Will Chinese New Energy Vehicle Manufacturers Survive Without Government Subsidies?

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ABSTRACT
New energy vehicles are now the preferred means of transportation for energy saving and emission reduction, but their prices are also higher than traditional oil vehicles. To encourage consumers to accept new energy vehicles, governments have introduced many preferential subsidies. As a result, the current market pricing of new energy vehicles is lower than their actual value. In recent years, government subsidies have been on the decline, which seems to be a negative situation for most new energy vehicle companies. Opportunities and challenges coexist. This paper will study the impact of government subsidies on BYD's profitability capacity, operational capacity, and growth capacity. In addition, this paper also compares BYD with several other well-known new energy vehicle manufacturers, thus further elaborating on BYD's technological advantages. At the same time, it is expected that other new energy vehicle companies will reflect on how to survive under the trend of government subsidy withdrawal to provide a reference.

Keywords: *New energy vehicles, BYD, government subsidy, the blade battery*

1. INTRODUCTION

1.1. The competition for new energy vehicles in China

As a high-tech incentive industry, the quality of new energy vehicles highly depends on whether the technologies of battery and energy are mature. Therefore, many carmakers spend lots of effort on R&D to take the market. The introduction of new energy vehicles, as the substitutes of traditional gasoline vehicles, aims at solving the issue of global environmental pollution. It is a brand-new product that barely finds other substitutes. The upper steam is the rare material cost at a market price, for example, primary steel and plastic, which has less room to bargain. The competition is surrounding the field of the auto chip. The most critical of new energy vehicles, due to the current shortage of auto chips and the low self-sufficiency rate of Chinese auto chips, the bargaining power of new energy vehicles in auto chips is very weak.

In China, restrictions on the use of fuel vehicles will encourage some customers to choose new energy vehicles, especially in cities like Beijing, Shanghai, and Guangzhou. In other second-and-third-tier cities, there are fewer restrictions on fuel cars, and consumers tend to choose fuel cars that are cheaper and with more mature technology. Therefore, new energy vehicles have moderate bargaining power over the downstream. From the new entrants, under the pressure of environmental protection, new energy vehicles are the trend of the development of the automobile industry in China in the future. As a result, many enterprises want to take part in it. Not only a traditional fuel car companies, such as BYD, begin to transition, many Internet companies, such as Baidu, also started targeting such industries. In general, the potential entrants in the new energy vehicle industry pose a great threat.

1.2. A brief introduction of BYD Auto

BYD Company Limited was set up in 1995, employed only 20 staff, and invested $0.3 million. By 2020, the company has grown to be the one of biggest automobile manufacturers in China, having 224,300 employees in the global arena and about $24.03 billons in sales [14]. The company opened its business initially for manufacturing smartphone batteries and was the most sensitive to introducing vertically integrated one-stop services making OEM handsets for the most

intelligent mobile terminal leaders. It stepped into the automobile industry in 2003, covering businesses of both traditional fuel-engine vehicles and new energy vehicles.

BYD, as the only Chinese car company that has mastered the entire industrial chain of new energy vehicle core technology R&D, design, production, and manufacturing, has achieved self-sufficiency in the three major fields of battery, electric control, and motor. The most representative is the launch event held in Chongqing in April this year, which announced that all of BYD's pure electric models will be fully equipped with blade batteries and synchronized listing. The core of the blade battery is [safety].

BYD's official website discloses the needling experiments of "blade battery", ordinary lithium phosphate battery, and ternary lithium battery, which is recognized as the industry's most difficult method to verify the safety of power batteries. The test results contrast obviously, the "blade battery" compared to the traditional battery flat shape, electrode plate layer reduction, when subjected to external damage, triggering the battery short circuit caused by the heat is very little. The "Blade batteries" are competitive not only in terms of safety but also in terms of range, which has increased significantly. Ordinary potassium phosphate batteries are more stable as far as materials are concerned, but their density is much smaller than that of ternary lithium batteries, which also leads to a shortage in range. More than 500km range on the market is equipped with ternary lithium batteries, ordinary potassium phosphate battery range of roughly 400km, while the "blade battery" according to official data show that can achieve 600km range, and even the future can reach 700-800km.

