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Competing and Co-existing Business Models for EV: Lessons from International Case Studies

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Abstract

This paper presents four innovative business models that are being developed in three countries to support the commercialisation of electric vehicles (EV). Using an original business model framework and interviews with EV company founders and directors, we analyse partnership strategies along the EV value chain (France and US) and the coexistence of competing business models (China). Findings emphasise the importance of designing flexible business models and leveraging resources and inter-industry partnerships in the emerging EV ecosystem. The results provide practical recommendations for industrial players and insights for policy-makers.

1 Introduction

In the last few years, climate change and energy security concerns have strengthened policy support for the electric vehicle (EV) industry as one pathway to reducing greenhouse gas emissions (GHG). However, the lack of profitable business models and many barriers to adoption still challenge the growth of the sector despite ambitious government targets: 5 million PEVs in China by 2020, 1 million in the US by 2015, and 2 million in France by 2020 [1]. Given the challenges to reaching targets for EV penetration in global markets, this paper examines how business model innovation is helping companies overcome barriers to adoption and enable value creation and capture in the sector.

Four cases of innovative business models around EVs are compared on the basis of an original framework developed from the academic literature and from original case study data. Our analysis shows a tendency towards new configurations of service delivery for EV with, for example, the bundling of vehicle sale and energy supply. Partnership strategies along the value chain appear essential to solve the EV industry's problems. In the short term, as the industry searches for a "dominant design" [2] in the charging services and vehicle technology, competing business models can co-exist. It is suggested, however, that business models that encourage competition and technological innovation in the ecosystem as a whole, and are compatible with the strategies of other players in the value chain, are likely to be successful in the long term.

2 Literature Review

This paper draws on the strategic management literature on business models. The definition that has been largely accepted as dominant in the literature stems from [3]. Six major functionalities [4], [5] of business models are:

- the value proposition;
- the customer market segment;
- the value chain;
- the cost and profit structure;
- the strategic position of the firm in a value network;
- the formulation of the competitive strategy.

Recently, scholars have devoted attention to the challenges companies face in innovating and implementing new business models [6–8]. This research expands the literature on business model design in an emerging business ecosystem by considering two central aspects of the commercialisation of a technological innovation: reducing the barriers to adoption and enabling value creation and capture.

3 Research Method

3.1 Case study selection

The complex and exploratory nature of the research topic and the early stage of the EV industry justify our use of the case study methodology [9]. Case studies from China, the US and France (Table 1) have been identified through a review of the academic literature, published case studies, and specialized industry news sources. These case studies are selected on the basis of their strongly innovative and contrasting approaches to EV business models. They focus on different critical levels in the EV ecosystem: EV manufacturing, charging infrastructure, end-user services. The four business models are battery-swapping, fast-charging, high-end EV manufacturing, and public electric mobility services (Table 1).

Table 1. EV business model case studies

Case No.	Company or Joint Venture	Country	Ecosystem Function	Business Model Strategy	Market Presence
1	Fast-Charging (BYD)	China	OEM	Partnership with electricity supply company; Technology leadership for fast-charging	Metropolitan area (Shenzhen)
2	Battery-swapping (WanXiang)	China	OEM	Joint venture with electricity supply company; Technology leadership for battery-swapping	Metropolitan area (Hangzhou)
3	EV manufacturer (Tesla)	United States	OEM	Niche market and entry in energy supply with fast-charging	Regional (California)
4	EV Sharing (Autolib')	France	Mobility-as-a-service	Public car sharing; Vertical integration	Metropolitan area (Paris)

