation after realizing it too hard to innovate with limited technology accumulation in automotive field. At the same time, it kept innovating in automotive technology related to battery where it can take advantage of its technology accumulation. With the growth of its technology accumulation, it combined both technology and make more innovations.

V. DISCUSSION AND CONCLUSION

Scholars have found that latecomer firms can catch up by both imitation and innovation. They usually increase their innovation activities gradually by continuous organizational learning and systematic improvement R&D capabilities during the imitation process [26-29]. This has been proven in East Asian cases[28, 30]. Yet less research figures out that latecomer firms can start from innovation [22]. BYD case shows that latecomer firms can start catching up process by both imitation and innovation, instead of first imitation and then innovation. When entering automotive industry, BYD lacked automotive knowledge and had to learn external knowledge by imitation, meanwhile, BYD has accumulated battery knowledge before entering automotive industry, making it possible to do innovation in EV batteries at the very beginning of its automotive business.

A notable reason for the difference between BYD's practice and existing literature lies in the assumption that a latecomer firm has little technological accumulation and is not able to do R&D work when entering a new industry, ignoring the possibility that a latecomer firm can benefit from its previous experience in other industry and starts by innovation. Another reason lies in the different domestic market size[1, 2, 6, 11]. Chinese large domestic market contributes to the success of BYD's bidirectional catching up by providing a market sensitive to price but tolerant to product quality, where BYD didn't have to start from being an OEM of world leaders, but can survive and profit by providing self-developed products with low price and decent quality.

When East Asian firms began to catch up by imitation, many start from duplicate imitation and paid limited attention to patent infringement [2, 6]. As intellectual property protection becomes more and more important, it is hard for current latecomer firms to follow the old track. BYD's experience can help other latecomer firms to learn from imitation without patent infringement. Latecomer firms should first search related patents and make the best of those

expired, then try to make improvements or changes based on those still valid, never copy those valid or do any infringement.

To conclude, this paper focuses on BYD case, a Chinese latecomer with battery background successfully catches up in automotive industry and become one of the leaders in EV market, to get a better understanding of how latecomer firms should catch up. We find that BYD catches up in a bidirectional way that it has done both innovation and imitation from the start and balance the two strategies according to its technology accumulation. Different from many previous latecomer firms ignoring patent infringement when doing imitation, BYD has paid great attention to avoid it and behave legally. This shines some light on whether latecomers should imitate or innovate at the beginning, and how to balance the two strategies. This paper also helps latecomer firms to catch up better by avoiding patent infringement.

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