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Evolution Path of Business Model in China's New Energy Vehicle Industry: Policy Impact and Technology Drive

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Abstract—With the decline of subsidy policy and implement of "double credit policy" in new energy vehicle industry, business model innovation will play an increasingly prominent role in the new energy vehicle industry. By analyzing the characteristics of policies, technologies and business models of China's new energy vehicle market, and based on sociotechnical transformation theory, this paper constructs a business model evolution model under sociotechnical transformation. Then base on this model, there exist seven business model evolution paths from the perspective of sociotechnical transformation. For China's new energy vehicle industry, five typical business model paths are studied in depth from four factors: landscape, regime, technology niche and business model. The research shows that the business model evolution model under sociotechnical transformation can clearly interpret the business model evolution path of China's new energy vehicle industry. With the development of China's new energy vehicle industry in the future, the impact of policy regime on business model innovation is weakening, and technology niche plays an increasingly important role in business model innovation.

Keywords—new energy vehicle industry; sociotechnical transition; business model; evolution path

I. INTRODUCTION

Affected by the global energy crisis and environmental problems, China's new energy vehicle industry has been rapidly developed with the support of industrial policy and technology innovation. By 2018, the total number of new energy vehicles in the world exceeded 5.5 million, and the total number of new energy vehicles in China was 2.997 million, accounting for 53% of the global market share [1]. In 2018, There sold 1.256 million new energy vehicles in China, increasing 61.7%, accounting for 62% of global sales, and occupies the top position in global sales [2].

The rapid development of China's new energy vehicle industry is attributed to industrial policy, technology innovation and business model innovation. Since 2001, Chinese government has issued more than 100 policies covering strategic planning, tax reduction, laws and regulations, and institutional establishment. In particular, in 2001, the National "863 Program" New Energy Vehicle Major Project, the "Ten Cities and Thousand Vehicles" "Energy Saving and New Energy Vehicle Demonstration and Application Project" in 2009, the "Continuing to Promote the Application of New Energy Vehicles" in 2013, the "double credits" in 2017, and related charging construction policy, which all play positive guiding roles on NEV. Driven by a series of policies, China's new energy vehicle technology has gradually improved, as following characteristics: firstly, types of products are more abundant. According to the "New Energy Vehicle Promotion and Application Recommended Model Catalogue", there are 2337 kinds. The models entered 11 effective catalogues and enjoyed central financial subsidies. Secondly, models of high energy-density increased significantly, while the highest density reached 182Wh/kg, and the models below 120Wh/kg were gradually phased out. Thirdly, the mileage range of vehicle is increasing year by year, and the maximum is 520km at present which replaces the medium and low range models and becomes the market mainstream. The battery technology and diversified products accelerate the survival of the fittest and promote the vigorous development of NEV.

In the future, with the cancellation of subsidy policy for in 2020, subsidies are gradually disappearing. At the same time, the long-term and high-input characteristics of technology have slowed down the commercialization of NEV, which has brought new challenges to the commercial operation. As an effective means to realize commercialization [3], the business model plays an increasingly important role in the operation of new energy vehicles. Under the same technical conditions, the application and business model innovation is benefit to the market. For emerging industries, the correct business model is really rare [4], thus evolution path study of business model, which not only has a theoretical contribution to the research of emerging industries that are different from traditional industries, but also has practical significance.

II. LITERATURE REVIEW

Business model, which is defined from the four perspectives of economy, operation, value and integration

concept. The economic business model answers what is the potential economic logic, and believes that the business model is that enterprises obtain a competitive advantage and provide customers with better logic algorithms than competitors through resource acquisition [5]. The definition of operational business models emphasizes resource dependence and restructuring of internal structures. The operational business model is described as a mechanism of "content, structure, and governance" [6], explaining that business models are a collection of activity choices, activity system structures (how), and who perform activities (who). The concept of the value field emphasizes that business model is the general structure of value creation and the topological relationship between value creation partners [7]. The concept of integration believes that business model is a collection of institutional, structural and strategic intent arrangements for enterprises to obtain excess profits together with stakeholders based on their own resource capabilities and external conditions [8]. The concept from integration includes all aspects of organization, strategy, profitability, operation, etc., and contains many elements.

Scholars also conducted in-depth research on the relevant variables of business models, of which business model as an intermediary variable. Chesbrough and Rosenbloom [9] argue that the business model is "the coordination and transformation mechanism between technology and value creation." Teece [10] believes that business models provide consumption patterns and value creation, transforming them into economic output through customers and markets, thereby reducing the “gap” between technology.

