INNOVATION IN THE LOCAL CONTEXT – A CASE STUDY OF BYD IN CHINA

1. Introduction

China's share of global R&D investment grew to 13% in 2011 (compared with US with 34%, Europe 23%, and Japan 12%) and reached 19% in 2014, and it surpassed the United States in 2011 in terms of patent application numbers filed through its intellectual property office (WIPO 2013). However, debates remain on the innovativeness of Chinese firms.

Out of 1.2million patents that were granted domestically in China in 2014, invention patents, which have the highest level of innovativeness in patent evaluations, only accounted for about 13%. (Data calculated from Chinese government SIPO annual patent report) In comparison, utility patents in the Unites States, which are equivalent to invention patents in China, accounted for about 90% of total patents granted in 2014 (USPTO data).

At firm level, one study on Apple's products (iPod and iphone) value-added at different stages from different vendors shows that Chinese manufacturers are only able to claim less than 2% of the entire gross margin (Dedrick, Kraemer, Linden, 2010; Dedrick 2012), which indicates a low level of technology innovativeness of those manufacturers. Meanwhile, although the number of R&D labs established in China by multinational corporations grew at an astoundingly high speed expanded over 10 times since the late 1990s, relatively low value added modules of R&D are still conducted in China to prevent intellectual property right leakage and correspond to a lack to comprehensive R&D talents in China. (Quan & Chesbrough, 2010) Some argue that most Chinese firms don't invest enough money in research (Simon, 2013).

Innovation however is not all about technology innovation. According to Schumpeter's definition, innovation is to carry out new combinations. There are five types of new combinations—production of new types of goods; introduction of the new method of production; opening of a new market; use of the new sources of raw materials and intermediate goods; and new organization of production. (Schumpeter, 1934) GM China president Kevin Wale observes that innovation in China's auto industry is more about commercialization than technical achievements. Indeed, as a recent McKinsey study pointed out, Chinese innovation is evolving in diverse ways and at an uneven pace across a range of different industries. (McKinsey Quarterly, 2012)

Scholars have been trying to understand Chinese firms' innovation, as shown in the following literature review section. However there is still no consensus reached regarding an overarching archetypal Chinese model of innovation. Due to the exploratory nature of the topic, in this paper we use a case study of a Chinese company BYD to help explore the nature of firms' innovation in China and how local context has contributed to innovation.

2. Literature review: Innovation in China

The term innovation can be interpreted differently. The common starting point for an innovation is mostly an invention plus successful commercialization (Utterback, 1971; Teece, 1986; Dewar & Dutton, 1996; Robert, 2007). A broader understanding of innovation is that any method different from traditional ones is already an innovation (Glynn, 1996). Brem (2009) states the difference between a European view of innovation and an Asian view of innovation. While the European understanding of innovation focuses mostly on the invention aspect in combination with a successful

market introduction thereafter, the Asian view is often based on modifying existing technology or product and introducing it to the market. Hence the focus of the Asian view of innovation is on the successful commercialization of an idea (independent of certain intellectual property rights). In this paper, we take the general view of innovation as in Glynn (1996) which emphasizes any method different from existing ones and we conform to the Asian view of innovation as explained by Brem (2009) focusing on the successful commercialization of an idea instead of invention at the front end. Innovation can be viewed as a main vehicle for a company to profitably enter a market and is a central force for driving competition among companies (Dosi *et al*. 1997).

Several terms have been developed and used to describe innovations originated in developing countries recently, such as frugal innovation, cost innovation, reverse innovation, Shanzhai innovation, Juggad/Gandhian innovation, resource constrained innovation, and indigenous innovation. Table 1 provides a summary of these similar but different terms.

Table 1: Describing innovation from developing countries: Terms and definitions

Type of innovation	Definition	References
Cost innovation	Leveraging developing economies' cost advantage to develop innovation at dramatically lower costs	Zeng and Williamson (2007)
Reverse innovation	Innovations adopted first in developing countries before being adopted in advanced economies	Govindarajan and Ramamurti (2011), Govindarajan and Trimble (2012)
Indigenous innovation	A process of making use of technologies transferred from the advanced economies to develop superior technologies at home	Lazonick (2004), Lu (2000)
Shanzhai innovation	Chinese low-quality, low-price imitations of foreign branded products	Peng, Xu, and Lin (2009)
Jugaad/Gandhian innovation	Innovations developed for the Indian market that responds to two Gandhian tenets: affordability and sustainability	Prahalad and Mashelkar (2010)
Frugal innovation	Innovation that has a large cost advantage, and in some cases inferior performance, compared to existing solutions, and developed in a resource-constrained context	Zeschky, Widenmayer, and Gassmann (2011)
Resource-constrained innovation	An architectural innovation and a modular design enabled minimizing costs to achieve innovation in emerging economies	Ray and Ray (2010)
Accelerated innovation	Innovation that reduces the time it takes to bring innovative products to mainstream market	Williamson and Yin (2014)

Source: Adapted from Von Zedtwitz *et al*. (2015)

Steinfeld and Beltoft (2014) believe that the China style of innovation comes from making ideas commercially viable, whether it involves product design in the semiconductor industry or novel ways of component sourcing in the wind turbine manufacturing. Erik Roth, a partner at McKinsey & Co.'s Shanghai office, also identifies the Chinese way of innovation as innovation through commercialization, and believe that Chinese firms figured out a way to dominate their markets by adapting existing technologies and business models. This echos the Asian view of innovation as described in Brem (2009).

Through interviews with 23 Chinese companies, Williamson and Yin (2014) find that Chinese companies are adopting an accelerated innovation approach, which allows them to reduce the time

it takes to bring innovative products to mainstream market. An example is Lenovo, which purchased IBM's PC business in 2005, and had since then managed to cut the new product development cycle in half to 6 to 9 months (from 12 to18 months previously). Another research on innovation by companies in China reports that there are at least eight types of innovation: cost innovation, process innovation, application innovation, supply chain innovation, product innovation, technological innovation, business model innovation, and non-customer innovation. (Yip & McKern, 2014)

Indigenous innovation has become a popular term in China especially after the Chinese government advocated using an indigenous innovation strategy to build China into an innovation-based economy. The indigenous innovation policy became explicit in 2006 in China; however discussions on indigenous innovation started earlier than that. In his book, from a historical perspective, Lu (2000) thoroughly studied four computer companies in China including Stone, Legend(now Lenovo), Founder, and Great Wall Computer, which all started with indigenous innovation with a 'top-down model of technology learning' (where firms started with product design) and later adopted vertical integration strategy to build up their manufacturing capabilities. Indigenous innovation was a key prerequisite of the top-down technology learning model there. Liu and Cheng (2011) examine China's indigenous innovation strategy from the perspective of national innovation system, involving entities such as central and regional governments, university and research institutes, state-owned enterprises (SOEs), private businesses, and research consortia. Grimes and Du (2013) discuss some dilemma between multinational corporations' R&D efforts in China and the indigenous innovation policy which are emphasized by the government. A recent paper concludes that theories on innovation in China are still scarce and calls for more focus on China's indigenous innovation capabilities (Vinig & Bossink, 2015).

