Research On the Driving Factors of China's New Energy Vehicle Market

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Abstract: Over the past decade, China has witnessed a rapid development of new energy vehicles (NEVs), with both an increase in the product price/performance ratio and the implementation of stimulating policies playing an important role in this growth. To examine the factors influencing the NEV market, this paper considers four endogenous factors, namely principal components, specific designs, materials cost, and market competition, which affect NEV sales. In addition, four exogenous factors, namely subsidy, fuel cost, traffic restriction, and infrastructure, are also considered in this analysis. Subsequently, a comprehensive examination of their impact on NEV sales and their trends in influence is presented chronologically. After that, the impact of these factors has been analyzed through three case studies about battery packs, subsidy reduction, and spatial distribution. The findings indicate that China's NEV market has undergone a transition from a phase driven by external factors in the past to one driven by internal factors currently and will continue to outpace conventional fuel vehicles in terms of product competitiveness in the future, which may even contribute to global vehicle electrification.

1 Introduction

Globally, NEVs have been identified by scholars as a more environmentally efficient alternative to conventional vehicles and play an important role in global and regional sustainability [1,2]. Consequently, countries have introduced incentives to drive NEV penetration [3]. However, when considering China, it is notable that the country has already achieved an annual market penetration of 30% in 2023, which is considerably higher than the projected global EV penetration sales growth to 30% by 2030 [4]. This illustrates the increasing importance of China as a key player in the global NEV market. Furthermore, China's technological advancement and marketing strategies are reshaping the pattern of the global vehicle industry. Chronologically, the vehicle market maintained robustly during the pandemic period, and remarkably rocketed in the post-pandemic era, although the macroeconomic circumstance recuperated obviously slower [5]. Due to the development of the new energy vehicle industry has already been recognized as the designated path to advance China from an automotive major country into an automotive great power, it's significant to study the mechanics of rocket vehicle sales, and extend it to further

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applications in global market, promote continuously vehicle electrification and sustainable development.

Previous studies about NEV sales have analyzed the market generally from two dimensions: the supply aspect and the demand aspect, advanced technologies and stimulative policies on both sides lead to the current burgeoning NEV market.

Starting from suppliers, Wang and Li indicated that period from 2009 to 2018, counter-intuitively government subsidies towards NEV firms have generally negative effect on their financial performance. However, the upstream level of the industry like raw materials suppliers were the major beneficiaries during this period, hence they were successfully stimulated and had established matured fundamentals for future development [6]. When it comes to the significant impact caused by the Novel Corona-virus Pneumonia (COVID-19), Wen held the view that import restriction irresistibly interrupted the imported supply of materials, and forced NEV brands to exploit domestic substitution, which declined materials cost in further development. Furthermore, financial pressure expelled small brands and concentrated the industry into several leading brands, which means competition would become more drastic [7]. Apart from upstream suppliers, NEV brands also impact the market significantly, Jiang studied China's domestic start-up brand NIO and found that these brands with limited technological accumulation and vehicle industrial experience, had already triggered subversive revolutions of industry with their systematic innovations within several years [8]. Concentrated on the case of NIO and Tesla, Liu found that those initially disadvantaged start-up brands also introduced advanced marketing strategies aimed at capturing more market share, triggering further price competition [9].