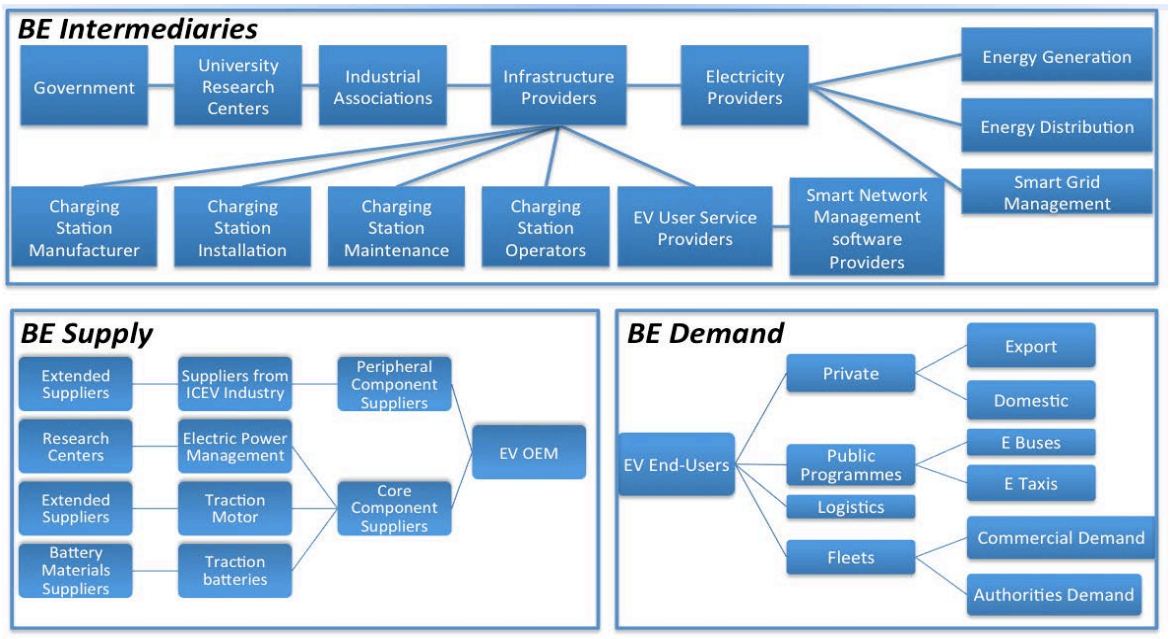

Figure 1. EV Business Ecosystem Structure [10]

3.2 Framework

Current frameworks in the literature [5], [11] are not sufficient for companies entering a new industry for a complex technology such as electric vehicles. This paper uses previous literature on electric vehicles and business models to develop a systematic framework of barriers to adoption and enablers of value creation and capture. The objective of the framework is to help evaluate the advantages of various business model configurations which are presented from our case studies. The framework is useful to make sense of the diversity of co-existing – sometimes competing – business models and to explore what "kind of business model configurations are possible within an industry"[7].

The research framework (Table 2-3) has the advantage over existing frameworks that it is not limited to one company and takes into account the ecosystem of companies in the EV sector. It is therefore useful in this study where the "business model" rather than the specific company is the unit of analysis. It allows to compare EV business models according to 11 criteria that were compiled from the academic literature on technology adoption, innovation, energy policy, as well as industry and consulting reports. Each business model is ranked on 6 scales relating to the supply side and 5 scales of change from the consumer perspective (Table 2-3).

4 Case Studies

This section provides the background and description of the case studies (sections 4.1, 4.2) followed by the analysis using the framework (4.3). The level of government involvement in the business model differs in each case, but all 3 states (China, US, France) strongly support their automotive sector and EVs as a strategic industry to achieve sustainable economic growth.

4.1 Context

China initiated research and development concerning the EV industry at the beginning of this century. Following the implementation of the "EV Key Project" and the "Key project of Energy-saving and New Energy Vehicles" from the National 863 Program, the Ministry of Science and Technology invested around RMB 2 billion in the course of the tenth five-year plan and the eleventh five-year plan. In 2009, the Chinese government carried out the "Thousands of Vehicles, Tens of Cities" program. This is an EV demonstration project where subsidies are given to the 25 pilot cities to use EVs in the public transportation system (buses, taxies, government vehicles, cleaning vehicles and postal vehicles). Among the 25 demonstration cities, 6 cities were chosen as the pilot cities for private usage of EVs. Both Shenzhen and Hangzhou were chosen to conduct demonstrations programmes for both public transportation and individual EV purchases. The business models of their major local EV OEMs are discussed and analysed below.

