

Incremental Innovation: Range Development and Innovation in Tesla's New Energy Batteries

Ling Peng*

Department of Sociology, University of York, Heslington, York, UK

**Corresponding author: 1309135036@qq.com*

Keywords: Tesla Motors, Innovation, Incremental Innovation, Product Markets, Management Strategy

Abstract: The impact of climate change is of great global concern and has led to a general consensus on the use of alternative energy sources to reduce carbon emissions. However, in the alternative energy vehicle market, Tesla Motors (hereafter Tesla), a pure electric vehicle startup, has been at the forefront of electric vehicle technology and is also a leader in battery range [1]. Tesla, as the current temporary leader, serves as the case study for this paper. This paper is an outline of Tesla's current new energy battery innovation and development projects, divided into three modules, including an overview of innovation types, sources of innovation and projects close to commercialisation. Finally, by discussing Tesla's capabilities and future challenges, new ideas and directions for the development of innovative enterprises are provided.

1. Introduction

With the development of batteries, and concerns about the increasing reserves of ore energy and oil prices, major car manufacturers have begun to experiment with new energy vehicles[2]. Some of the oldest companies, such as Ford and Toyota, have introduced battery cars and hybrid electric vehicles, but still seem to have failed to solve the range problems that have plagued new energy vehicles for almost a century[3]. Fortunately, however, Tesla, a start-up car manufacturer, has been innovating in terms of range[4]. The Roadster, the first all-electric sports car with lithium-ion batteries, was launched in 2008 and was the first electric car to travel more than 200 miles on a charge. Tesla Motors, an alternative energy startup, has grown to become the world's leading electric vehicle company[5]. However, at present, there are a number of emerging electric vehicle brands in the electric vehicle sector, and traditional fuel car manufacturers are also accelerating the development and production of electric vehicles[6]. Therefore, the competitive pressure in the new energy vehicle market can be seen as having an upward trend.

Tesla, founded in 2003, is an American automotive company that offers a variety of innovative electric vehicle models, solar systems, and charging infrastructure worldwide. These models have relatively high range, acceleration, speed, high safety, unique design, and digitization. As the spokesperson for electric mobility, Tesla is the most valuable autonomous driving company with a market value of \$848 billion (as of January 2021), and its market value even exceeds the combined market value of its nine largest competitors. Therefore, the competitive pressure in the new energy

vehicle market can be seen as an upward trend. Therefore, this article chooses to summarize and analyze the innovative development of Tesla battery products. Firstly, it analyzes the innovative types of Tesla battery products, namely incremental innovation. Secondly, it explores Tesla's innovative development from the perspectives of knowledge innovation and open source innovation. Thirdly, analyze the significance of Tesla's innovation from a commercial perspective and how Tesla drives the market through innovation. Finally, by analyzing the current problems of Tesla, suggestions are proposed to promote the development of the enterprise.

2. Incremental Innovation

Tesla's leadership in the electric vehicle industry is inseparable from the company's battery leadership. Specifically, Tesla's innovations in battery range can perhaps be considered incremental. As Tidd (2018) argues, innovation is more than simply opening up new markets; it can also provide new ways of delivering established and mature services[7]. Tushman and Romanell (1985) identify organisational change as Radical and Incremental, based on these two types. Where Radical change is argued that organisations should change their current practices and create a new paradigm that will respond to current obstacles[8]. Incremental, on the other hand, is seen as the organisation maintaining the status quo and moving in a better direction. In other words, Incremental is similar to doing better than before. In the case of Tesla, the company's innovation in the area of batteries is evident to all[9].

Table 1: Different types of Tesla cars and range (Tesla, 2022)

Type	Description	Range in miles	Price in US \$
Tesla Roadster 2008	<ul style="list-style-type: none"> ● Release 2008 ● 2 doors ● Convertible coupe 	244	109000
Model S	<ul style="list-style-type: none"> ● Release 2012 ● Four Door ● 7-seater ● sport sedan 	259-335	69500-97500
Model X	<ul style="list-style-type: none"> ● Release 2015 ● 4 doors ● SUV 	200-325	80000-144000
Model 3	<ul style="list-style-type: none"> ● Release 2018 ● 4 doors ● Hatchback ● Compact sedan 	220-310	35000-44000
Model Y	<ul style="list-style-type: none"> ● Release 2020 ● 7-seater ● Midsize SUV ● Hatchback 	280-330	39000-47000