For the model name, most of them are in English and numbers, the same domestic new energy car brand, [Xpeng] [NIO] are named with the founder's name or harmonics. Product naming needs recognition and exposure, dynasty series to Qin, Tang, Song, Yuan, Han, ancient Chinese dynasties named, that is, to improve the recognition also shows the BYD for its new energy car layout confidence.

1.3. Related research

Some of the previous research concludes that government subsidy is one of the main drivers for new energy vehicles to develop in China. Yeung examined the case of China and concluded how the non-firm sector can play a dominant role by employing proactive policies in establishing domestic production networks, new energy vehicles (NEV), without coupling with the lead firm in such industry like Tesla. The readjustment of governmental parameters and utilization of market scale is implemented by the Chinese regulator to improve the future development of domestic NEV production networks to push global manufacturers to reshape their product assortment and to facilitate joint capital with domestic NEV manufacturers [1]. Masiero et al. estimated the incentive of the Chinese government to invest heavily in electric vehicles, and the effectiveness of strategies that BYD Auto implemented. And they explained how these combined effects helped electric vehicles markets in China expand rapidly [2].

However, government subsidies are not a long-term solution to support the development of the new energy vehicle industry, and long-term high subsidies can affect government revenue or even offset the initial investment. Adler et al. discussed the impact of autonomous connected electric shared vehicles (ACES) on public finance, in which fuel consumption accounts for 30% of local tax revenue and 5-12% accounts for federal tax revenue. This would affect government transportation expenditure and in term affect the realization of ACES and its environmental benefit consequently [3]. Nevertheless, Hao et al. summarize that competing with conventional passenger vehicle (CPV) in the short run, battery-electric passenger vehicle (BEPV) must be supported by public finance, named Electric Vehicle Subsidy Scheme (EVSS) to remain its cost competitiveness from 2009-2015. The reduction in subsidy intensity after 2013 may temporarily increase the cost of BEPV to consumers, whereas such issue tends to be offset by the decreasing manufacturing cost and is anticipated to be eliminated by 2020 even without any subsidy. Now, the primary concern is the issue of technology limitation, small battery packs, which cannot be satisfied by the current EVSS for BEPV to lead the market in China [4].

Some research analyzes the demand for new energy vehicles and how industry changed in the wake of the epidemic. Helveston et al. conclude that interviewees from both China and US prefer gasoline automobiles to various types of electric vehicles, especially American consumers. With a similar subsidy regime, consumer preference in the two countries is different, in which the acceptance in China for EV is higher. Therefore, the demand in China tends to trigger global incentives for technology development on EV [5]. He et al. established a model to decide when the consumer should replace their gasoline vehicles with hybrid electric vehicles (HEV) if there is trade-in and subsidy. The fluctuation in fuel price helps to this estimation. They concluded that, without subsidy, the current fuel price is not at its optimal level for consumers to replace fuel-engine vehicles with HEV, especially BYD Qin in China. The adaption of sensitivity analysis showed that increases in fuel price would weaken the effect of subsidy, and the cost-effective replacement time (CERT) is likely to be longer [6]. Wen et al. found that although COVID-19 brings negative effects on the electric vehicle industry, the short-run decrease in sales of electric vehicles tends

to be compensated by the potential long-term demand for electric vehicles, especially high-quality large ones. Nevertheless, travel restriction and compelling lockdown are likely to shift the supply side on key parts to domestic substitutions, which lead the electric vehicle industry to be more concentrated by several large corporations [7].

Other research focuses on Tesla's market share and technological advantage over Chinese new energy vehicle competitor BYD. Wang took Tesla as an example to analyze its distinct brand marketing model, compare it with traditional automobile companies, give an insight into both its advantages and disadvantages [8]. Huang examined the positive and negative impacts of the development of BYD Auto by analyzing its financial annual report [9]. Gu, Liu, and Fang summarized the key indicators of 300 new energy vehicles online sales including its brand, model, pure electric endurance, slow charging time, fast charging time, battery capacity, maximum power, maximum torque, monthly sales volume, annual cumulative sales volume, monthly transaction price, user score, number of public praise, manufacturer guidance price (low) and manufacturer guidance price (high) of each new energy vehicle market. Such that, the company, BYD, is one of the manufacturers that has the largest market shares [10].