From the customs' demand, researchers majorly studied external factors like incentive policy and internal purchase intention. Dong and Lou evaluated previous industrial policies of NEV subsidies and acknowledged the remarkable positive effect brought by government policies. However, government subsidies should be reduced after the general formation of market orientation [10]. In addition, Hu pointed despite purchase subsidy policies and traffic restriction policies, the government should turn individual purchase subsidies into manufacturers' production subsidies [11]. Cheng analyzed several factors and justified Dong and Hu's viewpoints, found that subsidy reduction only has a limited negative impact on the vehicle market, while research and development (R&D) and market demand play significant roles in stimulating the development of the NEV market [12]. When it comes to customs, Liu also mentioned that competition between domestic brands and strong foreign opponents had created better product designs and performance for the customers, resulting in apparent configuration advantage compared with conventional fuel vehicles which effectively attracted potential customers [9]. Jiang also pointed out that consumers' purchase intention to start-up brand is mainly affected by brand image, brand awareness, brand identity, and perceived risk. By introducing advanced technologies, innovative designs, and market position to create an idiosyncratic brand image, and acquiring investment from global capital institutions to enhance reliability, Chinese NEV brands had successfully forged their irreplaceable competitiveness in competition [8]. Instead of product factors, Hu pointed out that environmental factors also impact the diffusion rate of electric vehicles. Despite existing purchase subsidy policies and restricted travel policies, the government should enhance infrastructure construction, comparison of energy costs between low electricity prices and high oil prices would promote customers' spontaneous interest in electric vehicles [11].

About the coming future of the ENV market, Nic and Cui predicted that within 5-10 years, electric vehicles' initial price will decrease, and will eventually reach the price parity of conventional gasoline vehicles due to the expected cost drop of key components like battery packs. With the foreseeable parity of initial price and intrinsic advantage of fuel saving, electric vehicles naturally will advantage in competition over conventional vehicles

[13]. However, some scholars worried that the current investment in the NEV market was overheated and faced the risk of future depreciation. For example, Zeng stated that the tendency of continuous growth would be significantly modest in later future. Therefore, risk caused by overheated investment in the NEV market should be considered discreetly by the government and investors [14].

This paper will analyze the factors that have had a positive influence on the NEV market, examining both the internal product factors and the external environmental factors. Secondly, it will explore the trend of influence of these factors over time, and at the same time consider the extent to which the enhancement or weakening of particular factors affects the overall NEV market. Finally, by comparing the change of several factors, the trends of NEV market drivers will be summarised.

2 Modeling and explication

2.1 Modeling

From 2019 to 2023, China witnessed a surge in sales of NEV, whereas the broader automotive market expanded at a considerably slower pace. This suggests that the shift in consumer preferences from traditional fuel-powered vehicles to NEVs has been a key driver of the accelerated growth in NEV sales. Liao identifies three key factors that drive consumers to choose new energy vehicles: vehicle attributes, infrastructure systems, and EV promotion policies [15]. In the subsequent analyses, these influences are broadly categorized into two types: endogenous factors, which include product performance and price; and exogenous factors, which include infrastructure and price, collectively give rise to interrelated changes in the three dimensions of consumers' personal consumption consciousness: product, cost, and convenience. The following structure has therefore been constructed and arranged according to the different dimensions of consumers' intention that each factor contributes to.

Fig.1 Sales-intention model

Fig.1 expands upon the four directions of endogenous and exogenous factors, concluding that there are a total of eight factors that influence consumer willingness to purchase. The endogenous factors are principal components, specific designs, material cost, and market competition, while the exogenous factors are subsidy, fuel cost, infrastructure, and traffic restriction.

2.2 Endogenous factors

2.2.1 Principal components

The principal component is defined as the indispensable basic architecture of NEVs. In the traditional fuel vehicle sector, China's development of principal components has been relatively constrained, necessitating reliance on joint ventures with foreign brands or direct

imports to access competitive products for an extended period. However, the situation has reversed when it comes to the NEV sector. As He and Sun observe, China has developed and now leads the world in new energy vehicle technology thanks to the 'Three Verticals and Three Horizontals' technology stimulus policy [16]. This indicates that the preeminence of the principal components is instrumental in bolstering the competitive edge of China's domestic NEVs. Additionally, due to Yuan, at the beginning of the era of NEVs, comprehensive energy efficiency was relatively low in long-range products, while technological advancement witnessed in recent years has already eliminated customers' worry and promoted the selling of long-range products [1].