However the concept of indigenous innovation, which emphasizes the source of innovation that should derive from domestic Chinese firms, is still opaque as the main characteristics of innovation remain unexamined. Much studies are still needed to research on how exactly Chinese firms innovate in the China market.

Indeed, many scholars in innovation believe that Chinese firms are mostly imitative, rather than innovative. In a special issue of Prometheus (Jun2012) which examines Chinese firms' innovation, the five research papers there argue that "Chinese indigenous innovation lacks the indigenous knowledge needed for substantive innovation, and is often no more than rhetoric." (Assimakopoulos, 2012) The case study of two technology/knowledge-based Chinese firms suggested the importance of government policy and funding support in firm performance. Specifically, it finds that both case firms are still more imitative than innovative, as "its technology had been imitated, adapted and adopted from its foreign partner". (Zheng and Wang, 2012)

On the other hand, literature on technology transfer have also provided insights on innovative capabilities of Chinese firms. For instance, Lewis (2007) has discussed the technology development strategies adopted by two wind turbine companies: India's Suzlon and China's Goldwind. While Sulzon has implemented technology licensing strategies and developed internationally based R&D capability, Goldwind has mostly focused on the Chinese domestic market with licensing arrangements with international wind turbine companies to acquire basic technical knowledge. Wang et al (2012) provides an analysis on a sample of 91 native Chinese firms in high-tech industries, showing that Chinese firms widely relies on external resources to innovate including strategies such as technology in-licensing agreements to obtain access to technologies, long-term

alliances with foreign partners to access state-of-the-art technologies, or collaboration with local universities and R&D institutes.

"Reverse Innovation" is a new term used to describe innovations that are first developed in developing countries and later emanated to advanced countries (Govindarajan & Ramamurti, 2011; Govindarajan and Trimble, 2012) That is, developing country is at the center of innovation. Von Zedtwitz *et al* (2015) expand the notion of reverse innovation by identifying three types of reversals in the global flow of innovation and associated reverse innovation, i.e. at the stage of ideation, development, and market introduction, respectively. As in this paper we focus only on innovation within China, we will not further discuss reverse innovation here.

Frugal innovation refers to products having extremely high cost advantages compared to existing solutions. They typically do not have sophisticated technological features but meet the basic needs at a low-cost level by comparably high value for the customer. (Zeschky et al, 2011; Brem, 2012) Examples of frugal innovation include Haier's mini washing machine and Galanz's low-cost energy-efficient microwave in China, Tata's Nano car in India, ad GE's portable ultrasound machine developed for use in rural Chinese areas. They are "good enough" products that meet basic needs at a low cost. (Zeschky, Widenmayer, Gassmann, 2011) Frugal innovations have also sometimes been termed as "cost innovations" (Williamson 2010) and "resource-constrained innovations" (Ray and Ray, 2010). In all these discussions, the emphasis is on low-cost which results from constraints on resources.

Despite increasing attentions given to examine how Chinese firms innovate, the main characteristics of the Chinese approach to innovation still need further research, especially that how firms innovate corresponding to local context challenges. Our paper uses a case study of BYD to examine the Chinese style of innovation in the local context in details.

3. Methodology

3.1 The case method

Whetten (1989) argues that there are two types of theories in social sciences. The first are propositional theories that involve hypotheses-testing and the second type is paradigmatic theories that are broad explanations of a phenomenon, which is a more appropriate lens of theory to be adopted in this study. Adopting an 'explanation' approach provides flexibility in construing, interpreting and gaining insight into phenomenon (Keil, 2006).

It is well accepted that "how" or "why" questions are more explanatory when using case studies, since such questions 'deal with operational links needing to be traced over time, rather than mere frequencies or incidence' (Eisenhardt , 1989; Yin, 1994). This paper hence uses an in-depth case study method to investigate how firms innovate in the China context and the case of BYD -- a Chinese domestic grown auto company-- is analyzed. The case study method allows the development of an initial theoretical understanding of the unique way of Chinese firms' innovation in the local context.

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. China became the world's largest automotive market in 2009. China's share of global auto production grew from 3.5% in 2000 to

26.4% in 2014 (OICA data), and it became the largest auto producer in the world in 2008. 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. Lastly, it is worth mentioning that BYD is not just an automotive company. It first started as a battery manufacturer, then expanded into the field of mobile phone manufacturing, then move to become a star in the automotive industry. This seemingly unique development path in fact also represents a common scene of diversification that can be observed among many Chinese firms.

The case analysis is based on eight in-depth interviews with senior managers of BYD totaling 12 hours and 31 minutes' interview time resulting 143 pages of interview transcripts (in Chinese language). Table 2 lists the details of the interviewees. The interviews were conducted by one of the co-authors and the open-ended interview questions cover broad business aspects of BYD ranging from its history, to products, to market, competition, R&D, patent protection, production line, and to human resource management strategies, all of which centered on BYD's innovation efforts.

Table 2: List of interviewees in BYD

Name	Title	Interview time	Pages in transcripts
Chuanfu Wang	Founder, President and Chairman	2 hours 12 min	pp. 1-28
Zhibing Xia	General Manager for Sales	2 hours 7 min	pp. 28-56
Huanming Liu	Director of Human Resource	40 min	pp. 56-64
Zhanghui Hang	Director of Intellectual Property	2 hours 10 min	pp. 64-86
Yizao Sun	Vice President	1 hour 45 min	pp. 86-104
Hongbo Deng	Project Manager	20 min	pp. 104-109
Nianqiang Wang	Vice President	2 hours 2 min	pp. 109-130
Qing Gong	Director of the Central Research Institute	1 hour 10 min	pp. 130-143

All interviews were transcribed, leading to a word document of 143 pages in length. The content of the transcribed data was examined and analyzed. We also triangulated our findings using multiple sources, backing up qualitative interview findings with extensive document research and company-internal information. For instance, we studied the transcript of Chuanfu Wang's announcement on the new auto product F6 and the following Q&A section in 2007, which contains information on BYD's product innovation.

3.2 Data analysis and analyzing framework

Our data analysis effort consisted of three components: (1) open coding, (2) axial coding, and (3) typologizing. These three components were derived from Strauss and Corbin's (1990) approach to

qualitative data analysis. Open coding involves a free-flow search for themes in qualitative data, which facilitates not only an empirical exploration of the emergent construct but also the typological evaluation necessary for categorizing subjects in the study. (Vandenbosch, 2006) In open coding, we specifically searched for many key words in the transcribed document relating to the central topics of discussion. As the transcribed interviews were entirely written in Chinese, we were unable to use software such as Nvivo, but instead used the 'search' functions in Word manually to try best to seek for all relevant discussions. For instance, to understand BYD's innovation, we searched the core term 'innovation', as well as other terms of 'business model' 'adaption', 'change', 'design', 'discontinuous', 'disruptive', 'evolution', 'experimentation', 'new', 'reinvention', 'rethinking', 'technology', and 'revolution', found in the transcripts, to help understand innovation in BYD from various perspectives as represented by the different department directors within BYD involved in the interviews.