2. IMPACTS OF GOVERNMENT GRANTS ON BYD

2.1. Impacts on profitability: gross profit remains low

BYD's non-recurring gains and losses are mainly made up of government grants. Analysis of its annual reports between 2013-2020 indicates that BYD received government grants that accounted for an average of about 98.9% of non-recurring profit and loss, with the highest value of about 162.06% in 2016. Thus, it seems that the most obvious effect on BYD's profit enhancement is the support from government grants. Table 1 summarizes the financial indicators of BYD to see how government subsidy influenced its profitability since 2013.

Table 1. Changes in BYD's profitability before and after government subsidies (Unit:000,000)

Years	Non-recurring gains/losses	Government subsidy (Gov. subsidy)	Gov. subsidy as percentage of non-recurring gains/losses	Net profit	Gov. subsidy as percentage of Net profit	ROA before gov. subsidy	ROA after gov. subsidy
2013	0.6	0.7	111.5%	0.6	123.6%	0.7%	-0.2%
2014	1.1	0.8	71.8%	0.4	183.7%	0.5%	-0.4%
2015	1.6	0.6	35.8%	2.8	20.6%	2.7%	2.1%
2016	0.4	0.7	161.4%	5.1	14.1%	3.9%	3.3%
2017	1.8	1.3	71.1%	4.1	31.4%	2.5%	1.7%
2018	2.2	2.1	94.5%	2.8	74.5%	1.5%	0.4%
2019	1.4	1.7	123.2%	2.1	81.0%	1.1%	0.2%
2020	1.3	1.6	125.0%	6.0	26.7%	3.0%	2.2%

BYD received two batches of large grants that had a significant impact on its net profit, with grants amounting to 0.67 million yuan and 0.79 million yuan respectively in 2013-2014. Since 2013, BYD cell phone, photoelectric cell business operating costs have been rising, resulting in a poor profitability position from 2013-2014. Among them, the return on assets in 2014 (0.5%) became the lowest point in 2013-2018 [11]. BYD used the marketing strategy of thin profit to capture the market, the strategy helped BYD to open the market and accumulate many customers while enhancing the brand premium. This seems to reasonably explain the fact that the ratio of government grants to net profit (14.07%) reached its lowest point in nearly seven years in 2016. However, its profit fell back slightly again in 2017 and 2018, probably receiving the impact of higher grant standards in the overall grant policy as well as a decrease in the number of grants.

Splitting its main business by gross profit changes in recent years can give more information on the profitability of BYD's three main business segments. Table 2 shows BYD’s profit margins breakdown by its product categories.

Table 2. breaking down BYD's gross profit margin from 2016-2020

Gross profit margin (%)	Years					
Product categories	2020	2019	2018	2017	2016	2015
Automobile and related products	25.20	21.88	19.78	24.31	28.24	23.79
Handset component and Assembly services	11.20	9.35	12.59	13.09	9.98	8.91
Rechargeable battery	20.16	18.63	9.46	12.21	(-)	14.12
Others	4.63	3.09	4.49	14.38	9.74	11.15

According to BYD's annual report released in 2020, its revenue and sales are not proportional to each other. BYD's 2020 revenue reached $156.6 million, year-on-year increased by 22.6%, but its sales for the same year were 4,270,000 units, year-on-year decreased by 7%[14]. Further research revealed that such a situation is mainly due to the composition of BYD's main business segments. BYD's automobile and related products, as it is known to the outside world, is one of its major revenue businesses, with operating expenses accounting for 53% of total revenue, but it is interesting to note that the automobile business is not its main profit growth point in 2020.

Specifically, BYD 2020 net profit rose significantly, mainly due to the growth of its cell phone electronics business, secondary rechargeable batteries, and photovoltaic business. Data show that the cell phone electronics business, secondary rechargeable batteries, and photovoltaic business net profit volume of 5.4 million, far exceeding the volume of its not-so-optimistic automobile business net profit. Table 2 shows that the gross profit of assembly service has been increasing over these years. Besides, the gross profit of its rechargeable battery fluctuated largely, which was double in 2019 compared to 2018. This was hypothesized as a result of the volatility of battery prices on the revenue side. The overall gross profit is not sustainable. Combined with the impact of the 2019 epidemic on various industries, new energy new vehicle sales have improved, but are still at less than expected levels. Therefore, whether BYD's future profitability can be improved by its automobile products remains to be considered.