From 2016 to the present, Tesla Motors has been working on a battery development project. Table 1 shows that from 2008 to 2020, Tesla's battery range increased from 244 feet to 330 feet, yet the price of the car dropped from \$109,000 to \$39,000. Recently, Tesla announced the next generation of its new battery, the "4680", to increase range and reduce the price of Tesla cars. In addition to this, Tesla is offering several different types of electric vehicles with varying ranges

around the world in an attempt to meet consumer demand for an electric vehicle range. From what has been discussed, we may conclude that Tesla can be seen as incremental change in the battery program.

2.1 Product Markets

In the electric vehicle industry, customers are perhaps more concerned with the range of the battery and its performance when choosing an electric vehicle brand [10]. Therefore, the big challenge facing the industry today is whether the driving range and the life cycle of the battery can meet the needs of the customers [11]. On the other hand, some data show that electric vehicles increased from 11 to 61 vehicle models in just two years between 2008 and 2010. This varies in terms of the price of the vehicle, the range of the battery and the infrastructure for charging. As can be seen, the demand for electric vehicles is booming and the industry is highly competitive. Nevertheless, according to [12], Tesla is firmly in first place in terms of market share in the all-electric vehicle segment. This means that Tesla's products are better able to meet the needs of consumers.

Tesla's ability to better meet consumer demand and occupy a front-row market position is perhaps based partly on its superior battery technology (long life, high range). However, the company's vision is to build mass-market battery electric vehicles (Tesla, 2021). And, with Tesla's value proposition being "best in class", Tesla, as a major player in electric vehicles, aims to offer some of the best in class electric vehicle models, as can be seen from Table 2, which rates 10 different brands of battery electric vehicles on 11 criteria [13] The best electric car in the first place was the Tesla Model S, with the most prominent advantages considered to be range, acceleration, top speed and maximum power. This was followed by the Renault ZOE and the Hyundai Ioniq EV. This shows that the Tesla car has a more pronounced advantage when comparing cars of the same type.

3. Innovation Knowledge and Sources

Table 2: Type of Knowledge, Sanchez (2004).

Explicit knowledge	<ul style="list-style-type: none"> ● Formal and documented knowledge that is easily accessible, recorded and applied. ● Shared in the form of data, specifications, manuals. ● Plans, technical specifications and innovation projects within the organisation.
Tacit knowledge	<ul style="list-style-type: none"> ● Personal knowledge, including the knowledge of employees and managers in the organisation. ● A combination of expertise, experience, skills, ideas, competencies and values. ● Not formalised or documented.
Market knowledge:	<ul style="list-style-type: none"> ● Knowledge about the needs, requirements and demands of customers and their business processes. ● Feedback on customers' needs and requirements. ● Provides an assessment of the value of the new product/service.
Technical knowledge	<ul style="list-style-type: none"> ● Knowledge of manufacturing or production methods and tools, including the level of education, work and technical experience of employees. ● Specific investments.

Organisations appear to rely on innovation to adapt to changing circumstances and to bring innovative products to market. Scholars have shown that innovation is a combination of ideas and knowledge that can bring change and value to organisations [14]. Furthermore, within organisations, knowledge is divided into explicit and tacit knowledge, market knowledge and technological knowledge, according to the theory of knowledge management [15]. It may be possible to distinguish between different types of knowledge through Table 2, however, the complexity of innovation may be increasing as the knowledge available to the organisation grows and the development and exploitation of new knowledge are fundamental to innovation. Therefore, strong innovation must support knowledge management.

The success of Tesla is evident in the type of knowledge. Among others, manager Elon Musk as a transformational leader is considered one of the best studied analyses of strengths within Tesla, which seems to affirm that the success of the organisation relies on strong organisational managers [16]. Whereas Tesla's marketing strategy and always an ongoing investment in technology seems to better build the organisation's understanding of the market, as well as its own technological capabilities [17-18].

Tidd argues that the sources of innovation may be in areas such as Knowledge push, need pull, making processes better, crisis driven innovation, users as innovators. Knowledge push innovation has long been considered as a source of innovative start-ups [19]. In addition to this, Tidd shows that demand pull is particularly important at the maturity stage of an industry or product life cycle when there are multiple products to choose from.[20] Therefore, when studying the sources of innovation in Tesla, a diverse approach is taken to find the key innovation signals.

