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Role of Business Model Innovation and Public-Private Partnership in the Development of New Energy Vehicles: Experience from Hangzhou, China

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Abstract

This paper proposes a framework of analysis to illustrate key variables in developing the new energy vehicles (NEV) industry. The development of this industry in Hangzhou, China, is considered to analyze the role of business model innovation and public-private partnership in the NEV industry based on the analysis framework. The findings suggest that business model innovation and public-private partnership foster the growth of the industry, the building of industrial infrastructure, and benefit to the approach of strategic niche management. This paper contributes to the development of emerging industries, which supplements the implementation of strategic niche management and public-private partnership.

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ABSTRACT

This paper proposes a framework of analysis to illustrate key variables in developing the new energy vehicles (NEV) industry. The development of this industry in Hangzhou, China, is considered to analyze the role of business model innovation and public-private partnership in the NEV industry based on the analysis framework. The findings suggest that business model innovation and public-private partnership foster the growth of the industry, the building of industrial infrastructure, and benefit to the approach of strategic niche management. This paper contributes to the development of emerging industries, which supplements the implementation of strategic niche management and public-private partnership.

Keywords

New Energy Vehicle, Public-Private Partnership, Business Model, Strategic Niche Management, China

Will China Achieve its Target on New Energy Vehicles in 2020? Experience from Hangzhou, China

INTRODUCTION

The new energy vehicles (NEVs) industry, as a sustaining technology (Bohnsack, Pinkse, & Kolk, 2014), satisfies social and environmental concerns (Midler & Beaume, 2010). Despite the promise of this industry, it still faces difficulties penetrating mainstream vehicle markets (REN21, 2013; Bohnsack, 2014). Governments have implemented various policies to support the development of this industry (Rijinsoever et al., 2014; Yilmaz & Ustaoglu, 2013). However, the development of NEVs industry is still slow in the world. Therefore, this paper focuses upon a case study where NEVs have been rapidly developed, through new business models involving both public and private actors.

Since the automobile exhaust emissions are considered to be one of the main sources of air pollution and greenhouse gases, new-energy, green, and clean alternative automobiles have emerged as an imperative to improve the quality of the environment. NEVs have attracted increasing attention from academics, businesses, and officials worldwide. For the Chinese government, developing NEVs has become a valuable and attractive option (Midler & Beaume, 2010), with at least four advantages for growing a strong NEV industry: 1) it can reduce dependence on oil; 2) it can reduce emissions and improve air quality (Feng & Figliozzi, 2012; Bohnsack et al., 2014); 3) it can lower per-mile operating and maintenance costs (Feng & Figliozzi, 2012); and 4) it can help promote the transition and upgrade of the automobile industry

to gain competitiveness from the first-mover advantage of developing a NEV industry.

Attracted by the promising future of NEVs and the important role they play (regardless of the fact that NEVs have suffered tough development and questionable outcomes), the government still supports the movement. To foster the market development of NEVs, in 2012, the State Council of China released its Notice on Energy Conservation and New Energy Vehicle Industry Development (2012–2020)¹ (the Notice in short hereafter). In this plan, the cumulative sales volume and production of pure electric vehicles and plug-in hybrid electric vehicles in China will reach 500,000 by 2015, with the goal of 5 million by 2020. Although the sales of NEVs in China have rapidly increased (from less than 10,000 in 2012, to approximately 20,000 in 2013, to more than 80,000 in 2014,² and to more than 171,000 from January to October in 2015),³ it is still impossible to achieve the sales goal of 500,000 NEVs by 2015. In addition, the goal of 5 million has been acknowledged as an impossible target by many international researchers. At this point, it is difficult to conclude whether this sales goal of 5 million will be met by 2020.⁴

There have been critics from the world regarding this ambitious target of the NEV industry in China. However, the development of NEVs in Hangzhou has attracted attention since (as of April

¹ It was issued by the State Council of China on June 28th, 2012. The plan in Chinese could be available at http://www.gov.cn/zwggk/2012-07/09/content_2179032.htm

² The data from 2012 to 2014 was available from the report at China's New Energy Vehicle Annual Conference 2015, organized by the Ministry of Industry and Information Technology of China in January 2015, <http://www.miit.gov.cn/n1146290/n1146402/n1146455/c3231748/content.html>.

³ The data was available from the statistical data of the Ministry of Industry and Information Technology of China, <http://www.miit.gov.cn/n1146290/n1146402/n1146455/c4424536/content.html>. The production of NEVs in 2015 is estimated to be more than 300,000, according to the data of China Association of Automobile Manufacturers, <http://www.caam.org.cn/hangye/20151216/1105181460.html>.

⁴ There was news in 2015 regarding the impossible sales goal of NEVs in China by 2020. For instance, the news from the Finance Times (Chinese) on April 20, 2015, <http://www.ftchinese.com/story/001061582?full=y>, and the news at <http://cleantechnica.com/2015/11/19/china-electric-car-sales-booming/>.

2015) there were 12,587⁵ NEVs on Hangzhou's road, which was far more than the target of Zhejiang province (11,000 by 2015). Hangzhou is the provincial capital. Regardless of whether China will meet the target, it is impossible to ignore the rapid development of the NEV industry and market in China. As a relatively new issue, research on the experience of this industry in China, especially in Hangzhou, is still in its infancy.

The Chinese government is believed to play a critical role in the development of NEVs, and strategic niche management is conducted in the pilot development of new energy vehicles. Therefore, this study focuses on one question: How does a local government implement strategic niche management to promote the development of NEVs? This study analyzes the development and strategic niche management of NEVs in Hangzhou concentrating on perspectives of public-private partnership (PPP), and business model innovation.

Strategic niche management (SNM), proposed by Kemp, Schot, and Hoogma in 1998, is a policy tool used to facilitate sustainable innovation and development (Kemp, Schot, & Hoogma, 1998; Schot & Geels, 2008), such as the diffusion of biomass (Van der Laak, Raven, & Verbong, 2007). SNM research in China has been limited. This study aims to breach this gap by analyzing the NEV development in Hangzhou from the perspective of SNM.