The US and California in particular has a history of promoting the EV market through environmental policies such as the Zero-Emission Mandate (1990) and the California Air Resources Board's act of 2006 (AB 32) to reduce corporate average fuel emissions. Tesla was founded around the launch of AC Propulsion's prototype sports electric car, the T-Zero, by successful entrepreneurs and investors in the Silicon Valley, who grew the company out of personal investments and private equity and venture capital funding rounds between 2003 and 2008. The US DoE awarded them a $465 million loan in 2009 out of the Advanced Technology Vehicles Manufacturing load program, to help the company develop and commercialise its Model S, a mass-market electric sedan. Between 2008 and 2013, the government has been supportive in funding the EV industry in many ways, including tax rebates and grants for infrastructure development.

Table 2. Business model innovation around barriers to consumer adoption

Scale	Description	Implications	Low score (0)	High score (10)
Reduces battery ownership costs (Andersen et al., 2011)	Who owns the battery?	- Technological risk associated with battery degradation and improvements - Capital costs	Customer fully owns the battery	Company fully owns the battery
Reduces vehicle ownership costs (Andersen et al., 2011)	Who owns the vehicle in the BM?	- Vehicle cost risk - Market risk associated with industry evolution	Customer fully owns the vehicle (-battery). Business-as-usual	Company fully owns the vehicle
Reduces customer exposure to electricity prices (Gomez et al., 2011)	Does the BM include the price of recharging, or do customers pay a fixed rate, or market prices?	- Fuel price risk - Elasticity of demand for electricity - Incentives for "smart" charging choices - Pay-back time of initial costs	Customers pay for electricity at market prices. Highest elasticity of demand and price risk.	The cost of electric recharge is fully included/ covered by the supplier.
Spreads risk across ecosystem (Visnjic & Neely, 2011)	Who bears the risks in this BM – technical, market, financial, infrastructural?	The distribution of risks influences EV adoption and entry strategies	All risks of adoption accrue to consumers. Business-as-usual	Risks are distributed over different agents
Advantage for long distances (Andersen et al., 2011)	Does this BM resolve the issue of range limitation?	- Solution to a major barrier to EV adoption	The BM does not address the problem	The BM explicitly offers a solution for long-distance recharging
Encourages change in consumer behaviour (Turrentine et al., 2007)	Does the BM change the way people drive and attitudes?	- Market research and modelling: cannot treat driving behaviour as exogenous	No changes in consumer behaviour	Full range of changes: driving habits, attitudes towards personal vehicles and mobility

Table 3. Enablers of EV ecosystem development

Scale	Description	Implications	Low score (0)	High score (10)
Enables technological innovation (Adner & Kapoor, 2010)	Does the BM allow for innovations in vehicle design, in battery technology, in charging networks?	Technology-based competition drives industry growth	The BM does not require or facilitate technological change	The BM requires significant technological change
Clear formulation of business model strategy (Chesbrough & Rosenbloom, 2003)	Does the company explicitly define its strategy as BM innovation?	Emphasis of entry strategy on technical vs. marketing aspects may be a determinant of success	The BM and its innovative component are not addressed explicitly.	Explicit focus of the company on BMI.
Enables business model experimentation (Chesbrough, 2010)	Is the BM flexible? Can it be adapted to new technological and market conditions?	BM flexibility improves firm resilience in a changing market	The BM requires irreversible actions	The BM can be implemented gradually and adapt to market needs
Uses intelligent charging infrastructure (Andersen et al., 2009)	Does the BM require smart charging and grid communication technologies to be implemented?	Arguably, ICT allow the full value creation and capture from innovations in the EV sector	The BM uses a "dumb" charging infrastructure	The BM requires smart controls for charging
Servitized business model (Tukker, 2004)	Is EV transportation viewed as a private good, a private service, or a public service?	Changes the value proposition	Vehicles as a product. Business-as-usual	Mobility as a service with maximum efficiency and optimisation