Axial coding involves conceptual grouping of the themes in a theoretically meaningful manner. The objective is to identify the themes that tend to converge on a higher level abstract category (e.g. a 'meta-code'). This enhances the conceptual coherence and the internal validity of the codes. In doing this, we once again go back to the basic concept of innovation. Schumpeter (1934) points out that innovation involves both invention and the new combination of resources. Similarly, Porter argues that companies "approach innovation in its broadest sense, including both new technologies and new ways of doing things. They perceive a new basis for competing or find better means for competing in old ways. Innovation can be manifested in a new product design, a new production process, a new marketing approach, or a new way of conducting training. Much innovation is mundane and incremental, depending more on an accumulation of small insights and advances than on a single, major technological breakthrough."(Porter, 1990: p74) This paper also interprets innovation in its broad sense, including both radical innovation and incremental innovation, and various recombination of resources. Typologizing consists of associating particular theme combinations with particular groups of subjects in the sample such that a mutually exclusive set of types are created on a sound empirical basis. In Zeschky et al (2011), three factors were believed as vital for frugal innovation: low-cost manufacturing, low-cost design, and a focus on basic functionality and minimal feature sets. Hence, based on the broad understanding of innovation and Zeschky *et al* (2011), we group BYD's innovation activities into three categories: production, design, and business strategy as discussed in Section 4.

Finally, Porter (1990) pointed out that companies achieve competitive advantage through acts of innovation. In analyzing why companies based in certain nations capable of consistent innovation, he put forward the famous diamond model where four local attributes were emphasized: factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry. In this paper Section 5, we will also borrow Porter's diamond model to help analyze how BYD innovate in the local Chinese economy to gain its competitive advantage.

4. BYD: case background and its innovation

BYD, short for 'Build Your Dream', was founded in Shenzhen, Guangdong Province, in 1995. It began as a rechargeable-battery factory, competing in the Chinese market against Japanese imports. Within ten years, BYD captured more than half the world's mobile-phone battery market and became the largest Chinese manufacturer (and in the top four worldwide) of all types of rechargeable

batteries. (Fishman, 2006) BYD Auto was formed in 2003 when BYD purchased Tsinchuan Automobile Company. BYD obtained RMB 55 Billion in revenue in 2014 in total, and Figure 1 shows the contribution of each category of products to BYD's total turnover in 2013 and in 2014 respectively. BYD built on its battery expertise to produce some of China's most innovative automobiles. In 2010, BusinessWeek ranked BYD the 8th most innovative company in the world, ahead of Ford, Volkswagen and BMW. (Einhorn and Arndt, 2010)

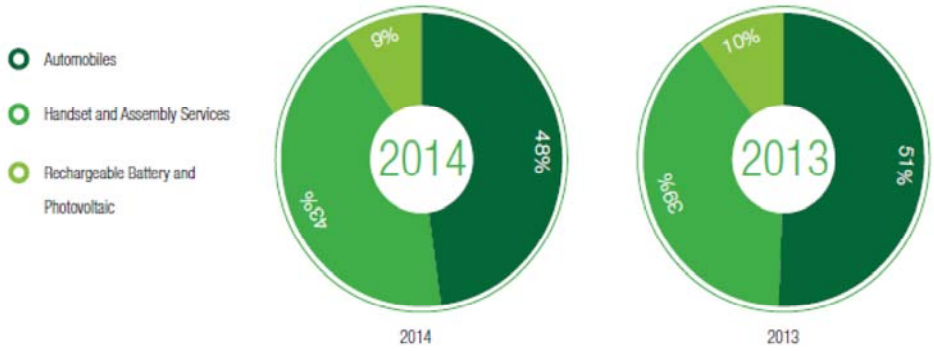

Fig. 1. BYD turnover breakdown by product categories
Source: BYD Company Limited Annual Report 2014.

4.1. Innovative design of vehicles

BYD Auto had made cars for only seven years when its F3 compact model became the top-selling car in China. The F3 model led China's compact car segment in November 2008 with sales of more than 17,000 units, an increase of 92% over November 2007. In 2009, BYD sold 440,000 vehicles. (Automotive News, 2010) The success of the model in a large part comes from the innovative design of the vehicle.

As the Chinese society emphasize the importance of face ('mianzi' in Chinese) in its social value and relations (Hwang, 1987), the concept of face also needs to be embedded in the products. This helps shape the design of BYD's F3 auto model. According to Chuanfu Wang, the founder and Chairman of BYD, "In China, besides moving people around, an important function of an automobile is to show face, (or status and prestige,) of the car owner. So the design of the car should be decent and show some grandiosity. In the west, people drive cars by themselves, and there is usually just one person in the car - the driver. But in China, typically you carry your whole family or several friends or colleagues in your car, and important people usually sit in the back seat. Therefore the back seat needs to be very spacious. That's how BYD designs its models. The exterior look of the F3 model is decent, and it's very spacious inside, especially for people sitting in the back seat." (Interview) The F3 model is targeted as family entry level car in China. BYD's later auto models such as F6, F8, and F3R have also followed the same design concept.

Furthermore, recognizing that the Chinese consumers are very price sensitive, Chairman Wang emphasized, "The price of the car must be cheap. Our average household income is still low, compared with many developed countries. So, we set our price for the F3 model in the range of several ten thousands RMB. For about ¥70,000 RMB (roughly $10,000 USD at the time), you'll be

able to get a very spacious car with much high quality electronics equipment in the car, and a car body length of 4.5 meters."(Interview) BYD is going to mass produce the world's cheapest automobile and bring inexpensive motoring to the masses in China. BYD's cars have been priced from ¥30,000 RMB (about $4,400) to ¥100,000RMB (about $14,600), which includes their product lines from mini cars to large sedans. (China Car Times, 2010) Furthermore, BYD Auto has marched further to the electric car market. Since its release of the model Qin in 2014, it has been dominating the electric car market in China. (See Figure 2)

Model	Jun 2015	YTD	June 2015 Market Share	2015 Market Share
BAIC E-Series EV	1506	5803	15%	13%
BYD e6	505	2900	5%	7%
BYD Qin	4015	16477	40%	37%
Chery eQ	476	2129	5%	5%
Chery QQ EV*	550	3248	5%	7%
Geely-Kandi Panda EV	824	2547	8%	6%
Tesla Model S*	150	2042	1%	5%
Zotye Cloud / Z100 EV	1214	4347	12%	10%
Zotye E20	776	4913	8%	11%
Others	1207	6041	12%	14%
Total	10016	44406	100%	100%

Figure 2: China electric car registrations
Source: EVObsession.com

4.2 ***Innovative way of production***

BYD's battery products has clearly demonstrated its innovative way of production. BYD managed to slash the price of batteries by replacing robots and machines in the manufacturing process with an army of low cost workers. As Chairman Wang stated, "for electric cars, the key is in the battery technology, which is also our great competitive advantage." (Interview)

Let us examine BYD's battery production from a historical perspective. When BYD was founded in the mid-1990s, the battery market in China was already large. About 90% of the batteries were imported from Japan, at extremely high prices. As a chemist and material scientist, Chuanfu Wang decided to start the firm BYD to produce batteries. At that time, a fully automated production line for lithium-ion rechargeable batteries cost at least $100 million USD, which was beyond imagination for the young entrepreneur. "In order to achieve our goal (of making lithium-ion batteries), we had to design our own production line then. We spent a lot of time and efforts to research the battery product and its production line. At the end, it cost us about 20 million RMB (less than $3 million USD) to build a semi-automated production line, with similar capacity of production (to the fully automated $100 million facility). For the semi-automated line, we needed a lot of workers. Since labor costs were very low, it helped us dramatically lower our overall costs. In 1998, we could sell one lithium-ion battery at $3 USD, while Japanese firms asked for $8 USD for a similar battery. With a $3 selling price, we still had about 60% gross margin for each battery. So we became very competitive then." (Interview)

BYD was the first Chinese company that was able to make lithium-ion battery. The production method invented by BYD helped lower the entry barrier for many local firms, in terms of capital requirements. The company also automatically became a training base for talents in the battery industry. Due to the high employee turnover rate in China, many employees left BYD and started their own battery manufacturing. As a result, there are about 100 lithium-ion battery manufacturers now in China, and the price of battery has dropped dramatically.