2.2. Impacts on operating capacities

According to its 2017's annual report, the account receivable is 588.5 million, about 98% of its net asset, which is far higher than the other automobile companies. The dramatic increases in its account receivable could be explained by two reasons. The government subsidy attracts many companies into the field of manufacturing new energy vehicles. This seems to force BYD to improve market competitiveness by adjusting its account receivable period to favor its clients. Additionally, BYD has entered a period of rapid expansion and gained an advantage in the fiercely competitive environment through credit sales. However, such a strategy is likely to cause non-systematic risks in the case of poor receivables management. For example, the speed of capital flow tends to slow down, personnel costs would rise, and profits would be inflated. BYD seems to also realize those problems. The company made the provisions for bad debts of accounts receivable within one year and to two years accordingly, which were 0.04% and 0.3% respectively [12]. Although BYD has made efforts on receivables management, and the numbers show improvement, it still needs to make further improvements to boost earnings.

Despite the weak performance of its account receivable management, the current ratio shows more information. The current asset of BYD Auto Company in 2020 increased by nearly ¥3,000 million and remain ¥800,000~¥1,000,000 million in total current assets over the past 5 years[14]. In theory, the lower limit of the current ratio is 1, therefore, the enterprise's current assets could be regarded as current liabilities. It is reasonable to conclude that only when all current assets can be realized timely and sufficiently to realize the turnover value without any losses, can debt repayment be guaranteed with such a material basis. Otherwise, BYD may face debt repayment risk. Table 3 summarizes the four financial indicators used to analyze the operational capacities of BYD Company Lit from 2016-2020.

Table 3. indicators for BYD's operational capacities in recent 5 years

	Years					
Indicators (%)	2020	2019	2018	2017	2016	2015
Total asset turnover	0.79	0.65	0.7	0.66	0.79	0.76
Inventory turnover	4.43	4.12	4.71	4.61	4.97	5.17
Account receivable turnover	3.68	2.74	2.41	1.98	2.71	3.11
Current ratio	1.05	0.99	0.99	0.98	1	0.82

Accounts (¥000,000)	2020	2019	2018	2017	2016	2015
Net asset	64.45	62.6	60.69	59.96	55.41	36.03
Account receivable	41.22	43.93	49.28	58.85	48.13	28.32
Account receivable proportion	64%	70%	81%	98%	87%	79%

Government subsidies can provide companies with funds for working capital, and BYD has received huge amounts of government subsidies in the past seven years, but the company's operating capacity has not improved significantly, which even shows a downward trend. This may be due to the lack of sufficient motivation in the operation and management of BYD as the government subsidies, which hurts the long-term business performance of the company. Table 4 analyzes the impact of government subsidy on BYD's operating capabilities since 2013.

Table 4. Changes in BYD's operating capability before and after government subsidies (Unit: 000,000)

Years	operating revenue	Government subsidy	Average total asset	Average total asset after gov. subsidy	Total asset turnover	Total asset turnover after gov. subsidy
2013	52.9	0.7	73.4	72.7	72.1%	72.7%
2014	58.2	0.8	86.0	85.2	67.7%	68.3%
2015	80.0	0.6	104.8	104.2	76.4%	76.8%
2016	103.5	0.7	130.3	129.6	79.4%	79.9%
2017	105.9	1.3	161.6	160.3	65.6%	66.1%
2018	103.1	2.1	186.3	184.3	69.8%	70.6%
2019	157.0	1.7	195.1	193.4	65.0%	81.2%
2020	128.0	1.6	201.0	199.4	79.0%	155.8%

Analysis from Table 4 shows that the impact of government subsidies on BYD's total asset turnover ratio does not seem to be significant, which indicates that the inflow of funds from government subsidies has less impact on BYD's operating capacity. BYD's accounts receivable turnover ratio and inventory turnover ratio continues to rise from 2013 to 2020, which indicates that BYD's assets lack short-term liquidity, and its operating capacity needs to be improved. However, of the three core ratios that measure a company's operating capacity, government subsidies only have an impact on the total asset turnover ratio. This seems to lead to the conclusion that government subsidies since 2013 have had a negligible impact on BYD's operating capacity.

2.3. Impacts on future development with fundamental analysis in cost control

The first two chapters analyze BYD's profitability and operating capacity in recent years, in response to which the impact of government subsidies on these two aspects of the company is derived. One cannot help but wonder how BYD has performed in terms of cost control. Table 5 calculates the ratio of BYD's three operating expenses and R&D costs to its gross profit respectively.