In France, various policies are in place to promote the emergence of the electric vehicle market, including a rebate of up to €5,000 on EV prices and the average emissions limit of 130 gCO_2/km for new vehicles by 2015[1]. The first reason the electric car-sharing service Autolib' was launched with the support of municipalities is probably the goal of the French state to support innovation and technological leadership from its automobile manufacturing sector, the second largest in Europe. The automobile industry in France represents 17% of total R&D spending (€5 billion) and more than 12% of France's exports[2]. French automobile manufacturer Renault, one of the forerunners of the EV market, launched four EV models in 2011: the Fluence ZE (185 km range), the Kangoo ZE, the Twizy, and the Zoe (100-150 km range). Autolib' is a marketing message to the public that the transition to EVs is occurring aiming to stimulate commercial demand for EVs. In 2011, electric vehicle sales in France were the second highest in the world after the US, with 2,630 units sold. The second motivation is the environmental concern with reducing tailpipe emissions in the transport sector. In France, 75-80% of electricity generated is from nuclear power. In 2011, the carbon intensity of electricity production was less than 100 g CO_2/kWh, much lower than its European neighbours that average 443 gCO_2/kWh. France is also a net exporter of electricity. Finally, the Autolib' service is provided with the intent to reduce congestion in the city center by reducing car ownership.

In the rest of the section we describe the four cases (Table 1) individually and rank and analyse them using the framework (Table 2-3).

4.2 Description

Case #1 (China, Shenzhen) BYD is a global player in the IT, energy and automobile sectors founded in 1995. The firm is a publicly listed company on the Hong Kong Stock Exchange with over 200,000 staff across 11 different sites in China. The firm has experienced doubled growth rate in 5 consecutive years and it was highly publicised when the subsidiary of well-known American investor Warren Buffet's Berkshire Hathaway Inc. purchased a 10% share of BYD in 2008. BYD specialised in mobile phone batteries in the early days, and the company has become the world largest rechargeable battery manufacturer in less than 10 years. The firm stepped into the automobile industry by creating a wholly owned subsidiary, "BYD auto" in 2003 after acquiring the Tsinchuan Automobile Company. By combining the battery technology it possessed and the production capability of automobile, BYD became a key player in the China EV industry. In this case, we discuss how BYD entered a joint venture agreement with the China Southern Power Grid as part of a pilot project for fast-charging infrastructure and services in the city of Shenzhen in 2012.

Case #2 (China, Hangzhou) Headquartered in Hangzhou Zhejiang, WanXiang group is a multi-national company supplying automotive components such as universal joints and bearings to over 40 countries around the globe. The group was the first Chinese private enterprise exporting automotive parts to the United States since 1984. Currently, WanXiang's automotive product has a local market share of about 70% in China while cooperating with global leading carmakers such as GM, Ford and Volkswagen. As an automobile component supplier, WanXiang started the R&D on pure EV in 1999 by modifying traditional cars, and the company has successfully manufactured the first self-designed pure EV in 2003. In both cases 1 and 2, an OEM has developed a joint venture or cooperation with a major electricity supplier to develop its vision. The evolution of these competing yet complementary business models is discussed.

Case #3 (US) Tesla is a start-up EV manufacturer focused on the high-end customer segment with high-performance vehicles. Tesla expanded its value proposition by providing solar energy to its customers at fast-charging stations in its sales area. Their strategy is discussed with a particular focus on their entry in the renewable energy supply function of the value chain.

Case #4 (France) Autolib' is the case of a government-led project to introduce EV sharing as a public transportation service in the city of Paris and over 40 municipalities in its suburbs. The fully vertically integrated structure of the value chain is discussed in the analysis. Autolib' provides all competencies in-house, from battery technology to maintenance and end-user services within the public-private partnership.