2.2.2 Specific designs

In comparison to the principal components, specific designs are more dependent on the positioning and distinctiveness of each brand. As indicated in the McCarthy report, the purchase considerations of Chinese customers for new energy vehicles diverge significantly from those for conventional fuel vehicles. In this context, static experience (space and interior) assumes greater importance than dynamic experience (driving dynamics), while the level of intelligence also increases [17]. In order to meet the specific designs requirements of Chinese customers, brands have devoted greater attention to specific designs.

2.2.3 Materials cost

The cost structure of NEVs tends to be more monolithic than conventional vehicles, with the cost of the battery pack accounting for up to 40% [18]. In addition, the procurement cost of the battery is highly dependent on the upstream raw material suppliers. Therefore, although the impact of raw material price changes on the downstream market is not direct, due to the multiple roles of the battery suppliers and the car brands, the competition in the market has led to the end of the sales price has always been closely linked to the price of raw materials, and this impact is more obvious in the economic positioning brand.

2.2.4 Market competition

In 2024, the price war within the NEVs sector reached a crescendo. By controlling the entirety of the production process, BYD Auto reduced the price of particular product lines by nearly 20%. This prompted a series of price reductions from middle- and low-end brands. However, the impact of the hot price war between car companies on consumers is limited, according to a McKinsey report: over 80% of customers believe that pure price competition has no positive effect on their car purchase intention [17]. Therefore, this paper considers the price-performance improvement of products due to price reduction caused by competition, which indirectly affects consumer purchase intention.

Therefore, over the past period of time, the product competitiveness aspect of NEVs has increased, while the price aspect has decreased. This represents NEVs' fundamental endogenous factors drive to promote a change in consumer purchasing intention through improvements in product competitiveness and overall price performance.

2.3 Exogenous factors

2.3.1 Subsidies

In 2009, the Chinese government initiated a regional pilot programme in order to subsidize consumers purchasing NEVs. In 2012, the detailed policy of subsidizing purchases was introduced. The subsidy policies have been deemed a success in terms of stimulating and advancing the market for NEVs by scholars. However, there has been a suggestion that the subsidy should be reduced [10-12]. Indeed, since 2016, the subsidy has been reduced on

several occasions, however, the impact of several reductions on the NEV market was differential [19].

2.3.2 Fuel cost

The cost of fuel has a significant impact on the relative cost advantage of NEVs. When consumers are able to substitute expensive fuel costs with cheaper electricity, they are more willing to switch to NEVs [11]. However, due to the Chinese government's regulative price policy, China's oil price is relatively stable and less susceptible to changes in global oil prices. Furthermore, this paper primarily concentrates on trend analysis, and, in the absence of a notable fluctuation in oil prices, the influence of such fluctuations on consumer inclination to purchase is presumed to be static.

2.3.3 Traffic restriction

In addition to implementing substantial economic policies, the government has also introduced differential traffic policies in several mega-cosmopolitan cities with strong consumption power and huge markets that also face excessive traffic burdens. For example, the Beijing 2024-related policy states that pure electric minibusses are not subject to the tail number restriction measures in Beijing. Furthermore, some facilitation policies can also yield tangible economic benefits, this is because the supply of green licenses for NEVs is plentiful and relatively straightforward to obtain, in comparison to the stringent control of blue licenses for fuel vehicles. To illustrate, in Shanghai, the average price of the license auction was approximately 91,000 yuan in 2017, whereas the licensing of new-energy vehicles is free of the lengthy waiting periods and high expenses [20]. The preceding analysis demonstrates that the convenience policy implemented in large cities is a significant factor influencing consumer willingness to transition to NEVs. However, its impact is limited in cities that do not enforce stringent traffic restriction policies.