Collective innovation is an effective method to improve the development of emerging industries (Mckelvey, Zaring, & Ljungberg, 2015), while PPP is a form of collaboration between government agencies and private institutions (Wettenhall, 2003; Bovaird, 2004; Rangan, Samii,

⁵ The data (in Chinese) is from the Hangzhou Daily on May 19, 2015, which is available at http://hzdaily.hangzhou.com.cn/hzrb/html/2015-05/19/content_1966875.htm.

& Van Wassenhove, 2006), particularly in public sector projects such as public infrastructure (Koppenjan, 2005; Zhang, Gao, Feng, & Sun, 2015). Previous studies on PPP in transportation have focused on the transportation infrastructure and system (Sperling, 2001; Koppenjan, 2005; Yuan, Skibniewski, Li, & Shan, 2010.). However, research on NEVs remains insufficient and therefore an interesting area to investigate.

This study contributes to the theories and implementation of SNM in developing countries as well as collective innovation and PPP in the emerging NEV industry. Although further research is necessary, innovation in governance in the NEV industrial development and the implementation of PPP could be considered as business model innovation in China's NEV industry. Thus, this study will also contribute to the theories of business model innovation.

The remainder of this paper is as follows. Section 2 reviews the literature on relative theories such as eco-innovation, SNM, PPP, and business model innovation. Section 3 proposes the analysis framework to analyze the role of business model innovation and PPP in the development of the NEV industry and research methodologies. Section 4 includes an introduction to the development of new energy vehicles in China and Hangzhou while Sections 5 and 6 discuss the contributions of business model innovation and PPP to the development of NEV in Hangzhou. This study concludes by addressing the implementation of various theories and providing future research suggestions.

LITERATURE REVIEW

Eco-innovation and Strategic Niche Management

Owing to the serious issue of climate change in the world, eco-innovation has attracted increasing attention from scholars, industries, and governments. Eco-innovation has been defined as “a product, production process, service or management or business method that is novel to the organization (development or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resource use (including energy use) compared to relevant alternatives” (Kemp & Pearson, 2007: 7). Eco-innovation includes three main aspects: 1) the technology; 2) the market; and 3) the regulation. However, the adoption of eco-innovation requires specific regulatory support (Rennings, 2000: 326).

To accelerate the diffusion and adoption of new environmental innovation and a change in the technology regime, Kemp, Schot, and Hoogma (1998) proposed the approach of strategic niche management (SNM): the creation, development, and controlled phase-out of protected spaces for the development and use of promising technologies through experimentation, with the aim of 1) learning about the desirability of the new technology and 2) enhancing the further development and rate of application of the new technology (Kemp et al., 1998: 186). SNM is considered to be both a research model and a policy tool (Raven, 2005). In a larger sense, the SNM framework has proven to be useful in analyzing the success and failure of experiments with a range of sustainable radical innovations, such as wind energy, biogas, public transport systems, NEVs transport, and eco-friendly food production (Raven, 2005). However, SNM, as a government approach to develop and diffuse sustainable technologies, such as NEVs, is still under research.

Based on SNM analyses and market formation, Sushandoyo and Magnusson (2014) proposed

four different stages: 1) technological niche, 2) niche market, 3) bridging market, and 4) mass market. They are described as critical actors and interactions (see Figure 1). Moreover, they imply that a network in the development of emerging industries exists.

Insert Figure 1 about here

In sum, as a key concept in sociotechnical transitions, SNM has become a niche in policy studies about sustainable innovation journeys. Initially, the SNM literature focused on individual transition experiments (Hoogma et al., 2002), but recently, it has centered on multiple experiments (Geels & Raven, 2006). However, further work and implementation is necessary to enhance the prospect of sustainability transitions (Schot & Geels, 2008).

Public–Private Partnership

Cooperation in innovation is a popular concept, especially since Chesbrough (2003) proposed the open innovation concept. Open innovation emphasizes the integration of internal and external innovation sources (i.e., knowledge, paths to market, ideas, etcetera) (Chesbrough, 2003, 2006), and the role of partners (Chesbrough, Vanhaverbeke, & West, 2006). Collective innovation is recognized as an effective method to improve the development of emerging industries (e.g., Mckelvey, Zaring, & Ljungberg, 2015). However, in the public sectors, such as education, housing, health care, transportation, social care, and related areas, (Grimsey & Lewis, 2002), and from the macro level, the partnership refers to PPPs, which are cooperative institutional arrangements between public and private sector actors (Hodge & Greve, 2009).

PPPs can be understood as networks as well as a type of open innovation, since they are formulated usually by more than two and often by a range of public, hybrid, and private players (Koch & Buser, 2006) that integrate internal and external resources in order to reduce project and administration risks (Hodge & Greve, 2007). In general, the approach of PPPs is used to fulfill the following purposes: policy design and planning, policy coordination, policy monitoring, policy evaluation and review, policy implementation and review, resource mobilization, and resource management (Bovaird, 2004). They thus entail significant positive externalities (Rangan et al., 2006). PPPs with a strong collaborative character may instigate an alternative approach to maximize existing resources and competencies (Bovaird, 2004) to reduce the high uncertainty for private actors (Rangan et al., 2006) and share risks and responsibilities, resources, and benefits (Bull, 2010: 480).

As defined by Hodge and Greve (2007), PPPs can be categorized into five different families, including 1) institutional co-operation for joint production and risk sharing; 2) long-term infrastructure contracts; 3) public policy networks; 4) civil society and community development; and 5) urban renewal and downtown economic development. According to the characteristics of the NEV industry, the types of PPPs in this study focus on the first two types; that is, collaboration for the development of NEVs to reduce risks and cooperation for building the NEV infrastructure.

Unfortunately, the academic research or practical applications of PPPs in environmentally benign industries, especially those in developing countries such as China, are rare. Existing research on PPPs in China has concentrated on the infrastructure industry as well as on water

supply and transportation systems (Adams, Young, & Wu, 2006; Zhang, Gao, Feng, & Sun, 2015). Research on PPPs in renewable energy industries has focused on “green” electricity (Ek, 2005) and wind power (Martins, Marques, & Cruz, 2011). SNM research by Sushandoyo and Magnusson (2014) suggests that government, producers, and users interact. Thus, it will be valuable to analyze the role of PPPs in the NEVs industry in China.