Table 5. Conclusion of fundamental analysis of cost control for BYD Company Lit

Conclusion	Years					
Accounts (%)	2020	2019	2018	2017	2016	2015
Gross profit margin net SG&A	9.36%	5.84%	6.30%	7.76%	7.13%	4.71%
Growth in gross profit margin net SG&A	3.52%	-0.46%	-1.46%	0.63%	2.42%	2.96%
Gross profit margin net R&D cost	12.98%	10.44%	11.01%	13.95%	15.92%	14.38%
Growth in gross profit margin net R&D	2.55%	-0.57%	-2.95%	-1.97%	1.53%	(-)

The Selling General and Administrative Expenses (SG&A) in this paper do not include operating costs, but only selling costs, finance costs, and management costs, which seems to indicate that BYD's SG&A ratio is not

high. The company's sales revenue has increased in recent years, so the company's large volume has brought scale benefits. Among them, the company has strong bargaining power in sales costs and financial costs. In addition, since the adjustment of the salary structure of managers in 2016, its management costs have also decreased, leading to a small increase in gross profit. Therefore, SG&A costs have decreased slightly, and the operating costs have been effectively controlled. From the data, it seems that the high investment in R&D since 2017 is the main factor leading to the low profit. Table 6 summarize the impact of government subsidy on BYD's asset since 2013.

Table 6. impact on future development before and after government subsidies

Years	Net profit growth	Net profit growth after gov. subsidy	Net asset growth	Net asset growth after gov. subsidy	Total asset growth	Total asset growth after gov. subsidy
2013	264.32%	-129.38%	2.95%	5.34%	13.54%	14.41%
2014	-4.64%	-158.59%	16.25%	16.20%	20.50%	20.52%
2015	324.05%	4805.62%	24.69%	26.17%	22.85%	23.27%
2016	74.63%	86.51%	53.79%	54.30%	25.62%	25.63%
2017	-10.27%	-23.63%	8.21%	7.28%	22.77%	22.49%
2018	-27.68%	-59.28%	1.23%	-0.10%	9.25%	8.86%
2019	-40.42%	-77.50%	3.14%	3.74%	0.55%	0.71%
2020	182.83%	90.90%	2.96%	3.10%	2.75%	2.76%

Table 6 shows that BYD's total asset growth rate as well as net asset growth rate has been increasing since 2013-2018, mainly because the company has made many new energy industry-related infrastructure investments in these five years, and the total asset size has accelerated year by year. In addition, BYD's ratio of various development indicators also increased in 2015 compared to the past, mainly due to the significant increase in the growth rate of operating revenue during the same period, which drove the rise of other indicators. In 2017, BYD's development capacity fell back, especially net profit decreased year-on-year, which is closely related to the impact of new energy industry policy changes. It is worth mentioning that the growth rate of total assets from 2014 to 2017 has been maintained at more than 20%, and the expansion rate of the asset operation scale has remained stable, reflecting the stable long-term development potential of the company.

3. COMPARISON WITH OTHER BRANDS

3.1. Internal problem that BYD faces

In recent years, the automotive segment revenue accounted for more than half of the total revenue of BYD Group (54% to 58% in the past three years). However, due to the impact of the macroeconomic downturn, the decline in industry sales, and the withdrawal of subsidies, the company's automobile segment revenue declined by 8 points year-on-year to 50% in 2019 as the revenue of the automobile segment declined but the revenue of the other two segments rose. The business with the second-highest revenue, gross profit, and net profit share is its cell phone segment, which maintains a revenue contribution of more than 30%. As it enters 2020, BYD's new energy vehicle share price has diverged from its sales pattern. On the opening day of 2020, its share price went from 48.22 yuan to a yearly high of 97.91 yuan on July 14 [16]. However, its new energy vehicle sales have been declining continuously for 12 months. This may be due to two reasons: one is the reduction to the gradual receding of domestic new energy policy subsidies, and domestic consumers are more rational in purchasing new energy models. Reduced subsidy intensive had negative impacts on the sales of electric vehicles in 2019, which consequently decreases its sales revenue to be the same level as in 2017. Moreover, sales revenue in 2018 increased by 34% compared with the level in 2017, whereas EBITDA decrease by around 1% as increasing in expenses and decreasing in gross profit. Table 7 compares the profitability capability of BYD with the other three new-energy carmakers.