With the development of industry and cooperation between enterprises, business model is no longer a conception of enterprise level, but the comprehensive role of participants in all aspects of value chain. Beattie and Smith [11] argue that business model is a unit at the industry level. Combined with literature, this paper believes that the essence of business model is the internal mechanism of value creation, value proposition and value acquisition. It is the way to pass technology to value, which is reflected in practice. As an important mediator of technology and economic value, business models are influenced by external factors on the industry level.

Sociotechnical transition theory has been introduced to explain the industrial conception [12-14]. Sociotechnical transition theory is the result of the interaction between macro landscape, meso-regime and micro-technology. Due to the interaction of three elements, new product, new organization, and new business model will emerge to replace the original sociotechnical system. Christina et al. [15] pointed out three roles of business model in sociotechnical transition. First, business model as a part of sociotechnical system, hindering transformation by strengthening stability. Second, as an intermediary variable between technical niche and institution, business model improves the stability of technology innovation, breaks the way from niche to institutional level and promotes transformation. Third, business model is a non-technical niche, which promotes transformation by establishing new innovation mechanisms. Loorbach and Wijsman [16] later studied that enterprises are reorganizing existing business models according to changes of landscape and social technology. Although there is no consistent theoretical framework linking business models to market, industry, and society. Sociotechnical transition theory plays a theoretical role in supporting business models in sustainable market [17].

Some scholars have applied the theory to study the evolution path of business models. Geels [18] pioneered five technology transformation paths: reproduction process, transformation path, de-alignment and re-alignment path, technological substitution, reconfiguration pathway. Boons proposed three business model evolution paths by studying institutional innovation: optimization (stability), restructuring (dynamic), and system innovation (change) [19].

Multi-level perspective (MLP) is used to analyze the interaction between technology and social factors, and to explore the change in s sociotechnical mechanisms. MLP can be applied to the transportation field and to explain technology diffusion of participants [20]. Geels divided MLP into three levels: macro level, with a large landscape that affects oil prices, international politics, oil peaks, middle level, including user practice, market, infrastructure, organization, social technology knowledge, micro level, such as the emergence of new technologies, stakeholder participation [18]. Scholars have also applied MLP to the field of new energy vehicles. Figenbaum studied Norwegian electric vehicles and applied MLP to analyze the role of niche, regime, governance and opportunities in the Norwegian electric vehicle industry [21].

As a strategic emerging industry, the new energy vehicle industry is a typical sustainable industry and a sociotechnical transition system. This paper constructs a business model evolution model, focusing on the typical path of business model in China's new energy vehicle industry, and revealing the external factors driving the business model at the industrial level.

III. Method And Framework

This paper constructs a business model innovation model from the perspective of sociotechnical transition. See Figure 1.

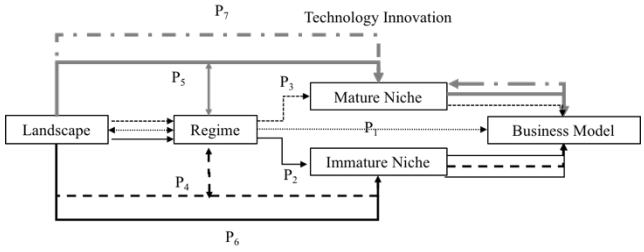

Figure 1 Business Model Evolution Model

A. Macro Level: Landscape

The specific landscape of new energy vehicle industry includes global energy crisis, environmental pollution and economic environment.

B. Meso-level: Regime

Referring to Steinhilber [22] put forward six characteristics of regime, this paper divides into three levels: social infrastructure, the strategic planning, governance, and the infrastructure construction; the second level is aimed at enterprises, including R&D incentives, technology and standardization, tax incentives, etc.; the third level is consumer, consumer incentives, purchase subsidies, public awareness and so on.

C. Technical niche

Battery technology is one of the three key technologies to promote the new energy vehicle industry. Battery materials, especially battery cathode materials, are at the heart of power cell technology innovation. Power batteries mainly include lead-acid battery, nickel-hydrogen battery, lithium-ion battery, hydrogen fuel cell, lithium air batteries, lithium-sulfur battery, solid-state battery, graphene battery [23]. In this paper, the technical niche is divided into immature niche and mature niche. Drawing on the definition of the maturity of new materials technology in the "New Material Technology Maturity Grade Division and Definition" (2018) standard issued by the Ministry of Industry and Information Technology (MIIT), the technology maturity is divided into laboratories (grade 1-3), engineering (grade 4-5) and industrialization (grade 7-9) three stages. [24]. This paper considers that the grade 1-6 are an immature technology niche, while industrialization means a mature niche.