Business Model Innovation

Since the mid-1990s (Amit & Zott, 2001), the business model has been gathering interest from scholars and practitioners. The business model is a system of interdependent activities designed to create value through the exploitation of business opportunities and enhance a company’s productivity, mobility, competitiveness, etcetera (Amit & Zott, 2001; Zott & Amit, 2010). In addition, the business model matters more than technology (Chesbrough, 2007). Johnson, Christensen, and Kagermann (2008) revealed four interlocking elements in a business model: 1) value proposition, 2) profit formula, 3) key resources, and 4) key processes.

Zott, Amit, and Massa (2011) identified three phenomena mainly adopted in business models: 1) e-business and the use of information technology in organizations; 2) strategic issues, such as value creation, competitive advantage, and firm performance; and 3) innovation and technology management. Business model innovation is believed to be critical to the value creation and competitiveness of a company, as in the case of IBM (Chesbrough, 2007).

Sustainable technologies often do not fit existing production methods, managerial expertise, and customer preferences (Johnson & Suskewicz, 2009). In addition, the potential benefit of resolving environmental degradation does not seem to be a sufficient condition to generate

widespread customer acceptance (Kley, Lerch, & Dallinger, 2011; Siegel, 2009). Based on these two points, some scholars have argued that firms require various business models to create economic as well as environmental value (Chesbrough & Rosenbloom, 2002). With business model innovation, sustainable technologies might be more acceptable to customers, thus positively impacting the environment (Chesbrough & Rosenbloom, 2002).

Some scholars (Román, Momber, Abbad, & Miralles, 2011; Bohnsack et al., 2014) have studied business models and business model innovation in the emerging NEV industry. Bohnsack et al. (2014) proposed four business model archetypes from the perspective of three components: 1) value proposition; 2) value network; and 3) revenue the cost models, as shown in Table 1. However, the emerging NEV industry is still in search of a viable business model (Kley et al., 2011; Christensen, Wells, & Cipcigan, 2012), which is understandable since a correct business model is rarely found in emerging industries (Teece, 2010: 187). Thus, this study reviews the role of business model innovation in the NEV industry. In this case, the business model will be based on three key components: 1) value proposition, 2) value network, and 3) revenue and cost as shown for the NEV industry in Table 1

Insert Table 1 about here

RESEARCH FRAMEWORK AND RESEARCH METHODOLOGY

Analysis framework of the research

The items in the Notice and the Draft of the NEVs Charging Infrastructure and NEV Diffusion in the 13th Five-Year Plan⁶ suggest that the NEV market size (sales volume in the Notice), industry scale (production volume in the Notice), and infrastructure (the number of charging piles) are key evaluation indicators in the NEV industry in China. This study thus proposes three elements as development targets of the NEV industry: 1) infrastructure development, 2) market formation, and 3) industrial growth (as shown in Figure 2).

Insert Figure 2 about here

Moreover, it is assumed that there is a co-evolutionary relation among these three elements. For instance, without the infrastructure of NEVs, such as charging piles and battery exchange stations, NEVs could not run on the road (at least not for hours or long distances), similar to automobile industry phenomena (Geels, 2002). Conversely, if there is a potentially increasing market of NEVs, then it will be most important to push companies and other institutions to invest more in the development of NEV products and NEV infrastructures. This is similar to the relation between market formation and industrial growth.

⁶ The draft is available at: http://jjs.mof.gov.cn/zhengwuxinxi/tongzhigonggao/201512/t20151215_1616225.html (12-30-2015).

As mentioned in the literature review section on eco-innovation and SNM, the policy aspect plays a critical role in the development of eco-innovation and environment industries (Kemp et al., 1998; Schot & Geels, 2008). The financial acquisition from various actors and technological access are recognized as important variables in the development of knowledge intensive start-ups (McKelevey & Lassen, 2013). In addition, upon review of industrial policies worldwide, incentive policies, especially financial ones, are important in the development of emerging industries. As a high-technology industry, technology is critical to the development and competition of the NEV industry. Thus, technological access, financial resources, and policy support are identified as key variables that influence the development of the NEV industry.

Based on the above, this paper proposes the following synthetic model, which identifies the key variables and phenomena that drive NEV industry development to achieve the three development targets, as seen in Figure 3 below. The framework is used to explore the business model innovation and PPPs in the development process of the NEV industry.

Insert Figure 3 about here

Measures of Variables

According to the analysis framework in Figure 3, the variables in this study are measured in the following ways.

Drivers

First, technological access and development refers to the participation of universities and research institutes in NEV industries. Second, financial resources include the government's financial subsidies and incentive policies as well as venture capitals or investment willingness in the NEV industry. Since there is no available data on venture capitals, venture capitals in this study will be operationalized as the increase of start-ups or new joint projects by existing companies in NEV industries. Third, policy support will be expressed as the main policies that encourage the development of NEV industries from the central government to local government agencies.

Targets

First, market formation refers to the number of NEVs on the road in Hangzhou. It is described as the sales volume of NEVs in Hangzhou, the phenomena of NEV rentals and sharing, and the scenario of NEVs in Hangzhou. Second, industrial growth refers to the change of the NEV industry in Hangzhou, which covers information regarding the development of component producers, NEV producers, and other organizations involved in the NEV industry network in Hangzhou. Third, infrastructure development alludes to the business model in charging systems, and the current and future projects on charging piles and charging stations in Hangzhou. In addition, it includes the stations for NEV sharing.

Research Methodologies

As an explorative research, a case study is conducted on the NEV industry in China since this type of methodology can help answer the research questions (Yin, 2009). Through a case study, it

is possible to enlighten and explain multiple-level phenomena that are too complex for tightly structured designs or pre-specified data sets (Yin, 2009). In addition, a case study is suitable for unraveling concepts (Yin, 2009). This study focuses on how NEVs industry is developed through innovation on governance and collective innovation in the PPP and uses the variables defined in the research framework to describe the development processes.