Table 7. Comparisons of profitability for 4 new energy vehicles manufacturers (Unit: 000,000)

Comparisons	Companies				
Financial indicators	BYD	Tesla	Xpeng	NIO	Average
operating revenue	156.60	31.54	5.84	16.26	10.49
Net income contributed to shareholders	4.23	0.72	-	-5.30	0.37

Gross profit	30.35%	6.63%	0.27%	1.87%	1.41%
ROE	7.43%	0.50%	-2.62%	-5.08%	4.76%
ROA	3.03%	1.67%	-	-15.31%	2.89%

The second is Tesla's strong occupation of the majority share of mid-to-high-end model sales. On January 7, 2020, Tesla's China factory officially delivered the Chinese-made Model 3 to 10 owners and announced the launch of the Model Y program. After that, Tesla stores were as hot as when the iPhone 4 was first launched in China in September 2010. iPhone 4 once introduced the Chinese cell phone market to the smartphone era, and Tesla Model 3 is expected to be the driving force to push electric vehicles to a wider audience in China. In the Top 10 of pure electric new energy production in the first half of the year, Tesla came in first with 49,800 units. In contrast, BYD Qin and e2, two models ranked fourth and tenth respectively, with the production of 11,300 and 6,100 units [16]. The gap between Tesla is increasing. To conclude, there remains uncertainty in future improvement in its new energy vehicles sales and growth in realized profit, since such profits include the parts where BYD benefit from government subsidy.

3.2. External problems remains

In the external market, BYD batteries are also experiencing fiercer competition and have failed to take more orders from car companies for power battery supply. After Tesla began mass production deliveries, its replacement LG Chemical ternary lithium batteries in the domestic installation rose sharply, stealing part of the market share. The other seven models in the top ten sales in the first half of 2020 are also mainly assembled with ternary lithium batteries from brands such as Contemporary Amperex Technology Co., Ltd. (CATL) and CALB Battery, none of which use BYD ternary lithium batteries. At the same time, with the cooperation of Tesla and CATL, its whole car price or will be further down. At that time, not only BYD will receive greater competitive pressure, but the domestic new power brands will also be greatly threatened.

With strong sales, Tesla's total market value has already exceeded $270 million, and BYD does not seem to be the same scale of rivals compared to it. Not only that, new and old players in the field of new energy vehicles are already involved in this new energy race.

In 2020 March, Japan's Toyota Motor announced the complete discontinuation of fuel vehicles by 2040. Morgan Stanley also predicted in a recent report that electric vehicles will account for 72% of total global vehicle sales by 2040 [15]. Concerning about 2,200,000 global cars in 2019, there is still huge room for future electric vehicle growth. Morgan Stanley further predicts that in 2040, Volkswagen's annual electric car sales will reach 11,200,000 units, becoming the world's largest electric car company; Toyota's sales will reach 6,500,000 units, becoming the second-largest electric car company; the current market leader Tesla's sales reached 4,900,000 units, ranking third in the world [16]. In 2019, Tesla's global sales reached about 367,500 units, increased by 50% from 2018 [16]. Morgan Stanley's forecast implies that despite being set to be overtaken by Volkswagen and Toyota, Tesla still has nearly 10 times more room to grow its sales over the next 20 years. As China is about to enter the third phase, the "product era" of new energy vehicles, market competition will be more intense and brutal, and it is doubtful that BYD will have a competitive advantage in the future.

4. COMPETITIVE ADVANTAGES OF BYD'S TECHNOLOGY

4.1. Review of BYD's automotive development

The manufacturing cost of new energy vehicles includes the "three electrics" (i.e., battery, drive motor, and vehicle electronic control), automotive electronics, car body, chassis suspension, and interior decoration. Relevant statistics show that the cost of "three electrics", especially the cost of the power battery significantly determines the manufacturing cost of new energy vehicles, such costs accounted for 42%, 10%, 11%, and a total of 63% [15]. Therefore, the pace of price reduction of power batteries seems to largely determine the future development speed of the new energy vehicle industry. This is also undoubtedly the most core competitiveness of the major car companies, especially the lack of subsidies in the context of the new energy industry. BYD, which initially relied on the battery business for profit, undoubtedly has certain innate advantages, and it is the only car company that has mastered the core technology of the new energy vehicle industry chain, such as the "three electrics" and Insulated Gate Bipolar Transistor (IGBT). In addition, BYD achieved mass production of the "blade battery" in the first half of 2020, which may become an important strategic breakthrough in the future.