D. Business model

According to the application field, typical business models that match the technical niche include: large-scale event, public transportation, car-sharing, and private purchases [4].

The business model evolution model from the perspective of sociotechnical transition represents the interaction of four elements sociotechnical transition elements and business model elements. P1, P2, P3, P4, P5, P6, and P7 are the seven evolution paths of the business model (Figure 1). The seven paths show the interaction between the landscape, regime, technological niches, and business models, and most of them have typical cases in the actual market, as shown in Table1.

TABLE 1 TABLE TYPE STYLES

Route	Name	Case	Description
P1	Landscape→Regime→BM	—	—
P2	Landscape→Regime→Immature Niche→BM	Tesla:Roadster	18650 LiCoO2 is an immature niche
P3	Landscape→Regime→Mature Niche→BM	BYD:battery technology	Li-Fe Lithium ion battery is mature niche
P4	（Landscape＋Regime）→Immature Niche→BM	Future battery	Lithium air, lithium sulfur, solid and graphene battteries are commercialized as immature niches
P5	（Landscape＋Regime）→Mature Niche→BM	Ternary lithium battery	The OEM cooperates with the battery factory to select ternary lithium battery
P6	Landscape→Immature Niche→BM	—	—
P7	Landscape→Mature Niche→BM	Phase out gas and diesel cars	Global government and OEM announced phasing out gas and diesel cars

IV. THE EVOLUTION PATH OF BUSINESS MODEL

A. Path 1: Business Model Expansive Innovation

At the beginning of China's new energy vehicle industry, it was less affected by the external landscape. The starting point of "Industrial Structure Adjustment Guidance Catalogue" is based on the adjustment of industrial structure, which stems from the demand for internal manufacturing industry upgrading, and has not yet touched on the issue of energy conservation and environmental protection.

Although the technology was in the research that is not mature, regime still supports R&D investment. The Chinese government, local government and enterprises had a total of 2.4 billion yuan to support R&D.

In terms of technical niche, the eight categories were handed over to the China Automotive Research Center for special research in 2008. During Beijing Olympic Games, 500 energy-saving and new energy cars service which were provided by Changan, FAW, BAIC, Foton, Shanghai Volkswagen, Jinghua Bus, Dongfeng Motor and other enterprises. From laboratory stage to the application stage, the maturity of the battery technology has risen from grade 3 to grade 6, but it has not yet reached industrialization.

Business model based on the immature technology niche appeared large-scale event demonstrations, and the subsequent Shanghai World Expo and Shenzhen Universiade extended the model（see Figure 2）. This business model path has a positive impact on the industry during the incubation and research and development phase.

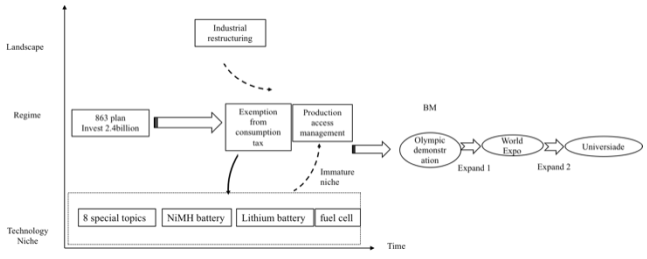

Figure 2 Pathway of Business Model Expansive Innovation

B. Path 2: Business Model Imitative Innovation

With the landscape turn abrupt, and the external voice is increasing, regime is greatly adjusted. Under the condition of stable regime, the immature niche is gradually cultivated into a mature niche, and the technical niche uses the opportunity window opened by the landscape to try to replace old technology. The business model applies an alternative technology niche to the traditional commercialization evolution (Figure 3). At this path, new business model and old business model have a competitive relationship.

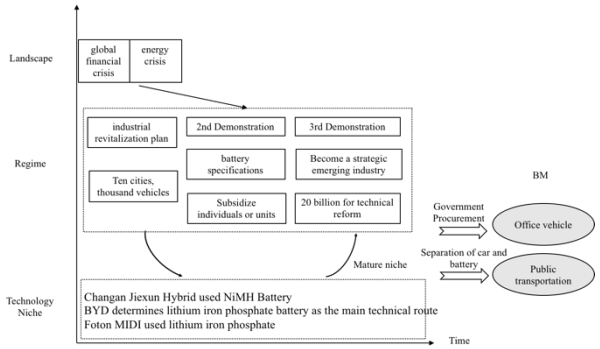

Figure 3 Pathway of Business Model Imitative Innovation

The global financial crisis in 2008 trigger the development of the new energy vehicle industry. Global governments put the energy crisis on the agenda.

