Investment Income Analysis of Automobile Enterprises Entering the Commercial Vehicles Field of Hydrogen Fuel Cell

Shuai Yuan[1, *]

[1]McCormick School of Enigneering, Northwestern University, Evanston, USA
*Shuai990920@163.com

Abstract:
Hydrogen energy is known as the ultimate solution of energy and has broad application prospects; Hydrogen fuel cell vehicle is favoured because of its short charging time, clean and environmental protection, high energy conversion rate and rich sources; However, at present, its development is hindered by expensive raw materials, high cost of hydrogen production, few hydrogenation stations and immature technologies. Taking the traditional automobile enterprises involved in Commercial Vehicles of Hydrogen Fuel Cell (CV-HFC) as an example, based on the financial data of mainstream listed automobile enterprises, the paper uses the market comparison and average methods to predict the long-term investment income of the example automobile enterprise in this field through the indicators of Net Present Value (NPV), Internal Rate of Return (IRR) and Dynamic Payback Period of Investments (DPPI). The results show that: (1) The DPPI of automobile enterprises with general comprehensive strength, market reputation and brand value in this field is long (more than 17 years) and the risk is high; (2) Automobile enterprises with strong strength, accumulated technologies and good market share have a relatively short investment cycle in this field (it also takes about 14 years), but their long-term investment income is well, which provides a valuable reference for relevant enterprises to invest in hydrogen fuel cell vehicle projects.

Keywords: *New energy vehicles; Hydrogen fuel cell; Investment income analysis; Dynamic analysis method; Market comparison method; Optimistic estimate*

1. INTRODUCTION

At present, the global new energy vehicle industry is developing rapidly, and capital from all parties have entered the field to seize the market opportunity [9]; Pure electric vehicles have been popularized and applied in China, but hydrogen fuel cell vehicles are still in the stage of R & D and small-scale demonstration application. Hydrogen fuel cell vehicles are favoured benefiting from their characteristics of short charging time, clean and environmental protection, high energy conversion rate and rich sources [2]. Hydrogen energy is also known as the ultimate solution of energy, and its future is well. Throughout the world, more than 30 countries have formulated hydrogen strategies. Although the United States, Japan, Germany and other European countries are at the forefront, they have not been popularized on a large scale due to the immature technologies, expensive raw materials and high cost of hydrogen production [7]. The Chinese government attaches great importance to the future planning and layout of hydrogen energy and its industrial chain, and has successively issued a series of subsidy policies, specifications and guidance. Mainstream automobile enterprises have also invested heavily in R & D and demonstration applications, but generally speaking, it is still in the initial stage of development [8]. It is predicted that the global hydrogen energy consumption will account for 18% of the total energy demand in 2050, and the whole hydrogen fuel application market will exceed the scale of 2 trillion yuan [11], which has a very broad prospect. At present, there are few studies on the investment income analysis of hydrogen fuel cell vehicle projects, and there is a lack of empirical research supported by data [6]; In terms of specific income analysis methods, dynamic analysis methods are generally used [4], and in order to predict income, it is necessary to reasonably estimate the sales data and profits after production in line with China's market.

© The Author(s) 2023
S. A. R. Khan et al. (Eds.): ICMSSE 2022, AHCS 12, pp. 279–285, 2023.
https://doi.org/10.2991/978-94-6463-056-5_40

The paper takes a vehicle enterprise's traditional automobile business development is limited and in urgent need of transformation and innovation as an example, and uses public and average sales and financial data in the field of CV-HFC to analyse and predict the future investment income and investment payback period. Based on the sales volume data, financial statements and basic data of new energy vehicle enterprises in the industry publicly released by 13 mainstream listed vehicle enterprises. The paper makes a reasonable estimation in terms of market share, sales volume, unit price and profit; then using the methods of DPPI, IRR and NPV, we analyses and forecasts the investment income and dynamic investment payback period, so as to provide certain data analysis support for relevant enterprises to invest in the field of hydrogen fuel cell vehicles.