4.3. BYD's Innovative Vertical Integration Strategy

BYD implements a strategy of vertical integration, unlike many firms in established industries in the developed world. In a relatively mature market for a complicated product, typically a firm collaborates with many specialized suppliers to increase efficiency and focus its own resources on the few important elements that form their core competency, and which maximize their value creation. However, in the case of BYD, vertical integration was adopted.

BYD's vertical integration dated back to its battery production. According to Nianqiang Wang, VP of BYD, "after we mastered the core technology [of battery], we started to integrate back to the raw materials and many components … The biggest advantage [of this backward integration] is cost. We were able to lower the cost of the batteries." (Interview)

Later on vertical integration was adopted to its mobile phone manufacturing in 2003, when BYD undertook a task on mobile phones for Siemens. At that time, a common pattern for mobile phone manufacturing was for a multinational corporation from developed countries such as US or Germany to create a design for the entire mobile phone, and also for many components of the handset. Local firms in China then started to manufacture these components based on the blueprints and specifications provided. "Each component supplier is usually allowed a small range of deviation from the original design parameters. There are over a hundred components for a mobile phone. When Siemens finally received all components from its suppliers, it found the phone was not able to function." says Ms. Qing Gong, the R&D Director of BYD. "Later, we found that the deviations were responsible for the problem. Even though each supplier was well within the allowable degree of deviation, the cumulative effect made the product unable to work." (Interview) BYD then proposed to take over manufacturing and assembly of all the components of the mobile phone, and promised a complete functioning product for Siemens. BYD's vertical integration strategy worked, and the same idea was later applied to its other customers such as Nokia and Motorola.

The experience of vertical integration in mobile phone manufacturing laid a foundation for BYD's auto manufacturing business model. "Most of the components of the automobile are done by us as well. We analyze all components at three different levels, and decide which components and their following integration may become bottleneck for the final product. We will research on that area first and solve potential integration problems. Through this method, we shortened our development cycle and lowered the overall costs." (Interview with Qing Gong, R&D Director) The difficulties of integrating poorly specialized supply chain partners make vertical integration attractive in China's markets.

5. The China context for BYD's innovation

BYD's innovation regarding its product design, production method, and vertical integration strategy as discussed above has illustrated the firm's capability to adapt to the local context. Let's now further understand how the contextual factors contributed to BYD's innovation applying Porter's diamond model (1990).

5.1 Demand conditions

The substantial and rising number of people in the middle class with its growing income is transforming the Chinese consumer market. In 2006, the proportion of private consumption in China's total GDP was 38.0%, well below the world's average of 59.2%. The expansion of the middle class will help boost the role of private consumption in the Chinese economy, turning it into

a key driver of economic growth. (Hodgson, 2007) A Chinese Academy of Social Sciences (CASS) study found 19% of Chinese were middle class in 2003, up from 15% at the end of 1999. This definition includes any household with assets worth $18,000 to $36,000. (BBC News, 2004) Estimation from CNNMoney in 2012 put the number of the middle class in China at about 300million, which is about 25% of the population[1]. A recent McKinsey study (Barton, Chen, and Jin, 2013) shows that more than 75 percent of China's urban consumers will earn RMB 60,000 to 229,000 ($9,000 to $34,000) a year by 2022.

Fast economic growth is a stunning fact of China with which few countries in the world can compare. China has maintained an average annual GDP growth of 8.1 percent over the past sixty years, according to China Daily (June 30, 2010). The per capita gross national income hit $2,770 in 2008, entering the lower-middle-income country bracket. While housing in big cities and luxury products in China are incredibly expensive for the local citizens, expenditures for daily necessities for the majority of Chinese consumers are still very low. This explains why attempting to become the supplier with the lowest price is still a viable competitive strategy in the China market, despite the fast growing economy and fledgling middle class.

For many decades, Chinese consumers have followed the tastes of the developed countries, especially for high technology products that originated in the west. However, with the growing purchasing power of the middle class and of the government, the Chinese market has increasingly become essential for transnational firms. China has become the world's biggest auto market, surpassing the U.S. In 2009, total sales in China surged 46 percent to 13.46 million vehicles. In the first quarter of 2010, sales jumped 72 percent to 4.61 million. China's tastes have now begun to influence the appearance and functions of some global products. For instance, General Motors design group frequently considers the "C-Factor", a term referring to China's impact on American styling, according to GM global design chief, Ed Welburn. The latest design for Buick is influenced by "jade sculpture, calligraphy and a lot of the art dating back centuries", said Welburn in an interview at the Beijing auto show in April 2010 (Greimel, 2010). Even at the high end, more and more research and development activities by multinational corporations in China are focused on global markets. (Quan and Chesbrough, 2010) This suggests that demand from China needs to be carefully studied and considered by firms looking for growth in this huge market. BYD's clear understanding and insight of the local consumers and local culture was illustrated in its design of the car model, and the low pricing strategy fit well with the demand thus helping it gain competitive advantage. .

5.2 Factor conditions: The supply factor – LC-HS labor

Low cost labor has contributed significantly to China's fast economic growth in the past few decades. Much has been discussed in literature about the immigrant workers from rural area who form the majority of the low cost manufacturing force across many industries, a deep pool of potentially 800 to 900 million workers, albeit decreasing in the recent years. There has also been abundant supply of Low Cost - Highly Skilled (LC-HS) labor in China, due to expansion of higher education over the past two decades. The LC-HS labor contributed significantly to the fast growth of many companies in China including BYD.

Higher education in China has experienced a huge surge since 1998. Tertiary student enrollment did not reach one million until 1997. In the decade that followed it expanded to 5.4 million by 2006. The annual growth rate was 22.2 percent during the 1998-2006 period, compared to 4.4 percent from 1985-1998. However, the job market did not expand as quickly as higher education, resulting

[1] http://money.cnn.com/2012/04/25/news/economy/china-middle-class/index.htm

in the overwhelming phenomenon of "educated unemployment" in China. From 2003 to 2005, unemployed bachelor degree holders at the point of leaving the university increased from 750,000 to 1.2 million. In 2004, there were 990,000 unemployed general degree holders, accounting for 41 percent of the total 2.4 million graduates. The problem worsened in 2009 when 2.0 million of the 6.3 million degree holders could not find jobs upon graduation[2]. As a result, many young people face the problem of unemployment immediately after graduation and those who were fortunate enough to get hired became part of the low cost but highly skilled labor force in the Chinese economy due to overly abundant reserves there. The tremendous surge in the numbers of graduates from Chinese Universities, hence the consistent improvement in the quality of Chinese post-secondary education contribute to a rich and deep supply of talent in China, which have been fundamental to China's economic development.