The study is based upon archival material as well as interviews. This study does not code the interviews since its purpose is to provide insights and illustrations into the emergence and development of NEVs.

The archival material and available statistics have been used to measure the variables described above. Moreover, details of the case description below are also based on two in-depth interviews conducted in 2013 with an officer at the Bureau of Industry and Information Technology in Hangzhou (who was in charge of creating the NEVs policies in Hangzhou) and the chief technology officer (CTO) of a NEV service company (who designed and led the NEV projects at the State Grid Corporation in Hangzhou and eventually moved to another company to lead the development of NEVs in Zhejiang province). The interview length for each individual was between one and two hours. Moreover, other interviews were conducted with drivers of electric taxis in Hangzhou and customers who rented new energy vehicles in order to gain an awareness of their experiences. Finally, public information from websites and companies' introduction documents was used as additional information and to triangulate the data.

DEVELOPMENT OF THE NEW ENERGY VEHICLES INDUSTRY IN HANGZHOU

Development History of New Energy Vehicles in China

Although the development of NEVs can be traced back to the early 20th century (for instance, the first NEV of General Motor was designed in 1912), they were not popular owing to the high investments required and high running costs, a belief that continued until the end of the 1980s. However, since the 1990s, an increasing number of countries (including China) have formulated policies and conducted projects to design and develop NEVs.

In the early 2000s, rising petroleum prices, the consumption of petroleum by the increasing number of automobiles on the road, and excessive urban pollution pushed China to find alternatives to using traditional automobiles with internal combustion engines. Consequently, the Chinese government has been supporting the research and demonstration of NEVs through its National High Technology Research and Development Program (863 Program⁷) since 2001.⁸ Subsequently, through the national Five-Year Plans (from the 10th Five-Year Plan), the development of NEVs has become one of the priorities of the automobile industry. In addition, the Chinese government has issued a series of policies to improve the research, development, and commercialization of the NEV industry. Further support was upgraded after the State Council identified NEVs (along with six other sectors) as the strategic emerging industries of China in

⁷ The 863 Program or National High-Tech R&D Program is a program funded and administered by the Chinese government. It is intended to boost innovation capacity in the high-tech sectors, to strive for breakthroughs in key technical fields, and to achieve “leap-frog” development in key high-tech fields. Partners of the 863 project include universities, institutes, and companies. Some information can be found at:
<http://www.most.gov.cn/eng/programmes1/>

⁸ MOST (2002), *Annual Report 2001 the National High Technology Research and Development Program of China (863 Program)*, available from the official website:
http://www.863.org.cn/english/annual_report/annual_repor_2001/index.html

2010⁹ and released its Notice.¹⁰ The key issues since 2001 are summarized in Figure 4.

Insert Figure 4 about here

The development and production of NEVs is recognized by the Chinese government as a plan for Chinese automobile manufacturers to compete with manufacturers in advanced countries. Encouraged by the policies and large new energy vehicle bids of the Beijing Olympic Games in 2008 and the Shanghai World Exhibition in 2010, an increasing number of entire-car and automobile-component manufacturers are entering the NEVs sector, e.g., CHERY, DONG FENG, CHANG AN, and so forth. However, the NEVs industry developed slowly before the Notice was issued in 2012. Although China did not achieve the sales target by 2015, as required by the central government, the NEV market in China has grown rapidly since 2012 (as shown in Figures 5 and 6). In addition, China has become one of the top three largest NEV markets in the world.

Insert Figure 5 about here

⁹ It was decided by the State Council of China in October 2010. The Decision on Accelerating the Cultivation and Development of Strategic Emerging Industries (in Chinese) is available at: http://www.gov.cn/zwggk/2010-10/18/content_1724848.htm

¹⁰ It was issued by the State Council of China on June 28, 2012. The plan (in Chinese) is available at: http://www.gov.cn/zwggk/2012-07/09/content_2179032.htm

Insert Figure 6 about here

The Development of New Energy Vehicles in Hangzhou

Hangzhou is a large city with a great demand for transportation. To solve traffic problems in Hangzhou and have better air quality for its citizens, the NEV industry has developed rapidly. In fact, as one of the pilot cities for NEV industries in China, the Hangzhou local government provides incentive policies to support the development of NEVs, especially the electric vehicles (EVs) in Hangzhou.

The NEV industry in Hangzhou began with the Y9 Sightseeing Hybrid Bus in 2006 after which it was further developed into hybrid taxis in 2011. With the running of electric taxis, the Hangzhou New Energy Taxi CO., LTD with 49% holding by the State Grid Corporation Hangzhou Branch was established. To shorten the battery charging time for electric taxi drivers, Hangzhou diffused the model of battery changing. Thus, the battery-changing stations under the control of the State Grid Corporation Hangzhou Branch were built, and a NEV service company (funded by the same branch of the State Grid) was established.

When electric vehicle battery charging and public transportation became the main priorities in the NEV industry in Hangzhou, product development is changed by market-pull innovation. In

addition, the service companies and institutes in the NEV industry became involved in product development. For example, to increase the speed of battery changing and reducing the battery charging time, the battery size and locations in the vehicles were designed first. Then, ZOTYE designed and produced the electric taxis to meet the requirement of the batteries.

In 2013, Hangzhou began diffusing the concept of electric vehicle rentals in which 100 EVs could be rented at an affordable price. This clean, EV-renting pattern became rapidly popular as China's first electric car-rental service that was both convenient and environmentally friendly. In addition, adopting the concept of "bike-sharing," Hangzhou proposed the "car-sharing" model in 2014. A new service company (Micro-Bus) was established to provide better service for car sharing, which was funded by GEELY and KANDI, two key NEV producers in Zhejiang province. The patterns of car renting and car sharing are gradually matured and even attracted those in Shanghai, Ningbo, and other neighboring cities. Furthermore, in 2015, the central government encouraged other provinces to adopt the system of public NEVs transportation.