In the context of economic turmoil and energy austerity, Chinese government accelerated the pace of developing new energy vehicle industry. In 2009, nine guiding policies were issued and more participants were called in. The concepts of "energy saving" and "clean energy" frequently appeared in the policy. The central government launched "Ten Cities Thousand Vehicles" project and identified the first 13 demonstration pilot cities. Until 2011, a total of 25 cities became the first round of new energy vehicle promotion cities. In 2011, new energy vehicle was listed as one of the strategic emerging industries and officially written into the "Twelfth Five-Year Plan".

As external pressures increase, incumbent companies actively adapt to regime changes and use mature niches to open new markets. Changan used mature technology nickel-metal hydride batteries for hybrid vehicles [23], and officially mass-produced the first self-owned hybrid car in China, Changan Jiexun. In addition, BYD's lithium iron phosphate is also a typical technology. BYD quickly achieved overtaking and became a leader in the new energy vehicle market.

The business model involves two aspects, government procurement and public transportation. By the end of 2012, the number of new energy public transportation in the country reached 11,000 [25]. By the end of 2013, cars in more than ten demonstration cities across the country, totaling more than 3,300 [26].

C. Path3: Business Model Subversive Innovation

Great changes have taken place in the external landscape, such as the new technological revolution. The regime undergone a series of innovative adjustments to adapt to changing landscape and technology niches. When the influence of the policy regime on the technical niche becomes smaller, the landscape can directly affect the technical niche (see Figure 4).

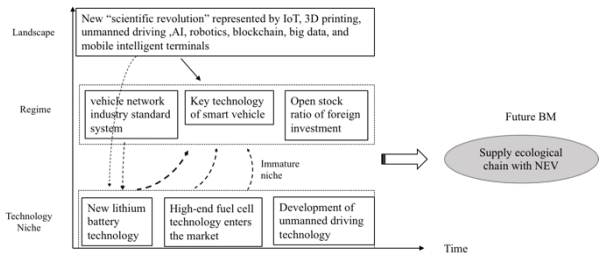

Figure 4 Pathway of Business Model Subversive Innovation

At the regime level, the Chinese government encourages smart technologies, while actively to adjust the structure of the vehicle industry to promote the diversification of the business model. The "Guide to the Construction of the National Car's Network Industry Standard System" was launched in 2017 to outline the blueprint for future new energy vehicles. Secondly, in terms of industrial restructuring, the "Guidance Catalogue for Foreign Investment Industries" was issued, which clearly stipulated the restrictions on the number of joint ventures established by foreign companies in China to produce pure electric vehicle products and batteries. All the changes mark China's auto industry entering an open competition.

Technology niche presents the following three development trends: First, the new lithium-ion batteries are developing rapidly. Huawei has released the latest technology of graphene batteries. Second, the high-end technology of fuel cell vehicles has also begun to enter the market. Global fuel cell vehicles including Toyota Mirai, Honda Clarity. Third, intelligent electric vehicle technology will greatly change the pattern of the entire automotive industry. Huawei have experimented in autonomous driving and remote control, especially 5G core technology. The maturity of the new lithium battery technology, fuel cell technology and intelligent technology is still in the experimental and engineering stage.

The future business model driven by immature niche has not yet appeared, but the industrial application with new energy vehicles as the interface has become more and more, so the trend of ecological and industrialized business models has emerged. As a platform industry of the whole industry chain, new energy vehicles may tend to be more flexible, such as providing a real-time supply chain for a certain demand, or building a new business logic for the supply chain to the private market to realize subversive innovation and development.

D. Path 4: Business Model Integrated innovation

As the landscape continues to increase, situation complexity has caused the regime to begin to compromise, such as strategic transformation of the nickel-hydrogen battery technology route. In this path, the landscape acts on both the regime and technical niche. Multiple technical niches will compete, some will turn mature, which continue to coexist. The regime changes (see Figure 5).