In terms of knowledge and demand as sources of innovation, it can be seen that Tesla's knowledge-driven innovation may be reflected in its upcoming next generation battery, the '4680', in the face of competing products with multiple options. However, of Tesla's 250 patents, those on batteries account for about half of the total [21]. Despite the leading technology, there is still fierce competition in the electric car market, with the Volkswagen Group planning over 70 new electric car models by 2030, Toyota is trying to electrify 50% of its models by 2030, and Apple planning to launch the Apple Car by 2024 [22]. This goes to show that there is strong consumer demand in the electric vehicle market to attract investment from large companies. This shows that knowledge-driven demand innovation is one of the sources of Tesla's innovation.

Another source of innovation that promotes knowledge flows within and outside the organisation appears to be restructuring innovation. Improving one's own knowledge while absorbing new knowledge is perhaps inevitable. As Hargadon and Sutton have argued, many firms are able to offer a wealth of innovative possibilities, mainly because they deliberately recruit teams with different industries and professional backgrounds. [23] Although Tesla employed JB Straubel, a lithium battery specialist, in its early team, it went on to acquire Maxwell, a manufacturer of ultracapacitors, as a way of taking over responsibility for battery technology[24]. It is thus clear that in the battery sector, Tesla has recruited and acquired other high-tech battery companies in order to achieve its own Tesla is recruiting and acquiring other high-tech battery companies in order to develop its own innovations in the battery sector.

3.1 Open Source

Tesla may have adopted a combination of internal and external open innovation. Open innovation is seen as maximising. Chesbrough (2003) through the collaboration of internal and external ideas [25]. Tesla's internal sources of innovation might be considered effective partnerships. Tidd (2014) argues that a creative climate, such as the development of organisational structures, communication policies and procedures, and reward and recognition systems provide creativity for

the organisation. And, Bass (1999) shows that transformational leaders motivate employees more intellectually than traditional leaders who emphasise normal practices[26]. What is certain is that Tesla executive Elon Musk has posed a new challenge: to implement open innovation and motivate employees to question traditional practices[27]. However, open source as part of an open innovation strategy, Tesla is also driving the electric vehicle market by developing an IP portfolio. Tesla's adoption of open source, i.e. patent sharing, has not only contributed to the global development of electric vehicles and impacted the internal combustion engine market. On the other hand, Tesla is seen as exporting technical standards through Patent open sourcing, implicating the construction of charging facilities, unifying charging standards for electric vehicles and creating a quality supply chain. Thus, it may be better to establish a business model than to enter the market first, and open source may bring maximum benefits.

However, the inevitable way in which innovation processes learn is from outcomes, even if they represent 'failures', and Tidd argues that accidents, as nasty interruptions, can also open up new innovations [28]. In this way, emerging trends, potential designs, etc. can be explored and refined in a process of continuous learning. Although Tesla is currently successful, the difficulty of innovation for start-ups cannot be overlooked, and scholars argue that until one enters the mainstream market, perhaps innovation is a case of 'learning as you go', trying things out, making mistakes, but using experience to get closer to what is needed. This is why Tesla takes an incremental approach to the innovation process, providing a more favourable opportunity for start-ups.

4. Commercialisation

In the product innovation process, the process by which a new product is introduced into the commercial market is considered commercialisation. Kitchen (2007) shows that new product commercialisation focuses on the match between the technical aspects of the new product and the market demand [29]. On the one hand, companies should focus on technology integration. On the other hand, new product commercialisation focuses on the launch of new products. As it is clear from the above that Tesla is a technological leader in new products, this section reports on the product launch process for new product commercialisation.

4.1 Product Launch

Notable in the product launch process is Tesla Battery Day. Benedetto (1999) argues that an effective product launch is a key driver of optimal performance [30]. Despite presenting the company's third master plan outlook back in the October 2019 Tesla earnings call, the focus fell on batteries [31]. However, at the Tesla AGM and Battery Day event on 22 September 2020, Tesla announced the production of a new next-generation battery, the '4680', to attract consumers with several times more range and a lower price [32]. This is still notable, however, as the primary determinant in the decision of electric car buyers is battery range, and the battery advantage will draw more market share for Tesla in the face of industry competitors.