Subsidies were mainly provided in terms of subsidizing electricity with 0.5 RMB (around nine cents US) per kilometer, rather than offering direct subsidies to the electric car buyers. Given that the potential buyers faced license limitations, exemptions from license registration through lotteries/auctions of NEV in Hangzhou promoted the sales of NEVs.

With the development of the EV market (taxis, car renting, car sharing, etc.), many companies in the NEV industry have recently been established. These companies focus on either NEVs themselves, the electric car business, battery and control systems or other relevant parts and equipment, such as battery changing stations. Thus, the NEV industrial network was created.

Moreover, Hangzhou organized several science and technology projects to encourage the involvement and investment of local companies and universities in the NEV industry, and connect NEV development to power grid construction. In fact, several local companies and research institutes have become participants of the national 863 Program.

The market demand for taxis, car renting, and car sharing, has attracted companies to invest in the NEV industry. According to statistics that are incomplete but nevertheless indicate trends, more than 20 companies specialize in the production or research of energy systems and other core components of electric vehicles. In developing an entire vehicle, WANXIANG merged one battery firm and formed WANXIANG EV Co., LTD in 2002 (hereafter called “WXEV”). Moreover, in September 2009, SPOWER was set up to develop and manufacture NEVs and their battery systems, control systems, and drive systems. Their products are now sold worldwide. In addition, six electric vehicle battery producers were established in Hangzhou. Furthermore, KANDI and ZOTYE who are the main two providers of taxis, car renting and car sharing in Hangzhou, are growing with the growth of market. GEELY then cooperated with KANDI to establish the KANDI NEV Co., LTD in March 2013, with the expectation that they will play a significant part in promoting the development of the Hangzhou automobile industry through the innovation of the car-sharing pattern.

Based on the above, it is apparent that the market has promoted the development of upstream and downstream businesses and it help formulate the NEV industrial network. Moreover, with the growth of the Hangzhou NEV market and industry, KANDI and ZOTYE have become the dominant brands in the Chinese NEV market (see Figure 7).

Insert Figure 7 about here

DISCUSSIONS

According to the analysis framework proposed above, this section concentrates on the role of innovation, especially business model innovation, and PPPs in the development of the NEV industry in Hangzhou, rather than the general development process. The co-evolution of targets in the NEV industries is illustrated.

Technological Access

Technology is critical in an emerging industry, including both access and development. Before 2010, the development of NEVs in China focused on research and development. Subsequently, participation in the national 863 Program helped several companies and research institutes access the latest technologies and conduct R&D on NEVs. For instance, WXEV has undertaken several national 863 NEV projects.

In the case of NEVs, battery changing is the priority model in Hangzhou. The technical requirements placed on the battery from the battery changing station have influenced the design and development of NEVs. It is important to note that the technology manager of an NEV service company (a key person when the company is established) has expertise in the NEV industry. Compared with automobile producers in Beijing, Shanghai, and other cities, NEV

companies in Hangzhou have technological experience in at least one key component of NEVs. For instance, KANDI (the NEV provider of car sharing) has extensive experience and technological background in batteries, and this is similar to BYD, one of the leading NEV companies in China. The customized electric taxis in Hangzhou indicate business innovation in NEV development and the importance of lead users (in this case, the taxi service company and the NEV service company) in the process of technological development.

The development of NEVs in China and Hangzhou reveals the role of PPPs in technological access. As shown above, at the national and provincial level, the national 863 Program and provincial projects on NEVs acted as a platform of collective innovation among different public and private institutions. In addition, many technologically strong universities in Hangzhou and Shanghai, such as Zhejiang University in Hangzhou and Tongji University in Shanghai, are involved in the NEV development in Hangzhou as technological resources. For example, design is important in the auto industry and according to one interview, the China Academy of Art is involved in the design of car renting and car sharing. Thus, it is assumed that PPPs in the NEV industry in Hangzhou plays a certain role in the technological access.

Therefore, in this case, linking various companies, technological institutions, and universities is extremely significant as a determinant of developing technology and in influencing the direction of innovation, in line with previous research (Hekkert et al., 2007). In addition, lead users and design play considerable roles in product development in the NEV industry. Finally, this case confirms the more general importance of technological access in the development of industries in emerging countries (Cho & Lee, 2003; Mu & Lee, 2005).

Financial Resources

Financial resources are also important for emerging industries. The case of NEVs in Hangzhou confirms the importance of this variable, and that business model innovation and PPPs can help how financial resources are obtained in this case. There are subsidiaries, tax reductions, and other financial supports from the central and local governments¹¹ to the buyers of NEVs, which are indirectly financial resources to the NEV producers. NEV producers, including the components providers, can obtain funds to support their research and development on NEVs from the central and local governments. The Notices issued in 2012 pledged to invest 100 billion RMB by 2020 to realize this plan. The latest reward policy for the diffusion of NEVs and the building of charging piles, issued in December 2015, is also an example of such financial support. In addition, NEV producers will receive advanced funds from the Ministry of Finance according to their productivity and sales. For example, KANDI received approximately 59.60 million USD in advanced subsidies from the Ministry of Finance in 2015¹² and Micro-Bus received around 30.89 million USD in subsidies from the Hangzhou government in December 2015.¹³

Regarding the financial subsidies to individual users of NEVs, the Hangzhou government has designed several new subsidy types for NEVs. First, there is the cheaper price to rent or share a NEV (after the subsidy), e.g., around 1,500 USD per year for a two-seater NEV or approximately 3 USD per hour for car sharing. Second is the subsidy to the charging cost or the battery changing cost. Third is the purchasing subsidy to new energy passenger cars. The first two types

¹¹ In general, for new-energy buses or new-energy vehicles used in post offices, logistics, and other public agencies, the ratio of the central and local government in subsidiaries is 1:1.

¹² Data can be found in the news at: <http://www.kandivehicle.com/NewsDetail.aspx?newsid=133>.

¹³ Data can be found in the news at: <http://www.kandivehicle.com/NewsDetail.aspx?newsid=147>.

of subsidies have attracted an increasing number of citizens to rent NEVs, which has also made it more difficult rent a NEV.