Formed in 1995, BYD was able to quickly take advantage of the low cost labor in China—both high-skilled and low-skilled labor. BYD's employee had experienced exponential growth since 1998. According to Mr. Liu, Director of Human Resource, "When I joined BYD in 1997, there were only a few hundred employees. In 1998, the number of employees increased to 3,000. It reached 10,000 around 1999. In 2004 we had over 30,000 employees, and grew to 50,000 in 2005, and 100,000 employees in 2007". The Human Resource Director believed it was not hard to hire good people since lots of university graduates could not find jobs. "In 2007, we hired more than 4500 fresh university graduates… we like to go to those best universities to recruit because we want first-class employees working for BYD. Although fresh graduates had no working experience, they are smart and intelligent, and can be great talent reserve for BYD's future development." Workers on the floor have lower education levels, and it was very easy and inexpensive to find enough of them at that time. (Interview) Indeed, the availability of low cost labor made it possible for BYD to implement to its innovative production strategy of using an army of labor to replace capital-intensive robots for its battery production. The big number of low-paid scientists and technicians focus on small improvements to products, which can potentially create huge value for BYD. Later on, the development and manufacturing of cars at BYD also relied heavily on jigs—tools invented at BYD that help control quality while replacing robots with labor.

Many of the LC-HS workers have strong learning capability. Their diligent and hard-working attitude contributes significantly to many firms' growth. However a high employee turnover rate can also be observed in many industries. In fact China's staff turnover rate was the highest in Asia, more than twice that of Japan, according to a Youth Daily report. (People's Daily online, Jan 2008) Across all industries, 47 percent of companies surveyed had turnover rates of more than 10 percent in the past 12 months, and 13 percent said that the rate was more than 20 percent. Unsatisfactory compensation and limited career progression were blamed for China's high turnover level. And fast learning capability and an entrepreneurial mindset of the LC-HS workers also propelled the high turnover rate. As mentioned earlier, BYD became a training base for talents in the battery industry, and many employees left BYD to start their own battery manufacturing in late 1990s and early 2000s. At BYD later on, in order to retain high skilled workers, BYD started to provide various benefits to employees such as offering stocks, low cost housing, childcare programs, and even providing private middles school education for employees' children requiring very low tuition fees (at about only 10% of what they charge non-BYD affiliated students). (Data source, Interview with Mr. Liu)

5.3 Local industrial environment and business strategy

[2] http://www.womenofchina.cn/Issues/Employment/217122.jsp

China are characterized by fast changing and volatile business environments (Sutcliffe & Zaheer, 1998; Li, Poppo, & Zhou, 2008) During BYD's initial years of development (1995-2000), relevant industries were at the beginning of the industry life cycle in China. That created huge amount of opportunities due to uncertainties in the China market such as the design or functions or price that end users will prefer, the distributions channels that will be most effective, and the players that may dominate the market. When BYD entered the battery industry, Japanese firms like Sanyo and Sony dominated the markets. Local Chinese competitors mostly were those supplying nickel batteries to toy industries, with inconsistent product quality. Focusing on improving product quality while keeping low prices, BYD quickly investigated the potential of newer technologies, particularly Li-ion batteries. Without knowing the chemical formula or process of producing Li-ion battery, the BYD R&D team delved into available patents information and utilized trial-and-error strategies to come up with making Li-ion batteries themselves. This trial-and-error later greatly contributed to BYD's innovative production methods. For instance, instead of relying on expensive humidity-control dry room to make Li-ion batteries as Sanyo did, BYD used different chemical formula which avoided the problem of humidity. As a result, although the final steps of battery formation needed still needed dry rooms, BYD overall might have only one tenth of the dry-room space comparing with Sanyo, according to Chuanfu Wang's estimate. Lack of information about their Japanese competitors' manufacturing process in fact contributed to BYD's innovation in its Li-ion battery production.

> As Wang recalled, "We noticed early on that humidity was harmful to the performance of battery and, at that time, we did not know that the Japanese relied so heavily on dry rooms to solve this problem. We realized that trying to build a large dry room would be very expensive, however, we focused on changing the product materials to make them less sensitive to humidity. As a result, we have much smaller dry room than our competitors. If we had known how much dry-room space they actually had, we might have been content just to model our process after theirs."

BYD was strategically agile in catching opportunities emerging in the China market. On the one hand, BYD identified its initial opportunities in the battery market which at the time was dominated by big Japanese players such as Sanyo. Understanding the low cost driven mentality of Chinese consumers, BYD marched bluntly into the battery market and figured out ways to produce competitive battery products at much lower costs. On the other hand, BYD moved quickly to the strategically related industries like handset manufacturing and automobile manufacturing in a timely manner to explore the huge unchartered market place. Both its handset segment and automobile manufacturing can rely heavily on BYD's strong competitive advantage in battery production. As Chairman Chuanfu Wang stated, "I set a goal for myself to have the company grow 100% every year." "I want to grow BYD big and fast. If BYD focused only on battery, the market size at most was a few hundred millions RMB; focusing on the mobile phone component business, market size for BYD can be at most a few billions RMB; by marching into the auto industry, we can grow our market size into tens of billions."(Interview) This strategic diversification is a response from Chinese innovative firms like BYD to the unique China context which is characterized by big uncertainty and vast business opportunities.

Meanwhile, the industry environment in China at the time lacked specialized suppliers in the market that firms like BYD can collaborate with. This helped lead to BYD's vertical integration strategy due to the nonexistence of a complete spectrum of specialist suppliers, or incapability of suppliers to provide as high quality components as customers need. BYD's vertical integration in mobile phone manufacturing as discussed earlier well illustrated the issue. The concept of vertical integration was first proposed for its customer Siemens, then applied to Nokia and Motorola. According to Qing Gong, the Director of BYD's Central Research Institute, "[with vertical

integration,] we were able to save our customers 20%-30% of their manufacturing costs, which they used to spend on communications with various suppliers." (Interview)

6. Further theoretical discussions

6.1 Is BYD's innovation best categorized as frugal innovation, cost innovation, or something else?

Zeschky *et al* (2014) differentiated three types of innovations: cost innovation, good-enough innovation, and frugal innovation. Based on the two dimensions of technology and market, they define cost innovation as those solutions or products that scored low on both the market and technical novelty dimensions, good-enough innovations as those scored low to medium on both dimensions, and frugal innovations as those scored medium to high on both dimensions.

Although it provides insightful understanding of the similar terms of innovation, the differentiation among cost innovation, good-enough innovation and frugal innovation in Zeschky et al (2014)'s definitions is still a bit blurry since it may be hard to define when the technology or market novelty level is low or medium, medium or high. For instance, GE's portable ultrasound device, developed for use in rural areas in China, is considered as frugal innovation with high novelty in both market and technology dimensions. However, incorporating only basic features of traditional ultrasound machines with huge price deduction might be a bit hard to justify its technology novelty.