[1] EC 443/2009

[2] http://www.finpro.fi/documents/10304/799ceeb6-77e8-483f-8c65-4d388cefbccf

4.3 Analysis

4.3.1 BYD's Business Model (Fast Charging) - Shenzhen

Since 2005, BYD has released 3 EV models, the K9, the F3DM and the E6. The K9 is a 12-meter pure electric bus with a range of 250 km per charge. The F3DM is a plug-in hybrid EV. The E6 are five-door hatchback EVs used as taxis in Shenzhen's demonstration project operated by a joint-venture company between BYD and China Southern Power Grid. In addition to the taxi fleets, BYD offers the E6 and F3DM to private customers along with two charging posts for free at the location of consumers' preference. The free establishment of charging infrastructure is a result of the collaboration between BYD and the electricity providers in Shenzhen. The company has also built a centralised charging station for the taxis and is planning to construct more charging stations in the future when the E6 is released to the public. The business model of BYD does not directly reduces the battery, vehicle and electricity costs for potential EV users, but subsidies have been granted from both the central and local governments in seeking to address such price concerns. BYD is collaborating with infrastructure and electricity providers, but the traditional nature of its business model in selling EVs as a product does distribute risks across ecosystem players for potential EV users and does not encourage change in consumer behaviour. The high investment costs in its fast charging technology restricts business model experimentation but is adaptable in the long run as it is compatible with alternative charging systems. BYD has a clear formulation of its business model strategy and its approach to EV commercialisation has triggered technological innovation affecting the EV industrial players in China.

4.3.2 WanXiang's Business Model (Battery Swapping) - Hangzhou

WanXiang is one of the main OEMs participating in the EV demonstration program in the city of Hangzhou. There are two types of EVs supplied by WanXiang: electric buses and private EVs[3]. The electric buses were served as public transportations inside the exhibition areas during the Shanghai Expo. The private EV model HAIMA has a range per charge of 150 km with a charging time of 3 hours and a maximum speed of 110 km/h. The business model of WanXiang focuses on battery swapping and offers a battery rental model. The HAIMA EV manufactured by WanXiang Group can be rented from retailers at a monthly cost (without the battery) while the battery can be rented from the State Grid on a monthly basis (costing around 200GBP per month). However, during the first 3 years or 60,000km following the EV purchase, customers enjoy free battery usage and swapping services through a government subsidy. As a result, the entry cost and the usage cost of the EVs have been significantly reduced. In addition, WanXiang is cooperating with the State Grid on developing a standardised EV battery pack that enables a quick system for battery exchange in the station operated by State Grid in Hangzhou. WanXiang's business model effectively incentivises consumers to adapt their behaviour while reducing the risks of battery ownership and spreading uncertainties across its EV ecosystem. WanXiang has formulated its business strategy clearly through working in collaboration with the State Grid. The business model uses intelligent charging infrastructure and has diversified from a business as usual model through a change of value proposition for its potential users. However, due to the sunk costs in the co-development with other ecosystem players of the battery swapping standardisation and infrastructure, WanXiang's business model has the disadvantage of restricting alternative business model experimentations (Figure x).

4.3.3 Autolib's e-mobility service - Paris

The electric mobility service company Autolib' in France obtains the highest possible score in terms of customer financial dimensions: with the all-inclusive service package, customers pay a tariff in two components, a membership fee and a time-of-use rate. The business model therefore removes the cost burden of vehicle purchase, battery costs, and electricity prices from the customer onto Autolib'. The service is vertically integrated, i.e. all elements from vehicle concept

[3] WanXiang's passenger EVs are not used in the Hangzhou taxi fleet as opposed to the case of BYD. The EVs produced by WanXiang are part of the demonstration programme for private purchases, while the participating OEM supplying electric taxis for the Hangzhou demonstration programme is Zhongtai.

and design, to call centers and electricity charging and billing services, are provided by Autolib' and its subsidiaries. Part of the financial investment cost falls onto the participating municipalities. Therefore, a large share of the risks associated with EV technology, market evolution and infrastructure fall onto Autolib' alone. Though the business model prevents all of these risks from falling onto the customer, it scores neutrally for not distributing the risks amongst many ecosystem players. The service is limited to urban areas and does not allow long distance travel (despite the high range of the battery of 250 km). This mobility-as-a-service with electric cars requires significant change in consumer behaviour. However, the goal of Autolib' is not to cause this change but rather to take advantage of an observed trend towards services in private transport, therefore it scores a 4/5. The closed business model as is does not encourage external or internal technological innovation or enable business model experimentation. However, if the management decided in favour, it could change some elements of the business model, such as letting other OEMs to supply vehicles to their platform. The business model strategy is mostly explicitly formulated though the profitability and revenue focus do not seem to be a priority. The system does not currently use "smart charging". It is a 100% service business model.