Although there is no explicit data on venture capitals in the NEV industry, the start-ups and new joint projects by existing companies in the industry imply investments from companies. In addition, some start-ups are collaborative results of public and private institutions. For instance, the new energy taxi company has investments from the State Grid Corporation Hangzhou Branch. The car-renting and car-sharing businesses in Hangzhou have attracted new ventures by various companies regarding the sharing IT system, such as those by GEELY and KANDI, the State Grid Corporation, hotels, social communities, and so on.

This case reveals that direct and indirect financial resources have been used to enhance NEV development, in turn influencing technology, demand and company formation. In addition, the innovative allocation of subsidies and investments from public-private cooperation contribute to the development of the NEV industry and the expansion of the NEV market.

Policy Support

A series of policies, included in Figure 4, indicate the incentive policies issued in China in order to support the development of NEVs, which helps explain the importance of eco-innovation policies (Rennings, 2000) to understanding this case study. After reviewing the industrial policies in Hangzhou, there are two types of business model innovations that accelerate and strengthen the growth of the NEV industry and NEV market in Hangzhou. One is the battery-changing model (rather than the charging plug-in model), while the other is the microbus model, including car renting and car sharing. The design of these two business models considers

the low willingness to buy a NEV of individual buyers and the need to upgrade the environmental performance of transportation. In addition, technological development primarily aims to meet the demands of these models. Furthermore, some financial resources are allocated according to the implementation of the battery-changing and microbus models.

The value proposition in the first business model is the high performance of NEVs with standard batteries and the change service provided by the battery changing stations (taking approximately three minutes to change batteries at a change station). The network of changing stations has gradually extended to nearly 30 changing stations, which cover the Hangzhou urban area and other cities along the highways.¹⁴ The revenue comes from the price of changing, the low cost of charging batteries in the evening, and the subsidies from the government. The value proposition in the second business model is the urban commuter NEVs (two-seaters or four-seaters) and the sustainable, innovative service. In fact, individuals can rent a NEV at a rental station or sharing station and return it at any other station. The revenue comes from the leasing of the vehicle, the pay per hour, and the subsidies from the government. These two business models are summarized in Table 2.

Insert Table 2 about here

This case suggests that public and private institutions are working together to implement and promote both of these two business models at the same time. For instance, many automobile

¹⁴ The plan is to build charging stations and battery change stations along the highways.

manufacturers in Zhejiang (e.g., GEELY, KANDI, ZOTYE, and YOUTH), state-owned companies (e.g., State Grid Corporation Hangzhou Branch and the Hangzhou Public Transport Group), universities (e.g., Zhejiang University and the China Academy of Art), hotels, social communities, and government agencies are involved in the operation of car renting and car sharing in Hangzhou.

Co-evolutionary of targets

According to the April 2015 data, consisting of more than 12,000 NEVs in Hangzhou and more than 9,800 NEVs for car sharing and renting,¹⁵ demonstrates the growth of the NEV market in Hangzhou. In addition, more than 70 battery-changing stations, more than 50 car-sharing stations, and thousands of charging piles formulate the NEV infrastructure in Hangzhou. The increasing number of battery-changing stations and car-sharing stations make the usage of NEVs more convenient, which attracts more individual customers to use NEVs. It is assumed that it will help cultivate customer behaviors of NEVs and lead more individual consumption of NEVs.

The growing market of NEVs has also attracted more companies to invest in this emerging industry. Moreover, the increasing number of companies in the NEV industry in Hangzhou implies industrial growth. Substantial parts of NEVs in Hangzhou were produced by local companies and the production capabilities of local companies increase with the growth of the market, which, in turn, leads to their competitiveness in markets outside Hangzhou.

¹⁵ Information is available at:
http://www.moc.gov.cn/zhuantizhuanlan/gonglujiaotong/gongjiaods/jingyanjl/201507/t20150713_1848606.html

Consequently, this study proposes that there is a co-evolutionary relationship among the following three targets: 1) market formulation, 2) infrastructure development, and 3) industrial growth. These three targets influence and reinforce one another.

Summary

In sum, this case study illustrates the role of business model innovation and PPPs in technological access, financial resources, and policy support in order to enhance the development of the NEV industry. Additionally, business model innovation and PPPs contribute to the implementation of eco-innovation in pilot cities, such as the NEVs in Hangzhou, which provides insight into the practice of SNM. Moreover, the development targets of NEV industry are interactive. Thus, it is difficult for the government to set up a best portfolio of development targets, covering market formulation, infrastructure development, and industrial growth.

CONCLUSION

This study analyzed how the key variables in the development of the NEV industry in Hangzhou (according to the proposed analysis framework) played out, in order to comment on understanding the dynamics of the NEV industry in the world in general and in China in particular. Previous sections have given the details of how and why technological acquisition, financial resources, and policy support are critical factors in the commercialization of the NEV industry.

In addition, this study suggests that business model innovation should be conducted, involving both private as well as public actors. By this we mean not only according to the governance and

industrial guidelines from government agencies, but also in the diffusion of NEVs. For instance, the Hangzhou government has prioritized car renting and car sharing to promote the NEV industry. In addition, the government has used them as measurements to attract investments from companies in the NEV industry and to change the driving preferences and behaviors of customers. Thus, the findings of business model innovation in industrial governance provide insight into business model innovation, and extend research on the level of policy implementation.

This study also reveals that PPPs play a vital role in the formulation and growth of the NEV industrial network, technological acquisition, and entrepreneurial activities. Overall, the business model innovation in governance and the PPPs make the implementation of niche strategies run smoothly. It also provides evidence and contributes to the theoretical and practical research of SNM.

Furthermore, the co-evolution of the development targets in the NEV industry implies that there are challenges in effectively matching the types of trade-offs that the local government targets need to achieve. How to make the trade-offs in the NEV targets will be an important issue in the near future.