2. FORECASTING METHODS OF REVENUE

2.1 Method of NPV

NPV refers to the algebraic sum of the present value of NCF in each year of the investment period [1]. The basic steps of calculating NPV are divided into three steps [10]: First, determine the benchmark rate of return of the investment. Secondly, the benchmark year of the present value is determined. Generally, the first year is expressed as year 0. Finally, the NCF generated in each year is discounted at the determined benchmark rate of return (discount coefficient) as the present value at the benchmark year, and then summed. Combined with the actual situation of the example automobile enterprise, the paper adopts the unequal payment formula of NPV, as follows:

$$NPV(i_0) = \sum_{t=0}^{n} F_t (1+i_0)^{-t} \tag{1}$$

Where, t represents the serial number of the year to which the NPV flow belongs, F_t represents the NCF in year t, and i_0 represents the benchmark rate of return.

2.2 Method of IRR

It refers to the discount rate that makes the cumulative NPV of an investment project equal to zero during the investment period. Specifically, the discount rate when the cumulative present value of cash inflow in each year is equal to that of cash outflow [5]. It is expressed by i*, and the formula is as follows:

$$NPV(i^*) = \sum_{t=0}^{n} F_t (1+i^*)^{-t} \tag{2}$$

The specific calculation of i* is generally solved by the trial calculation interpolation method [5], and its formula is:

$$i^* = i_{\text{small}} + \frac{NPV(i_1)}{NPV(i_1) + |NPV(i_2)|} \times (i_{\text{big}} - i_{\text{small}}) \tag{3}$$

In order to make the error of i* as small as possible, the difference between i_{big} and i_{small} is required to be less than 1 ~ 2%.

2.3 Method of DPPI

It discounts the annual NCF according to the benchmark rate of return, and then compares the cumulative NPV with the investment present value until the NPV is positive [10]. The formula is as follows:

$$P = \sum_{t=0}^{n} F_t (1+t_0)^{-t} \tag{4}$$

Where, P is the present value of investment, F_t is the cash flow in year t, i_0 is the benchmark rate of return, and n is the DPPI. The DPPI P_t is calculated as follows [3]:

$$P_t = k\text{-}1 + \frac{|\sum_{i=0}^{k-1} NPV(i)|}{NPV(k)} \tag{5}$$

Where, k represents the number of years in which the cumulative NPV begins to be positive, and NPV(i) represents the NPV in year i.

3. ESTIMATION OF OPERATING DATA

After investing in the hydrogen fuel cell vehicle project, the future sales volume, profit and other data of automobile enterprises are the key to the prediction and analysis of investment income. In this paper, when predicting the investment income, the basic data mainly consider four modules: market share estimation, sales estimation, single vehicle price estimation and profit estimation. The hydrogen fuel cell vehicle is still in its infancy and demonstration application stage in China, and its existing sales, profit and other data do not have reference value. The paper takes the average value of financial data published by mainstream automobile enterprises in the automobile industry over the years, national development plan, industry white paper, industry direction and technology roadmap as a reference, and focuses on the data of automobile enterprises involved in new energy vehicles, such as BYD, Yutong, Zhongtong, BAIC, etc. The following describes the prediction logic and basic assumptions of each module.

3.1 Estimation of industry sales volume

The prediction of the future sales volume of the hydrogen fuel cell commercial vehicle industry is based on the following data: Based on the sales volume data of CV-HFC predicted by the hydrogen energy alliance in 2030, taking the retention of 2030 hydrogen fuel cell vehicles specified in the “national innovation driven development strategy outline” as the auxiliary verification data, and taking the phased target sales

volume and the average growth rate of new energy electric vehicle sales as the reference basis. Taking the sales volume of 8000 units in 2021 (historical data) as the starting point and the sales volume of about 360000 units in 2030 as the intermediate benchmark, and calculate forward and backward respectively, and allocate the retention of about 1 million to each year (2022 ~2031). It is assumed that the average growth rate of sales volume in the short, medium and long-term stages of hydrogen fuel cell commercial vehicle sales is basically equivalent to the average growth rate of historical sales volume of new energy vehicles. Therefore, the predicted industry sales data are shown in Table 1.

Table 1: Estimation of industrial and example enterprise sales volume (unit: Set).