Considering lacking of consensus in the various terms as mentioned above, in this paper, we would like to emphasize the resource-constraining aspect of innovation, which in fact derives from local context. We would go with the broader understanding of "frugal innovation" which are "used to denote innovations specially developed for resources-constrained consumers in emerging markets"(Zeschky, Widenmayer and Gassmann, 2014, 2011). However, resource-constrains should not be limited only to consumers. Sharma & Lyer (2012) emphasized resource-constrained product development from the producers' perspective. "..[R]esource-constrained product development is driven by resource scarcity and/or the motivation to use the least possible resources in developing products that find an acceptable fit with the market. We define resource-constrained product development (RCPD) as the process of developing new products that use minimal resources and are affordable to a broader market. The overriding tenet of RCPD is the development of a new product at the lowest possible cost." (Sharma & Iyer, 2012: 600) Ray and Ray (2010) stated, through their case study of an Indian company, that the key elements of the resource-constrained innovation model include "lowering costs of R&D by drawing on existing core technologies and modularity in design, eliminating unnecessary functionalities, leveraging local talent, deploying labor-intensive and capital-sensitive processes throughout the value chain, and striking linkages with local partners to create an ecosystem of entrepreneurs to ensure a low-cost local supply chain."(p151) In our discussions, the emphasis is on low-cost which results from constraints on resources. We do not find any architectural innovation in our case of BYD, which is different from Ray and Ray's (2010) findings.

In Zeschky et al (2011), three factors were believed as vital for frugal innovation: low-cost manufacturing, low-cost materials and design, and a focus on basic functionality and minimal feature sets. Our case study supports the aspects of low-cost manufacturing and low-cost design. However, BYD's frugal innovations are not just a focus on basic or minimal feature, rather, they were designed for local demand. For instance, the design of BYD's F3 car provides spacious room for people sitting in the back row. Thus, our BYD case emphasizes the importance of contextual dimension of frugal innovation which leads to low-cost manufacturing, low-cost design and local tastes.

Overall, we find from our case that resource constraints is the vital factor in determining the characteristics of innovation in China. Resources constraints can come from both production perspective and consumers' perspective. Furthermore, the presence of resources highly relies on local context. Existing research have not emphasized that frugal innovation shall be context-based other than stating it originates from emerging markets. We believe that analysis of local context is essential in understanding low-cost innovation and the resource constraints. We borrow Porter's model as a good framework to start with for the context analysis. It is worth to mentioning that abundance of certain local resources may complement constraints in another resource. In our case, abundance of labor in China at the early stage of BYD's development acted as a key factor complementing the capital constraints.

6.2 Applying Porter's model

Our case study of BYD examined in details how the firm succeeded in innovating in the local context. Applying Porter's model (1990), we discussed the important factors in the local context that contributed to its innovation such as demand from the growing middle class in China, low cost – highly skilled (LC-HS) labor, the local industrial environment, and the business strategies. The main goals of BYD's innovation centered on low cost and customer satisfaction. We have observed its innovative product design to meet local taste, its innovative way of production, and the strategy of vertical integration in its products. Figure 3 uses a framework to illustrate our analysis.

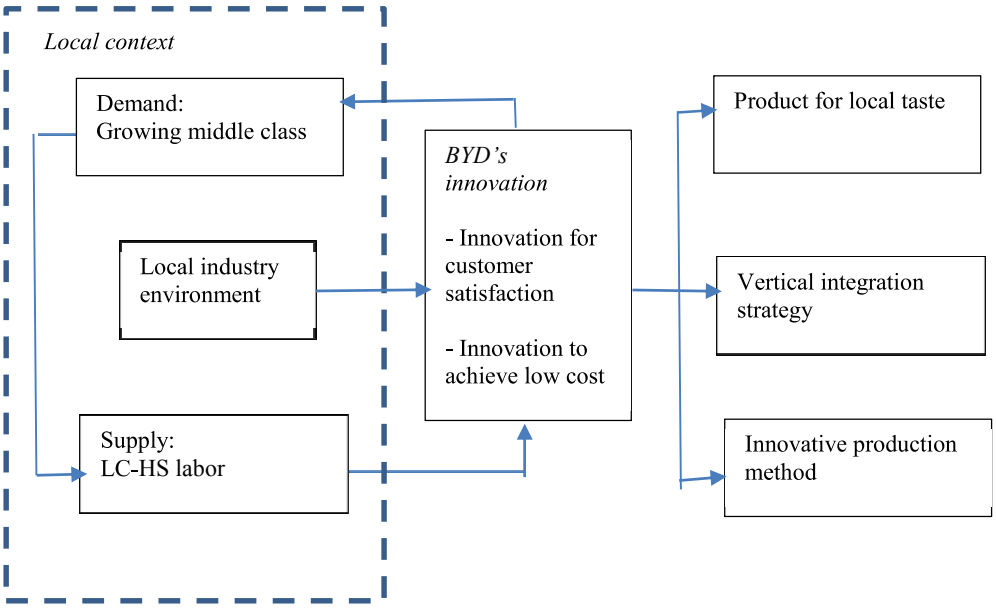

Figure 3. BYD's innovation in the local context

Our research find that BYD's innovation focused on BYD's goal to achieve low costs as illustrated in its innovative production method and design for price sensitive customers. And that way they have become agile in responding to market need. As Nahm and Steinfeld (2014) pointed out, much existing literature on China's distinct forms of innovation emphasize not on upstream

research and development (R&D) or new-to-the-world invention, but instead on downstream efforts involving both the redefinition of existing technologies and the commercialization of new ones (Breznitz & Murphee, 2011; Ernst & Naughton, 2008, 2012; Ge & Fujimoto, 2004; Brem, 2009; McKinsey Quarterly, 2012; Thun & Brandt, 2010).

In this paper we have only discussed those important local contextual factors as we see essential contributing to BYD's innovation. There may still be other factors that remain to be examined. A comprehensive literature review paper (Yang, Liu, Gao, & Li, 2012) summarizes research on technological innovation in China, where the authors conclude research from three perspectives including external factors, internal factors, and interfirm cooperation factors. For external factors, three elements—government, culture, and market and competition were emphasized there. For our study of BYD, we focus on the local context from a supply and demand perspective and also industry environment, borrowing from Porter's diamond model (1990). Although the role of government was crucial for the early development of many industries in China such as computer industry (Lu, 2000) and software industry (Quan, 2008), it was not the case for BYD, which emerged purely as a private firm. With China's continuing economic reform, less and less government intervention can be observed for business development, especially in the private sector.

When applying Porter's model, we have found some distinctive features of BYD's case. Where Japanese firms relied heavily on capital, BYD used abundant low-cost labor in the domestic market to offset the disadvantage of lack of capital. This validates Porter's argument that "selective disadvantages in the more basic factors can prod a company to innovate and upgrade—a disadvantage in a static model of completion can become an advantage in a dynamic one".