However, the present case (i.e., the NEVs in Hangzhou) is limited in its generalizability of the research findings and the implementation of suggestions in other regions. Further research, e.g., more cases and other research methods, should be conducted in the future to investigate the NEV industry. In addition, with the decline of international petroleum prices, the cost advantage of per kilometer battery changing compared to gasoline has diminished. This will lead to new questions

for the service company and the government: How will existing customers continue using NEVs if the energy cost per kilometer is not lowered? How much of a reduction in energy costs of NEVs will influence the implementation of policies in the 13th 5-Year Plan?

Ultimately, the greatest research challenges in the NEV industry may be those that illuminate the paradigm shift as a social transformation and as an industrial transition. This study was only a small step in the research regarding the NEV industry in China. Thus, further analyses of the network development of NEVs and the roles of actors in the network are necessary based on other network analyses methods. Future research might delve more into the open regional innovation system of the NEV industry in which NEV companies in developing countries catch up and even overtake. Moreover, future research should focus on more cases of emerging environmentally benign industries based on the theories of SNM and PPP. Finally, barriers and drivers in the NEV industry, such as consumer behaviors and preferences regarding transportation and automobile purchases, are challenges that need to be resolved in the development and diffusion of this industry. Finally, a key theme for the future should be the successful integration of micro, meso, and macro perspectives with a more systemic view of concerns about emerging environmentally-friendly industries, such as the NEV industry.

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TABLE 1**Business Model Archetypes of New Energy Vehicles**

Archetype	Value proposition	Value network	Revenue & cost model	Examples
Luxury specific-purpose	-High-performance two-seater -Delivers fast acceleration	-Flagship stores -Dealers	-Sales and leasing	Tesla roadster
Luxury multi-purpose	-High-performance sedan two-seater -Delivers fast acceleration	-Flagship stores -Dealers	-Sales and leasing	Fisker Karma
Economy specific-purpose	-Urban commuter two-seater -Sustainable and innovative	-Internet	-Pay per mile -Rent battery	Car2Go
Economy multi-purpose	-All-round sedan -Sustainable and innovative	-Dealers	-Sales and leasing -Rent battery	Tesla Model S

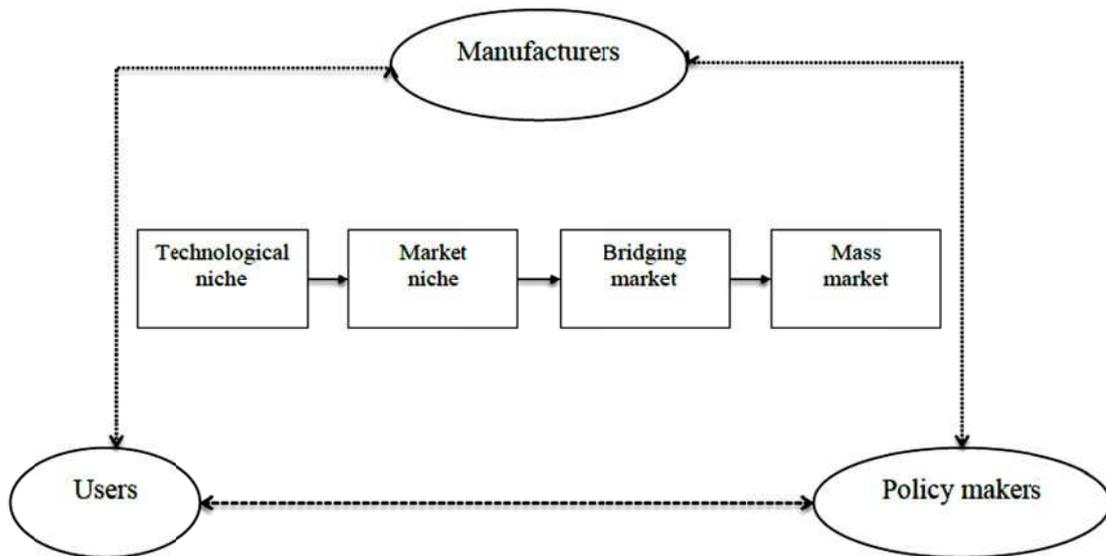
Source: Adapted from Bohnsack, R., Pinkse, J., & Kolk, A. 2014. Business models for sustainable technologies: Exploring business model evolution in the case of electric vehicles. *Research Policy*, 43: 284–300. Page 289.

TABLE 2**Business Models in the New Energy Vehicles Industry in Hangzhou, China**

Archetype	Value Proposition	Value Network	Revenue & Cost
Battery changing	High-performance NEVs with standard batteries Fast service to change battery	Battery changing stations	Service price to change battery Low cost to charging batteries in the evening
Micro Bus	Urban commuter NEVs Sustainable and innovative	Renting stations Sharing stations	Leasing Pay per hour

FIGURE 1

Temporal and structural dimensions of SNM and market formation



Source: Adapted from Sushandoyo, D. & Magnusson, T., 2014. Strategic niche management from a business perspective: Taking cleaner vehicle technologies from prototype to series production. *Journal of Cleaner Production*, 74 (7), 17-26.