4.3.4 Tesla's high-performance EV manufacturing- California

Tesla's business model does not address battery, vehicle and electricity costs to consumers. However, their R&D in battery technology indirectly contributes to overall reductions in battery costs. Their entry into electricity provision with free solar-powered fast-charging contributes to reducing electricity prices to customers, but is only useful for a small proportion of their charging needs. The business model focuses on high-end vehicle manufacturing and sales and does not have any particular focus on decreasing technology or financial risks for customers, or on changing consumer attitudes towards electric or private transportation. By providing the highest range EVs in the market and fast-chargers, Tesla's value proposition serves long distance travel well. The business model enables technological innovation in the rest of the ecosystem, complements, components and alternatives, by focusing on a particular part of the value chain independently of others. The business model strategy is clear on all aspects (cf definition) as can be expected from experienced entrepreneurial founder. Though Tesla have focused on a specific niche, the business model is flexible enough to be adapted to changing market conditions. The EVs are compatible with intelligent charging infrastructure though it is not intrinsic to the business model. The value proposition contains a service offering with the fast-charging system, however the main focus is on the EV product rather than a service business model.

Figure 2. Framework analysis of BYD's business model (fast-charging)

Figure 3. Framework analysis of WanXiang's business model (e-mobility services through battery swapping)

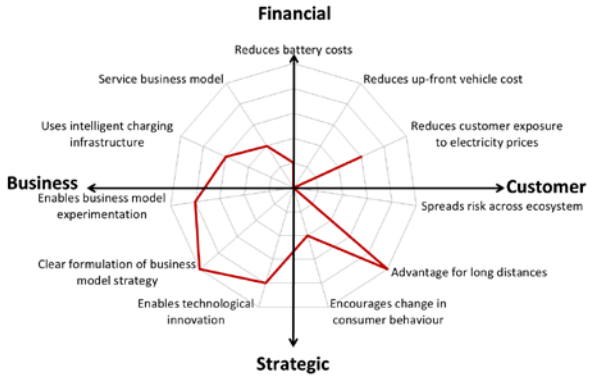

Figure 4. Framework analysis of Tesla's business model (high-performance EVs and free fast-charging)

Figure 5. Framework analysis of Autolib's business model (e-mobility services in urban metropolis)

4.4 Cross-case analysis

Four radically different business models (BYD, WanXiang, Tesla, and Autolib') have been analysed using the framework tool. The benefits of the mobility service (Autolib') and battery-swapping (WanXiang) business models seem to be weighted towards solving financial issues and customer barriers to adoption, and monetising value through service revenue for the company. In contrast, Tesla's and BYD's strengths lie in the business-strategic quadrant, due to their expert understanding of entrepreneurship and of the importance of high-performance innovation in establishing competitive leadership. Both start-up EV OEMs are moving into providing fast-charging infrastructure services to support their products.

These cases in emerging EV ecosystems show examples of companies that are succeeding at providing EVs and/or EV-related services while the rest of the market is still very immature. In practice, Autolib' which started in 2011 is about ¼ of the way to reaching its financial objective and Tesla, founded in 2007, just announced its first annual profit in 2012.

The differences in institutional environments are striking. Autolib' benefits from the financial support of local and national authorities [12]. Tesla benefits from a financially active technology innovation cluster in the Silicon Valley. BYD and WanXiang's EV projects have been encouraged by the local and central government through financial subsidies and supported by the collaborations between the demonstration program office and their electricity infrastructural providers locally. In all cases, end-users tend to be progressive early adopters and environmentally aware.