According to Porter, "A nation's companies gain competitive advantage if domestic buyers are the world's most sophisticated and demanding buyers for the product or service.", because "home demand gives their companies a clearer or earlier picture of emerging buyer needs, and where demanding buyers pressure companies to innovate faster and achieve more sophisticated competitive advantages than their foreign rivals."(p79) However, the BYD case showed a different picture, where Chinese consumers were in-fact less demanding in innovative features of a product. In comparison, producing with low-costs is more desirable by the Chinese consumers. And this is generally true for emerging economies; which is different from advanced countries where companies compete based on innovation in the front end. The case of BYD suggests that a deep understanding of characteristics of local demand is more important than being pressured to innovate faster and provide sophisticated products to consumers.

In Porter (1990), regional differences within a nation was not discussed. We acknowledge that China is a huge country, and different regions can demonstrate very different attributes. For our analysis of BYD here, we use the term 'local' to refer to the Southeast China regional environment from which BYD emerged. It's worth pointing out that in mid-1990s labor costs in China were still low in most of the regions/provinces in China, and there was in general not big difference in demand conditions across China due to the low income level on average. However, Shenzhen, where BYD started, was a more economically advanced region at the time with supporting industries relatively well developed. Specifically, Shenzhen's GDP was ranked No. 8 in 1995 and 1996 national wide, improved as No. 5 in 2000, and had since maintained that rank for the first decade in the twenty-first century. (Source: data compiled from various official statistics sources) BYD was able to take some advantage of the economic advancement such as customers with relatively large disposable income and abundant high-skill but low-cost labors who moved to the Shenzhen area from all over countries for job opportunities. Today, low cost labor is becoming less of an advantage in China especially in rich cities and regions such as Shenzhen. Firms therefore have recently started to rely more on capital (as reflected in the increasing number of robots) instead of labor to maintain their competitive advantage (Whelan & Fung, 2016).

Our research is limited as a single case study. We plan to examine more in-depth cases from China as next step to help strengthen our theoretical building. It is also limited in the data accessibility in general for case studies. Since it is in general extremely hard to obtain extensive first-hand data like we have had in China, we believe our data are valuable, especially when we try to understand BYD's innovation from a historical perspective. We expect our findings on innovation practices from BYD can be extended to many other firms in China. For instance, Williamson and Yin (2014) also state that a number of Chinese firms use the approach of "dividing the innovation process into a large number of small steps and then assign teams to work on each stage". The goal is for this "assembly line" to accelerate the process and deliver results quickly (p28). They studied Chinese companies such as WuXi AppTec, a pharmaceutical, biopharmaceutical and medical-device outsourcing company, and their finding is similar to BYD's innovative production method as we discussed earlier. BYD's model of innovation may be further applied to other emerging countries where resources are also constrained. The model may not work across all Asian emerging markets since some companies such as those in India have been engaged in more technological innovation (Ray and Ray, 2010, 2011). However, our case can provide meaningful lenses examining the Chinese way of innovation especially before capital is becoming an abundant resource.

7. Conclusion

In this paper we have used the case of BYD to examine firm innovation in the China context. From a historical perspective, with its strategic diversification from battery to mobile phone manufacturing to automobile manufacturing, we find that BYD has been innovative in its production method, vertical integration strategy, and design of product for local customers. It confirms the feature of frugal innovation that originates from resource constraints. Furthermore, we emphasizes the local context analysis for frugal innovation. We borrowed Porter's model (1990) to help analyzing the local contextual factors including supply of labor (especially Low Cost-Highly Skilled labor), growing middle class, and local industry environments that have played important roles for BYD's innovation. For instance, BYD has disseminated the assemble line, and well taken advantage of the abundant supply of labor in China by using an army of labor and jigs to replace robot arms in its battery production.

We believe that a full understanding of the differences between the Chinese local context and the mature market in the western countries is a necessary condition for firms' innovation and success in China. Much work remains to be done to test, refine, and expand our arguments. China presents both challenge and opportunity for this generation of business leaders in the world, and is also the testing ground for this generation of business scholars.

References

1. Assimakopoulos, D. (2012) Innovation in China. *Prometheus*. 30(2): 153-154.
2. . New Haven, CT: Yale University Press.
3. Barton, D., Chen,Y, and Jin, A. (2013). Mapping China's middle class. *McKinsey Quarterly*. June. Accessed online at McKinsey China website. http://www.mckinseychina.com/mapping-chinasmiddle/
4. *BBC news* (2004). China's middle class growing fast. March 30. Accessed online. http://news.bbc.co.uk/2/hi/business/3582015.stm
5. Brem, A. (2009) The term innovation and its front end-Is there a specific Asian view?. In *The China Information Technology Handbook*. Springer US: 1-12.
6. Brem, A. (2012) Learning from failure: Case insights into a UK-India technology transfer project. In Technology Transfer in a Global Economy. Audretsch, D.B., Lehmann, E.E., Link, A.N., Starnecker, A. (Eds.). Springer US: 253-275.
7. Breznitz, D., & Murphee, M. (2011). *Run of the red queen: Government, innovation, globalization and economic growth in China*
8. *China Car Times* (2010). BYD to take fight into JV segment. June 1. Accessed online at http://www.chinacartimes.com/2010/06/01/byd-to-take-fight-into-jv-segment/.
9. Dedrick, J. (2012). Who Profits from Innovation in Global Value Chains? iPhones and Windmills. Accessed online on May 12th, 2013. http://www.usitc.gov/research_and_analysis/documents/Dedrick_USITC_3-21-12.pdf
10. Dedrick, J., Kraemer, K., Linden, G., (2010). Who profits from innovation in global value chains?: a study of the iPod and notebook PCs. *Industrial and Corporate Change*, 19 (1): 81–116.
11. Dewar, RD and Dutton, JE. (1986). The Adoption of Radical and Incremental Innovations: An Empirical Analysis. Management Science, 32 (11): 1422-1433.
12. Dosi, G., Malerba, F., Marsili, O. and Orsenigo, L. (1997). Industrial Structures and Dynamics: Evidence, Interpretations and Puzzles. *Industrial and Corporate Change*, 6: 3–24.
13. Einhorn, B. and Arndt, M. (2010) The 50 Most Innovative Companies 2010. *BusinessWeek*. April 15th. Accessed online.
14. Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review* 14(4): 532-550.
15. Ernst, D., & Naughton, B. (2008). China's emerging industrial economy: Insights from the IT industry. In C. A. McNally (Ed.), *China's emergent political economy*. New York, NY: Routledge.
16. Ernst, D., & Naughton, B. (2012). Global technology sourcing and China's integrated circuit design industry: A conceptual framework and preliminary research findings. In East–West center working papers, economics series. Honolulu, HI: East-West Center.
17. Fishman, T. (2006). *China, Inc.: How the Rise of the Next Superpower Challenges America and the World*. Simon & Schuster. New York.
18. Ge, D., & Fujimoto, T. (2004). Quasi-open product architecture and technological lock-in: An exploratory study on the Chinese motorcycle industry. *Annals of Business Administrative Science*, 3(2), 15–24.
19. Glynn, MA (1996). Innovative genius: A framework for relating individual and organizational intelligences to innovation. *Academy of Management Review*, 21 (4): 1081-1111.