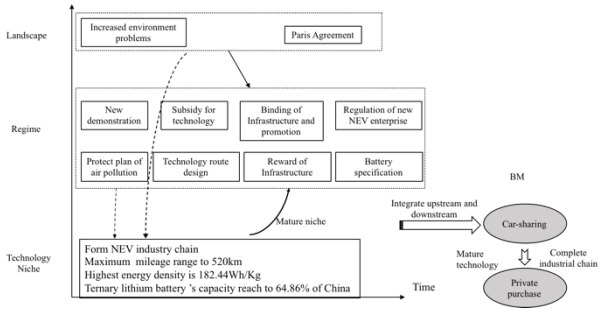

Figure 5 Pathway of Business Model Integrated Innovation

The external landscape changed dramatically. In 2015, more than 200 parties agreed to adopt the Paris Agreement. That means that China will make active efforts to reduce carbon dioxide emissions globally. As a green energy-saving and sustainable industry, new energy vehicles accelerate energy technology innovation.

The regime has built a complete system, and the structure has been adjusted. First, reduce market subsidies and policy declining. Second, strengthen the prediction and research of the technical route. Third, introduce charging infrastructure incentive policies and improve charging infrastructure.

The technical niche gradually matures and presents a situation in which multiple technical routes coexist. In 2016, lithium iron phosphate battery was the main product. The capacity of ternary lithium battery is only 6.3Gwh, accounting for 22%. However, in 2017 the number reach to 16.04 Gwh, accounting for 44.01% of the total capacity. [27].

The business model restructures the emerging elements from industry. The innovative entities adopt new supplier products and adopt more mature technologies, which enhances the competition among suppliers in the entire industry chain. Car-sharing is the most competitive business model in this path.

E. Path 5: Business Model Disruptive Innovation

Directly affected by the external landscape, the technical niche splits and reorganizes, discards unsuitable technologies, and retains mature technologies adapted to landscape. Mature technology niches will use the opportunity window to promote new business models. The niche is no longer dependent on regime. When technology is stable, new business models develop into new round (see Figure 6).

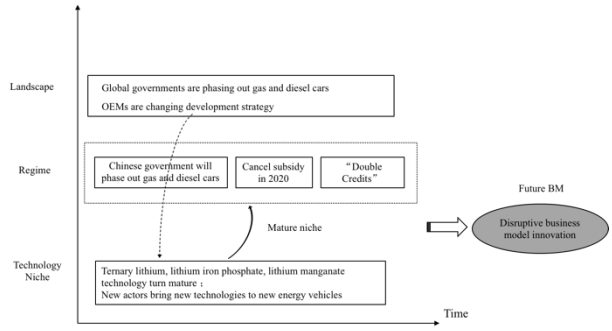

Figure 6 Pathway of Business Model Disruptive Innovation

Governments and enterprises are phasing out the gas and diesel cars. The new energy vehicles will become the trend of the times. Under such landscape, the Chinese government has also started to study the timetable for phasing out the gas and diesel cars.

The Chinese government has arranged a decline in subsidies after 2020. That is, in 2019 subsidy will decline by 50% on the basis of 2018. As the abolition of subsidy policy, the "Double Credit" policy was proposed to increase the proportion of new energy products and gradually phase out fuel vehicle products. Due to the "Double Credit" policy, some foreign companies seek opportunities to cooperate with Chinese companies. However, with the impact of landscape, the exchange of new energy credits will no longer be feasible, and the role of regime will no longer appear. The landscape will eventually lead auto companies to the commercialization driven by technology innovation.

In terms of technical niche, the technical route of new energy vehicle batteries: ternary lithium, lithium iron phosphate and lithium manganate are relatively stable. Mature niche based on ternary lithium battery is still increasing.

As more and more technology companies, financial institutions and other stakeholders enter the automotive industry, the automotive industry's product chain, value chain, and innovation chain will totally change. Disruptive innovation will occur in the evolution path of the business model.

V. Discuss And Conclusion

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This paper studies the business model's evolution path of China's new energy vehicle industry based on the theory of sociotechnical transition theory. Business model evolution model constructed and form seven evolution paths. This paper argues that the business model evolution model from sociotechnical transition has positive theoretical significance. With the development of China's new energy vehicle industry, the guiding role of policy regime on business model is getting weaker, and the impact of technology on the business model will become more important. Through research, we propose two important findings.

The evolution path of the business model of China's new energy vehicle industry exists in sequence, five paths alternate appear or exist simultaneously. The emergence of new technologies and the entry of new stakeholders may promote unpredictable disruptive innovation in business models.

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