In conclusion, the cocktail for success in each of these cases with contrasting approaches, was the following:

- specialised "capabilities": focus on strengths in a particular area, either focus on the end-user experience or on the competitive strategy; each business model occupies the same total area on the figures, but in different quadrants of the framework
- a favourable context for innovation, either supported by the State (France) or by the entrepreneurial culture and community (Silicon Valley)
- a market of customers relatively receptive to innovations, particularly environmental ones.

The framework was designed to represent all the potential strengths of business models in the EV ecosystem. However, the cases have shown that strengthening one's position in a few specific areas is enough to have a viable business model. We suggest that the four companies could improve their business models by considering other aspects of the framework that they didn't previously focus on. Tesla, for example, has started thinking of consumer experience and barriers to adoption by offering fast-charging services; they could progressively increase their value proposition by offering innovative solutions around battery costs and smarter energy management. Autolib' could also increase their use of ICT and smart charging systems in their service though some dimensions, such as the range of travel for users, have limited opportunities for improvement.

5 Discussion

5.1 Competing vs. co-existing business models

From the case studies of BYD and WanXiang, we have observed competing business models for charging systems, fast-charging and battery-swapping, operating in two cities in the context of Chinese government demonstration programmes. While BYD (working in collaboration with the Southern Grid) are developing a fast-charging business model in the city of Shenzhen, WanXiang (working with the State Grid) on the other hand are seeking to implement the battery-swapping model in the city of Hangzhou. Compared with BYD, the battery-rental model of WanXiang has certainly shown strength in reducing the financial barriers of the high upfront cost for potential EV users. However, it is unclear at this stage whether this business model would be sustainable in the long term without the government subsidy for the cost of batteries and the battery-swapping stations operation. Through this country-wide demonstration programme, the government is able to encourage different types of business models to compete and evaluate against the advantages and disadvantages of each, so as to deploy a wider infrastructure project for EV emergence for the next stage of its industrial development.

5.2 Partnership strategies along the value chain

Tesla focused on producing highest quality EVs in the sports car market at first and then expand their target with a mass-market EV. Tesla started investing in solar-powered fast-charging stations, a move downstream into providing electric charging services, perhaps in reaction to insufficient dynamic competition in the charging infrastructure sector. This case shows that it is possible to remain an aggressive competitor with a very targeted strategy – become the leading entrant in EV manufacturing – while leaving opportunities open for other ecosystem competitors around it to develop, whether in the vehicle sector or in downstream charging and mobility services. In comparison, Better Place[4]'s strategy implied asphyxiating any other competing business model at the level of charging services.

In contrast, while Autolib', WanXiang and BYD's vertically integrated organisational structure may have been effective at launching the service quickly, it prevents any competitive ecosystem for similar or other types of EV services from developing. The "in-house" strategy is advantageous in the medium term but once the market evolves with new demands and innovative alternative services, the business model will be threatened.

5.3 Recommendations

Our 3 main recommendations based on this research for entrants in the EV industry at any level of the value chain, are the following:

1. Leverage ecosystem resources
2. Design a flexible business model: be prepared for ecosystem reconfiguration
3. Capitalise on your specific competencies, then expand your value proposition.

- **Leverage ecosystem resources**

Companies that will succeed in the EV ecosystem will be the ones that are able to envision a shared future for the ecosystem as a whole and build strong partnerships and alliances with both complementor and competing firms. In defining a strategic positioning and value proposition for EVs, whether it is in selling EVs and providing charging services, or selling electricity and providing additional services such as smart home energy management systems, companies must fully map out the resources and capabilities of the network of firms around them. Designing a business model that is compatible with other players in the ecosystem and that makes best use of their capabilities is essential.