FIGURE 2

Development Targets of New Energy Vehicles

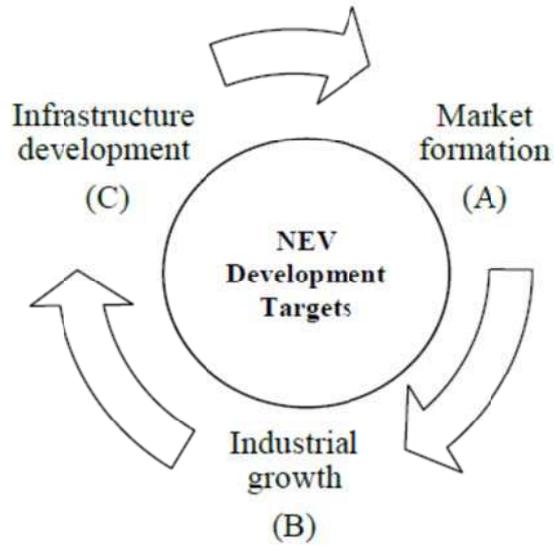


FIGURE 3

Analyses Framework of New Energy Vehicles Industry

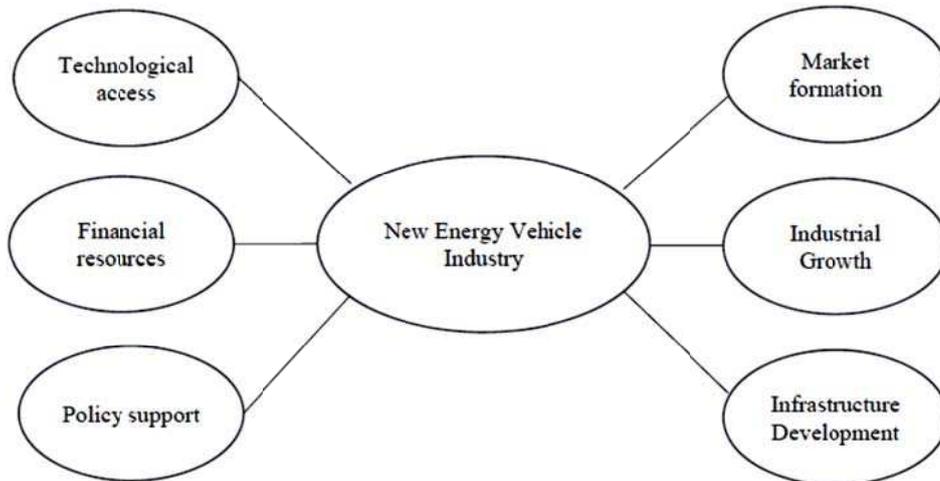


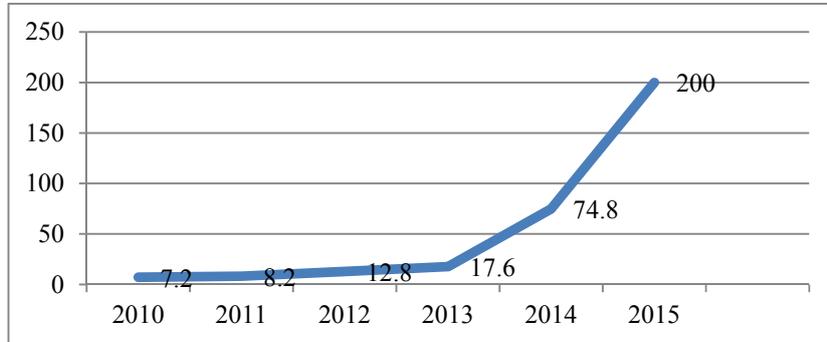
FIGURE 4

The Key Issues in the Development History of NEV in China



FIGURE 5

Sales of New Energy Vehicles in China

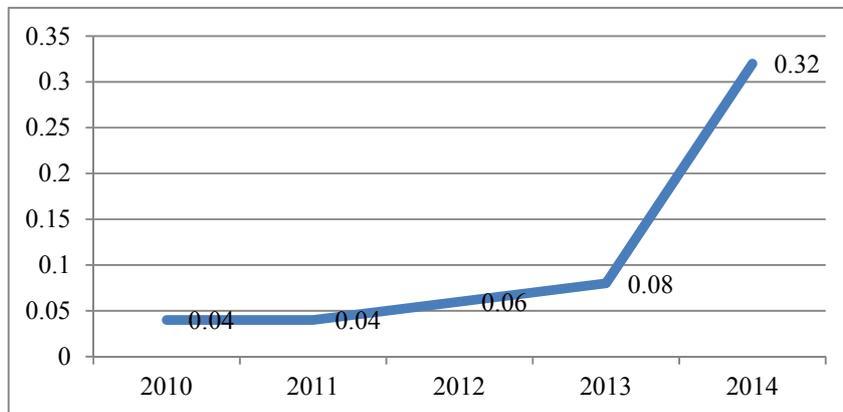


Unit: thousand

Source: Adapted from China Association of Automobile Manufacturers

FIGURE 6

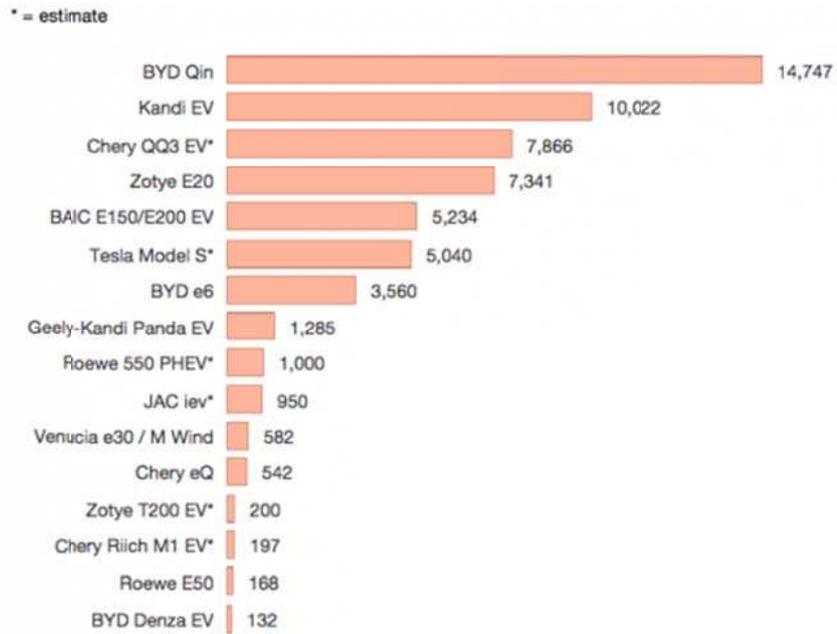
The Shares of New Energy Vehicles Sales in the Chinese Automobile Market



Source: Adapted from China Association of Automobile Manufacturers

FIGURE 7

Sales of Electric Vehicles in China in 2014



Source: James Ayre, *BYD Qin & Kandi EV Dominate China Electric Car Sales*,
<http://cleantechnica.com/2015/02/21/byd-qin-kandi-ev-dominate-china-electric-car-sales-chart/>