Figure 1 outlines some of the advanced models that BYD has launched in three dimensions, including fuel vehicles, plug-in hybrid vehicles, and electric vehicles.

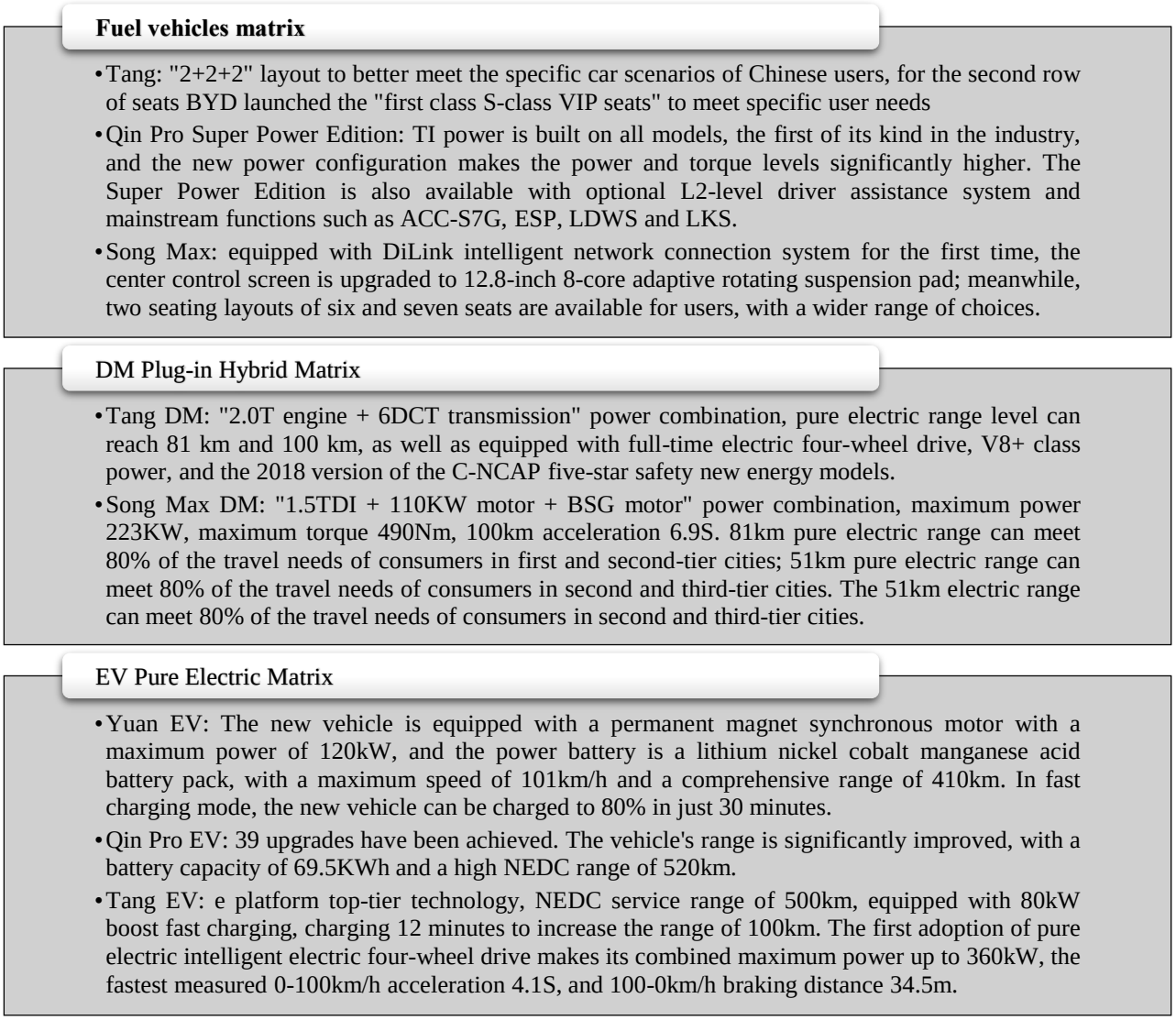

Figure 1 BYD Auto three-dimensional matrix

4.2. The 'Blade battery': a new force in the industry

There are two technical routes for power batteries: one is lithium iron phosphate batteries, which have the advantages of high safety performance, longer service life, and relatively low cost, and are mainly used in commercial buses; the second is ternary batteries, which have the advantages of high energy density and good cycle performance and are currently used in private passenger cars. BYD has been continuously investing its R&D efforts in these two fields to steadily advance the technological progress of batteries. In 2019, BYD's ternary battery industry position has been stable in recent years, with an installed capacity of 7.98GWh and a market share of 19%, ranking after CATL [10]. In addition, due to the business transfer in recent years the installed capacity of lithium iron batteries has decreased, with an installed capacity of 2.98GWh and a market share of 14%, ranking after CATL and Guoxuan High-Tech Co., Ltd [16]. In the same year, a series of BYD private passenger cars were changed to ternary batteries, while commercial passenger cars continue to use lithium iron phosphate batteries.

Process improvements have increased the overall energy density of the BYD Blade battery pack (about 50%), thus overcoming the problem of short-range lithium iron phosphate batteries, which can make the new car NEDC range of more than 600 km, better than Tesla's 445 km, while retaining the advantages of high safety and long life of traditional lithium iron phosphate batteries. Its battery space utilization is improved by 50%, but the cost is reduced by 30% [10]. This may explain the reason for BYD's declining sales but is still favored by the capital market.

BYD continues to carry the use of blade batteries in the Han EV launched in the third quarter of 2020, and in the fourth quarter of the Qin Pro, Qin EV, Song Plus, and other models one after another. It can be expected that with the continued development of BYD's second-

generation blade battery, its range and safety will be further improved and its cost performance more prominent. In summary, the 'blade battery' will probably change the competitive landscape of power batteries. The significant improvement in the range can meet the needs of A-class to C-class new energy private passenger cars. For other car-making new forces and brands positioning luxury new energy vehicles, more attention to safety and cost competition is a natural choice. The "Blade battery" with both low cost and high safety performance will undoubtedly occupy a favorable position in the future new energy battery competition.

4.3. IGBT: the heart of BYD's electric car