4.2 Sales Strategy

Unlike traditional dealership sales models in the automotive industry, Tesla markets and sells its vehicles directly to consumers. The new products for this launch are still being sold in the same way as they have always been sold. After customers are satisfied at the experience centre, they place their orders on the Tesla website: offline experience, online customisation and self-owned 4S sales strategy. According to Jing (2020), direct sales facilitate Tesla to have all the information about its customers and not only reduce the pressure on inventory but also price transparency compared to

the traditional on-board sales model [33]. In addition to this, Tesla has a high degree of vertical integration, with a supply chain from components to charging stations to meet demand [34]. However, the perfect customer requires better coordination between customer service, product development, marketing and operations within Tesla. As a result, Tesla differs from the traditional automotive industry in its sales strategy.

To achieve Tesla's main goal, Tesla also utilises a degree of traditional advertising, including product placement in various media channels and paid advertising on websites and media apps relevant to its target demographic [35]. And online campaigns are also run in advance of the launch of new products on battery day (Tesla.com, 2020). On the other hand, in the customer generation program, Tesla has made different strategies based on three different consumer groups. Despite previously adopting a segmented high-end sports car market, however, for the launch of the new battery 4680, capturing investor and consumer demand with a longer range and lower price, perhaps with more of an objective of mass production and market penetration. This provides the latest impetus for Tesla's electric vehicles and will win Tesla futures markets.

5. Conclusions

The ability to attract consumers and investors is important for start-ups. However, Tidd (2018) shows that there is no way of knowing what the 'right' configuration of technological means and market demand is, and so a range of players, including many new start-ups, have engaged in extensive experimentation and rapid learning. [36] For example, Better Place, which had raised over \$850 million since its inception in 2007, announced in May 2013 that it would cease investment in the company and shut down operations [37]. Despite the company's financial failure, it is clear from the company that the separation of vehicle and battery ownership did not benefit the company. Furthermore, Better Place has only established a partnership with one car manufacturer, Renault, which has failed to achieve its market share targets in Israel [38]. Therefore, relying on a single car manufacturer to produce a bespoke electric vehicle may be too limiting. It is clear that startups need to consider more about the market, the technology and their own shortcomings in order to succeed.

5.1 Current Disadvantages

Considering its own shortcomings, Tesla Motors' disadvantage may be its lack of capacity. Studies have shown that although Tesla has four superfactories, the capacity of the factories cannot keep up with customer demand [39]. Currently, Tesla is adding partners, including Toyota, which is also a car company. In addition to this, Tesla's new energy electric vehicles consist of three parts: the lithium battery, the electric motor and the complete vehicle. Tesla has also chosen a strategy of decentralising suppliers as a way to increase production. Nevertheless, for start-ups, 50% of them consider retention to be a key talent management challenge. Therefore, Tesla needs to establish a talent pipeline to its contact centre and the wider organisation in order to enhance its creativity. Overall, Tesla Motors have not reached full maturity and is still strategising its development and making timely adjustments to the market.

Tesla has made timely adjustments in the corresponding weak areas, however, the range is often a limiting factor for electric vehicles and a major concern for customers. This is despite the fact that in 2015 the Honda Fit electric car had a range of only 82 miles. Other established companies such as Ford, Nissan and Mitsubishi were late to the market in terms of electric vehicle technology. However, the rapid growth of Tesla vehicles has prompted these established names to begin launching their own electric vehicles, albeit with range figures that lag far behind those of Tesla vehicles. For the pre-release of Tesla's latest battery, and the research Tesla has been doing in the battery sector, it is probably safe to assume that Tesla Motors are currently leading the way in the

battery sector and growing immeasurably.

6. Reflective Statement

Tesla Motors has been working on the development of the range of its vehicles and the pre-launch of the new battery "4680" has attracted the attention of consumers. Tesla Motors has certainly pushed the boundaries of the pure electric vehicle industry and is constantly innovating with new products to meet the needs of the public in order to continue to compete in the market. However, Tesla has been open to innovation and has continued to compete. However, while Tesla is open to innovation, it needs to adapt its strategy effectively and in a timely manner to meet the strong competition in the market. In addition, Tesla's development in the battery sector could perhaps benefit from more policy support in order to obtain more financial support to further the green consensus.

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