2.3.4 Infrastructure

It is a widely held view among scholars that the strengthening of infrastructure, particularly the provision of public charging points, represents an effective means of promoting the market share of new energy vehicles [11]. Nevertheless, an analysis of the 25 cities with the most advanced infrastructure in the country reveals that over 60% of the charging piles have a utilization rate of less than 20% [21]. This indicates that the significant number of charging piles constructed during the off-peak period may have been somewhat excessive. Conversely, in Hangzhou, which ranks third in the country in NEV consumption, the density of charging piles is less than 20 units/km², yet the coverage rate is more than 80% [22]. Furthermore, the utilization rate is relatively high, at close to 50%, which demonstrates the public charging piles in Hangzhou have an optimal distribution density, sufficient to support the significant NEV consumption market [21]. It can thus be concluded that, although infrastructure is closely related to consumers' purchase intention to NEVs, the marginal benefit of increased infrastructure to enhance consumer willingness is evident.

3 Case discussions

3.1 Decline in battery pack cost promotes NEVs' price parity

The cost of NEVs, in particular BEVs, is significantly influenced by the price of battery packs, which are integral to the construction of these vehicles. Consequently, the competitiveness of NEVs is closely linked to the performance of the battery industry.

In a recently published research report by Goldman Sachs, Nikhil Bhandari predicted that

by 2025, the cost of EV power batteries will have decreased significantly to $99 per kilowatt hour (kWh) (Fig. 2) as a consequence of declining prices of raw materials and operating costs, with battery pack prices expected to decline by an average of 11% per year from 2023 to 2030 [23].

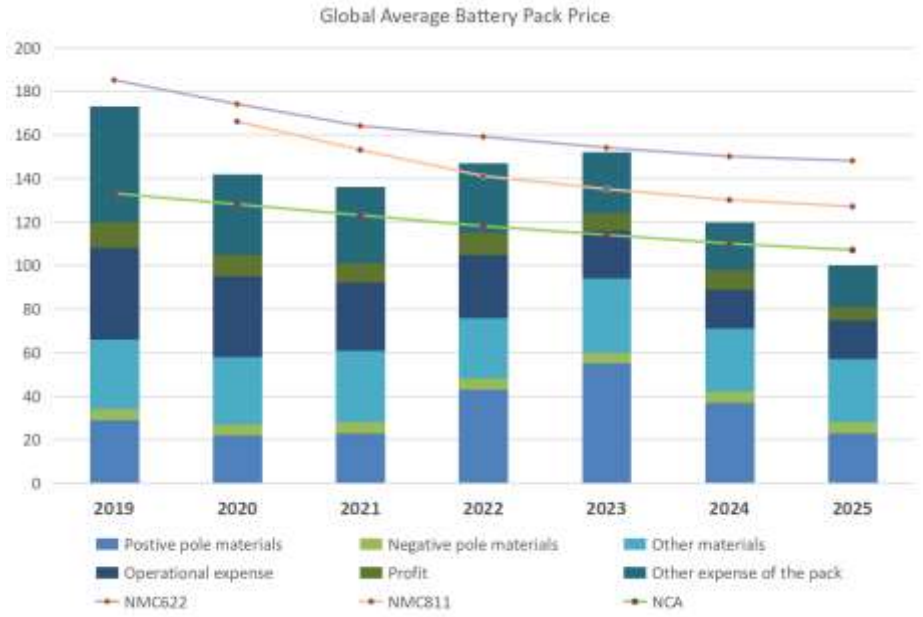

Fig.2 Tendency of Battery Packs cost and brands' procurement cost

The reduction in the cost of battery suppliers is reflected in the declining price of battery packs purchased by manufacturers, as illustrated in Fig.2, The NCA, NMC811, and the NMC622 lines illustrate the battery pack cost of several prevailing brands [24]. It can be observed that NEV manufacturers, irrespective of the battery material employed, will continue to witness a decline in battery costs due to the dual influence of the maturation of the raw material supply chain and the advancement of the battery industry. As battery costs decline, Goldman Sachs research predicted that NEVs will achieve price parity with conventional vehicles on a cost basis within five years, without the need for government subsidies. Through modeling analysis, Cui and Yu highlight that with the continuous decline of major costs, battery electric vehicles(BEVs) with shorter ranges will achieve price parity with fuel vehicles in 2026, while BEVs with longer ranges will achieve price parity in 2030 [25]. Once price parity is achieved, the inherent cost-of-use advantage will result in NEVs becoming more cost-effective, providing consumers with more attractive options.