20. Govindarajan, V., and R. Ramamurti. (2011). Reverse innovation, emerging markets, and global strategy. *Global Strategy Journal* 1 (3–4): 191– 205.
21. Govindarajan, V., and C. Trimble. (2012). *Reverse innovation: Create far from home, win everywhere*. Boston: Harvard Business Review Press.
22. Greimel, H. (2010). China's tastes now dictate global products. *Automotive News*, May 3.
23. Grimes, S and Du, D. (2013). Foreign and Indigenous Innovation in China: Some Evidence from Shanghai. *European Planning Studies*. Sep2013, 21 (9): 1357-1373.
24. Huang, Y. (2010). Debating China's economic growth: The Beijing Consensus or the Washington Consensus. *The Academy of Management Perspectives*, **24**, 2: 31-47.
25. Hwang, K. (1987). Face and favor: The Chinese power game". *The American Journal of Sociology*, **92**, 4: 944-974.
26. Hodgson, A. (2007). China's middle class reaches 80 million. *Euromonitor International*. Jul 25.
27. Lazonick, W. (2004). Indigenous innovation and economic development: Lessons from China's leap into the information age. *Industry and Innovation* 11 (4): 273–97.
28. Lewis, J. (2007) Technology acquisition and innovation in the developing world: Wind turbine development in China and India. *Studies in Comparative International Development*, 42(3-4), 208-232. Springer US.
29. Li, J, Poppo, L, Zhou, Z (2008). Do managerial ties in China always produce value? Competition, uncertainty, and domestic vs foreign firms. *Strategic Management Journal* 29 (4): 383-400.
30. Liu, X, and Cheng, P. (2011). Is China's Indigenous Innovation Strategy Compatible with Globalization? *Policy Studies* (61), p1-74.
31. London, T., and Hart, SL. (2004). Reinventing strategies for emerging markets: Beyond the transnational model. *Journal of International Business Studies* 35 (5): 350–70.
32. Lu, Q. (2000). *China's Leap into the Information Age: Innovation and Organization in the Computer Industry*. Oxford: Oxford University Press.
33. McGahn, A. (2004). How industries change. *Harvard Business Review*, **82**, 10 : 86-94.
34. *McKinsey Quarterly* (2012). Three snapshots of Chinese innovation. Feb 2012.
35. Nahm, J., STEINFELD, E. (2014) Scale-up Nation: China's Specialization in Innovative Manufacturing. *World Development*. 54: 288–300.
36. Peng, SZ., Xu, YF., and Lin, XQ. (2009). *The Great Revolution of Shanzhai Economy: The Innovation Comes from Imitation*. Taipei: Showwe Information Co., Ltd.
37. Prahalad, CK. (2004).*The Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits*. Upper Saddle River, NJ: Pearson Education.
38. Prahalad, CK., and Mashelkar, RA. (2010). Innovation's holy grail. *Harvard Business Review* 88 (7–8): 132–41.
39. Quan, X. (2008). The government's multirole and a resulting importance of guanxi in the Chinese software industry. *International Journal of Technology Marketing*, **3**, 3: 258–275.
40. Quan, X. and Chesbrough, H. (2010). Hierarchical segmentation of R&D process and intellectual property protection: Evidence from multinational R&D labs in China. *IEEE Transactions on Engineering Management*, **57**, 1: 9-21.
41. Ray, PK, & Ray, S. (2010). Resource-constrained innovation for emerging economies: the case of the Indian telecommunications industry. IEEE Transaction on Engineering Management, 57(1), 144–156
42. Ray, S., and P. K. Ray. 2011. Product innovation for the people's car in an emerging economy. Technovation 31 (5–6): 216–27.
43. Roberts, EB. (2007). Managing invention and innovation. *Research Technology Management*, 50 (1): 35-54.

44. Schumpeter, J. (1934). The theory of economic development- An inquiry into profits, capital, credit, interest and the business cycle. New Brunswick (U.S.A) and London (U.K.): Transaction Publishers.
45. Shama, A., and Iyer, G.R. 2012. Resource-constrained product development: Implications for green marketing and green supply chains. *Industrial Marketing Management* 41(4): 599-608.
46. Simon, D. (2013). China's Innovation Gap. *Mechanical Engineering*, January: 35-39.
47. Steinfeld, E. and Beltoft, T. 2014. Innovation lessons from China. MIT Sloan Management Review. 55(4). Summer 2014. Pp49-55.
48. Sutcliffe, K. and Zaheer, A (1998).Uncertainty in the transaction environment: an empirical test. *Strategic Management Journal.* 19(1): 1-23.
49. Teece, DJ. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15: 285-305.
50. Thun, E., & Brandt, L. (2010). The fight for the middle: Upgrading, competition, and industrial development in China. *World Development*, 38(11), 1555–1574.
51. Utterback, JM. (1971). The process of technological innovation within the firm. *Academy of Management Journal*, 14 (1): 75-88.
52. Vandenbosch, B. 2006. Idea management: A systemic view. *Journal of management studies*. 43(2): 259-288.
53. Vinig, T and Bossink, B. (2015). China's indigenous innovation approach: the emergence of Chinese innovation theory? *Technology Analysis & Strategic Management*. Jul2015, 27 (6): 621-627.
54. Von Zedtwitz, M., Corsi, S., Søberg, PV., & Frega, R. (2015). A typology of reverse innovation. *Journal of Product Innovation Management*, 32(1): 12–28.
55. Wang, Y, Roijakkers, N, Vanhaverbeke, W, & Chen, J. (2012) How Chinese firms employ open innovation to strengthen their innovative performance. *International Journal of Technology Management*. 59 (3/4): p235-254.
56. Whelan, R. & Fung, E. 2016. China's factories count on robots as workforce shrinks. *Wall Street Journal*. Aug 16th 2016.
57. Williamson, P. and Yin, E. (2014). Accelerated innovation: The new challenge from China. *MIT Sloan Management Review*. 55(4): 27-34.
58. World Intellectual Property Organization (WIPO). (2013). *PCT Yearly Review: The International Patent System*. WIPO Economics and Statistics Series.
59. Yang, J, Liu, H, Gao, S, & Li, Y. (2012). Technological innovation of firms in China: Past, present, and future. *Asia Pacific Journal of Management*, 29 (3): 819-840.
60. Yip, G. and McKern, B. (2014). China's Many Types Of Innovation, *Forbes*, Sept 19, 2014. Accessed online http://www.forbes.com/sites/ceibs/2014/09/19/chinas-many-types-of-innovation/ on Dec 1st, 2015.
61. Zeng, M., and Williamson, PJ. (2007). *Dragons at your door: How Chinese cost innovation is disrupting the rules of global competition.* Boston, MA: Harvard Business School Press.
62. Zeschky, M., Widenmayer, B., and Gassmann, O. (2011). Frugal innovation in emerging markets. *Research Technology Management* 54 (4):38–45.
63. Zeschky, M., Winterhalter, S., and Gassmann, O. (2014). From cost to frugal to reverse innovation—Mapping the field and implications for global competitiveness. *Research and Technology Management*. July-August, 2014: 20-27.
64. Zheng, C. and Wang, BX. (2012) Innovative or imitative? Technology firms in China. *Prometheus* 30 (2): 169–178.