In addition to battery technology, another core component of new energy vehicles is the electric motor, the core of which is the insulated Gate Bipolar Transistor (IGBT). IGBT chips are as important to electric vehicles as the CPU is to computers. It is the second most costly automotive component, accounting for about 5% to 10% of the manufacturing cost of the vehicle [15]. Before BYD's IGBT chips were successfully put into the market, China had been restricted in this field for a long time like other chips. There was a serious shortage of mid-to-high-end IGBT production capacity, with about 90% relying on imports, most of which were provided by international giants such as Infineon, Mitsubishi, Fuji, ON Semiconductor, and Asea Brown Boveri (ABB). 2019's financial report shows that BYD's IGBT chip production capacity has reached 50,000 pieces/month. BYD's IGBT chips are mainly supplied internally, the market share in 2019 is still as high as 18%, second only to Infineon [13]. The company has become the largest domestic manufacturer of automotive-grade semiconductors. Its production capacity is expected to reach 100,000 chips/month in 2021, which can supply 120,000 new energy vehicles a year, equivalent to the total number of new energy vehicle sales in 2019.

In addition to the field of new energy vehicles, IGBT chips have a wide range of applications in the fields of home appliances and industrial control, and the market size continues to grow. The IGBT market size reached 15.5 million yuan in 2019 alone [16]. However, BYD is still in the state of following and catching up in IGBT technology iteration. Combined with BYD's comprehensive advantages in the field of intelligent control and power battery technology, not only are the current products more competitive, but the future is also even more indefinable.

5. CONCLUSION

This paper examines the impact of government subsidies on BYD, a new energy vehicle company, and compares it with other new energy vehicle companies to uncover its technological advantages. The following conclusions are drawn. The company's profitability has been unsatisfactory in recent years due to the increase in amortization and depreciation expenses caused by BYD's R&D expenses and model technology upgrades. However, it is BYD's high investment in R&D over time that has ensured the company to continuously make progress and breakthroughs in key technology areas. Today's BYD continues to invest internally in R&D to drive down costs and to enable external cooperation and supply. Models of Changan Ford and Beiqi Foton equipped with BYD batteries, mark a substantial step in the outward sale of its batteries. As the government subsidy dividend decreases, the technological advantage will be the main driving force for BYD to surpass Tesla as the world's number one new energy vehicle manufacturer in the future.

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