3.2 Subsidy reduction impact on NEV sales becomes increasingly negligible

The reduction of government subsidies commenced as early as 2016 and has thus far been implemented in seven distinct phases of formal policy adjustment.

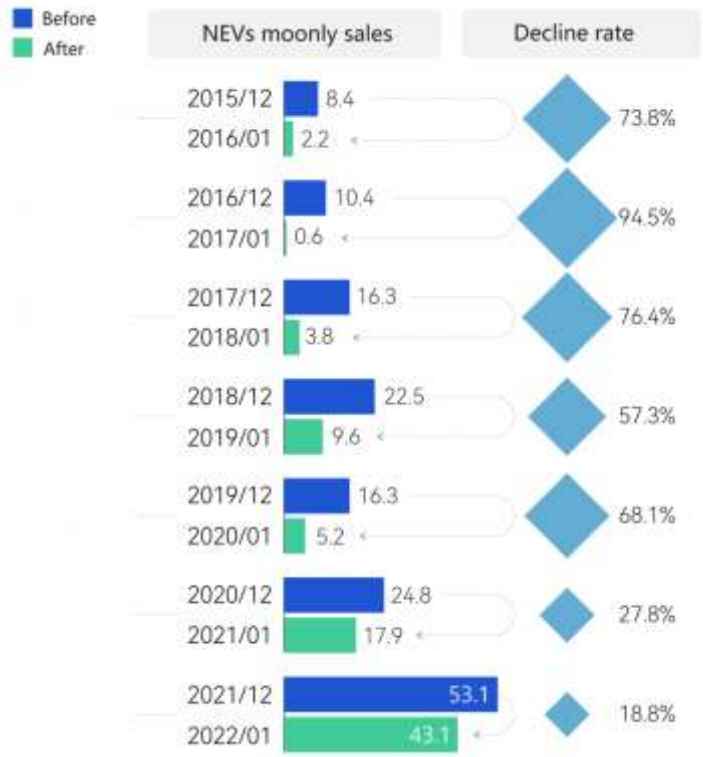

Fig.3. Effect of seven times subsidy reduction

Fig.3 illustrates that in the initial month following the implementation of the first subsidy rollback- January 2016, monthly sales of NEVs represented a precipitous decline. Even in 2019, the impact remained significant. However, by January 2022, after the subsidy reduction, the NEV sales in that month dropped remarkably more modest. This is in addition to the routine decline of approximately 14% YoY due to the impact of festivals and holidays. This indicates that the negative effect of subsidy reductions on the NEV market has largely dissipated and that the influence of subsidies on consumer intentions has been declining continuously.

3.3 Spatial distribution of NEV sales and growth trends by type of region

The data on NEV sales in the Chinese market in 2023 demonstrates that the main markets for NEVs in China are East China and South China. The metropolitan cities of Shanghai, Beijing, Guangzhou, and Shenzhen, which had implemented strict traffic restriction policies, had the highest sales of NEVs in China. These cities rank first (364k sales), sixth (206k sales), second (234k sales), and fourth (225k sales) in terms of EV sales, respectively [22]. It would be reasonable to posit that high sales figures are still closely linked to traffic restriction policies, without other consideration of the customer base and the economies in question. However, an analysis of NEV consumption in megacities and other types of cities reveals a contrasting trend.