Autolib' in France, for example, leveraged its internal knowledge of lithium metal polymer battery technology [12] as well as its capabilities from its parent company (Bollore)'s subsidiaries: IT services, infrastructure and logistics, while building partnerships to integrate external competencies in vehicle design and

[4] Better Place is a battery-swapping company founded in California that pursued an aggressive fundraising strategy that filed for bankruptcy protection in May 2012.

manufacturing. BYD and WanXiang, as OEMs who realised the necessity of building a charging network to support their EV sales, entered partnerships with utility companies to leverage their competencies in energy infrastructure and services. They both also leveraged the support from local and central government. Tesla started its operations in California, where the favourable investment environment due to a successful entrepreneurial culture supports competitive and dynamic innovation in the area. Mobility service company Move About, for example, developed its corporate EV sharing service in Norway, where tax and others benefits for EVs have favourable impacts on their market success either indirectly or through direct financial impacts [13]. These examples highlight that understanding the socio-political context for EVs is a key part of an ecosystem strategy.

- **Be prepared for ecosystem reconfiguration**

Second, the rapidly evolving EV ecosystem requires business models that are able to adapt to changing external conditions. For example in the OEM functions, if market demand takes the direction of a specific technology such as PHEV or EV, OEMs must have the manufacturing and design platforms ready to launch either vehicle [14]. In the charging business, standards for charging must be developed as open platforms that find the least common denominator for other players in the industry.

- **Excel in specialised competencies, then expand the value proposition**

All cases start out in niche markets and have different expansion strategies and potential. Autolib' will use its battery technology in markets for energy storage and services [12], while its mobility service know-how will help it replicate its business model in other cities and countries, either through the provision of consulting services or through direct involvement. WanXiang is aiming to consolidate its EV supply chain through increasing its control of the core component manufacturers through acquisitions of lithium ions batteries companies (e.g.A123 in the US). Tesla is exporting its mid-range Model S worldwide and can expand its manufacturing base to meet increasing demand. As mentioned previously, WanXiang, Tesla and Autolib' succeeded in establishing an EV business by focusing strongly on a specific area of strength: customer-centric WanXiang and Autolib' address customer financial barriers to adoption of EVs, while entrepreneurial Tesla and BYD built an effective business strategy.

The third recommendation is therefore to incorporate new competencies identified from the framework into the business model. For example, a company that has been particularly good at designing the customer experience should think of focusing on business strategy and financial advantage dimensions, e.g. by developing optimisation systems with intelligent charging networks, or transitioning into service revenue models.

5.4 Generalisability of findings

While each of the company strategies was embedded within a specific socio-economic, political and environmental context, which allowed for very different business models for EVs to emerge, the main recommendations above are applicable to all settings of EV ecosystem emergence. The framework offers a comprehensive way of thinking about business models in the EV ecosystem: from the consumer and the business perspective, and including strategic and financial value. It integrates views on barriers to adoption and enablers of value creation and capture. While the business models in the cases would not work directly (as they are) in other countries or cities, companies in other locations can assess their strengths and strategic objectives in comparison with them. In addition, demonstration programmes using competing business models are recommended in the early stages of industrial development to develop co-opetition in the EV ecosystem.

6 Conclusion

In summary, this paper has explored a spectrum of business models operating in the current EV sector. Employing an original business model framework developed through literature, four case studies of BYD, Wanxiang, Tesla and Autolib (from China, the US and France respectively) have been analysed. From the cross-case analysis, we have gained insights on the competing business models of fast-charging and battery-swapping between BYD and Wanxiang and their co-existence in the context of the Chinese government demonstration programmes. Moreover, the partnership strategies within the

EV ecosystem of Tesla and Autolib has provided learning points regarding the ways in which organisations configure their position and relationships in seeking to lead EV ecosystem emergence. Concerning the business model framework, both Autolib and Wanxiang have demonstrated strength in the Financial and Customer dimensions through the benefits of mobility-as-a-service and battery-swapping. In contrast, BYD and Tesla obtained higher scores in the business-strategic areas because of their entrepreneurship driven ethics and their goals in achieving high-performance innovations. Through these analysis, we provided three recommendations for industrial players who are seeking to operate in the EV ecosystem: 1) Leverage the ecosystem resources; 2) Design a flexible business model and be prepared to reconfigure your ecosystem and 3) Capitalise on your specific competencies and then expand your value proposition. As a result, the paper has offered practical contribution concerning the development of a multi-dimensional framework as a tool to help firms in the EV ecosystem systematically evaluate their business model propositions.

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