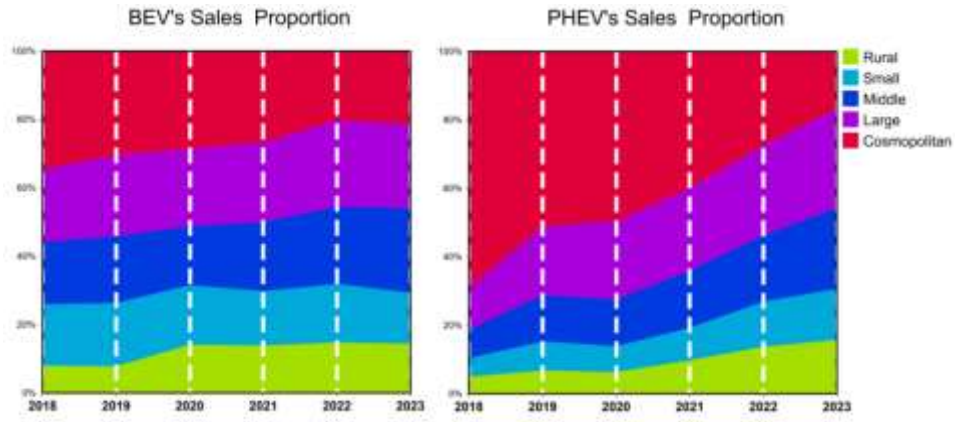

Fig.4. BEV and PHEV sales proportion in different regions

Fig.4 illustrates a persistent decline in the proportion of Battery Electric Vehicles(BEVs) and Plug-in Hybrid Electric Vehicles(PHEVs) purchased in megacities in overall consumption, in contrast to the surge in NEV consumption in medium-sized and small cities and even in rural areas. This represents a shift in NEV consumption from megacities, which are most affected by external policies, to other cities, which are less affected by external policies, even partially offset the perceived risk of poor infrastructure in rural areas.

Nevertheless, BEV consumption in megacities continues to demonstrate consistent growth and maintains a considerable share of the EV consumption market, while the proportion of PHEVs was rapidly declining. This was primarily attributable to the fact that the traffic restriction policies in each megacity had generally tightened restrictions on PHEVs, with only BEVs being exempt from such policies. This illustrates that the traffic restriction policy continues to exert a considerable influence on consumption patterns, although other cities continue to demonstrate robust consumption growth in the absence of such policies, with more consideration given to the endogenous factors of NEVs.

4 Conclusion

This paper examines the endogenous and exogenous factors that impact NEV sales, with a particular focus on the three dimensions considered by consumers. Furthermore, the analysis examines the trend of the impact of the three factors through three case studies. In these studies, the impact of principal components, specific designs, and materials cost is observed to be rising, while the impact of subsidies and traffic restriction is evidenced to be appreciably decreasing, and the impact of infrastructure is also seen to be slightly decreasing. Additionally, the impact of market competition and fuel cost is observed to be relatively stable.

Generally, in light of the growing influence of endogenous factors and the waning influence of exogenous factors, coupled with the rapid growth in the sales volume of Chinese NEVs, it can be unequivocally stated that, China's consumer market for NEVs is transitioning from an externally driven to an internally-driven phase. From the perspective of the consumer, the willingness to purchase NEVs was previously more influenced by subsidies and traffic restriction policies. However, there is now a greater focus on the competitiveness and price of the product, which demonstrates that Chinese NEV brands have gained a competitive advantage compared with conventional vehicles.

The experience of China's NEV market demonstrates that while stimulative policies have

played a pivotal role, the competitive advantage of electric vehicles over conventional fuel vehicles is a significant factor in promoting spontaneous vehicle electrification. This advantage can be gained by high-quality principal components suppliers and manufacturers with reasonably detailed designs. Furthermore, a competitive price advantage has been achieved by reducing the cost of raw materials and through intense market competition. Therefore, the establishment of a mature supply chain is necessary for every country planning to develop its NEV industry.

In the future, it seems reasonable to posit that the ongoing decline in the price of NEVs and the concomitant improvement in quality will continue. These advantages over conventional fuel vehicles will facilitate the vehicle export of mature NEV industries from countries such as China or Japan. It is therefore likely that the global penetration of NEVs will continue to increase with the involvement of several leading countries.

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