Year	Industrial sales	Enterprise share	Enterprise sales
2017	1275		
2018	1527	0%	0
2019	3018	0%	20
2020	1497	0%	40
2021	8000	2%	160
2022	14380	2%	288
2023	20678	4%	827
2024	29736	5%	1487
2025	42760	7%	2993
2026	65551	8%	5244
2027	100489	9%	9044
2028	154050	10%	15405
2029	236159	11%	25977
2030	362031	10%	36203
2031	554994	10%	55499
2032	665993	10%	66599
2033	732592	10%	73259
2034	805852	10%	80585
2035	886437	10%	88644
2036	975080	10%	97508
2037	1072589	10%	107259
2038	1179847	10%	117985

3.2 Estimation of market share

According to the data of China Automobile Industry Association, the top three sales volume of domestic new energy vehicle enterprises in 2018 were 247800 Set (accounting for 19.73%), 158000 Set (accounting for 12.58%) and 142000 Set (accounting for 11.31%), of which BYD topped the list and the other two were also large automobile enterprises. The sales volume of the companies behind is not high, accounting for about 2.5 ~ 7%. According to the sales volume of new energy vehicles from January to October 2020, the market share of the top three is more than 10%. Generally speaking, the market share of automobile enterprises that have entered the new energy vehicle industry for a long time and have strong technologies will be larger, while that of other mainstream automobile enterprises will generally be maintained at 3 ~ 6%. The market share of those automobile enterprises with weak strength and technologies is less than 3%.

The example vehicle enterprise entered the field of CV-HFC in 2018. A small number of mass-produced vehicles were sold from 2019 to 2021. However, due to the previous weak competitiveness of traditional fuel vehicles, the market share is very low (accounting for about 0.2%, and the average annual sales volume is about 10000 Set), and it is only regional sales; Therefore, when it enters the field of CV-HFC, its market share will not be greatly improved in the short term. However, the example enterprise have a certain accumulation in hydrogen fuel cell technologies which is in the leading position in the industry. So in the medium and long term, its market share will have a good performance.

Based on this, its market share is estimated: in 2021 and 2022, after being put into operation, thanks to the early-stage technology accumulation and effective marketing, the market share will be maintained at about 2% for the time being; In 2023 and 2024, due to excellent technologies and good market feedback, word-of-mouth was gradually established, and the market share increased to 4 ~ 5%; In 2025 and 2026, the market share will increase to 7 ~ 8%; From 2027 to 2029, the market share increased year by year, about 9 ~ 11%; After 2030, with the maturing of hydrogen fuel cell vehicle technologies and large-scale mass production in the industry, the market share will decline appropriately. It is assumed that it will remain stable at about 10% after 2030. The estimated annual sales data is as shown in Table 1.

3.3 Estimation of single vehicle price

According to public information, CV-HFC are very expensive at current stage, which is also more expensive than new energy electric ones. This is mainly due to the cost of hydrogen fuel cell system, hydrogen storage technologies, raw materials, spare parts and R & D investment. Among them, the production and development of key parts mostly rely on imports and are in a state of technological monopoly. At the initial stage of investment, there is no large-scale and batch production effect, so it is difficult to reduce the cost in the short term.

Considering the key types of commercial vehicles (such as passenger vehicles, trucks and tractors) of the

example vehicle enterprise, as well as the dealer channels, sales regions, customer resources and other factors formed over the years, combined with its planning layout and current development trend in the field of CV-HFC, it mainly sells urban buses, conventional trucks, tractors and light trucks equipped with hydrogen fuel cells. If the example enterprise adjusts its sales strategies after the transformation, it is assumed that the sales of urban buses (UB), conventional trucks (CT), tractors (T), light trucks (LT) and other special vehicles (OSV) account for 30%, 30%, 20%, 10% and 10% respectively. Based on the average sale price of vehicles in the industry, it is estimated that the average selling price of each hydrogen fuelled commercial vehicle sold by the example company should be about 1.63 million yuan, as shown in Table 2 (The average price of traditional fuel vehicle is abbreviated as AP-TFV, and the average price of hydrogen fuel cell commercial vehicle is abbreviated as AP-HFV). The unit of price, profit and NPV involved in the paper is 10000 yuan.

Table 2: Sales proportion and price estimation of the example enterprise.

Vehicle type	LT	UB	CT	T	OSV
Proportion	10%	30%	30%	20%	10%
AP-HFV	90	200	150	200	90
AP-TFV	18	50	35	40	18
Magnification	4	4	4.3	5	4
Final AP-HFV	163.0(2021~23)				
Final AP-TFV	37.1(2020)				

McKinsey predicts that the output of fuel cell vehicles is inversely proportional to the cost. The larger the output, the lower the cost, that is, large-scale benefits have obvious advantages in fuel cell vehicle manufacturing. In addition, according to the prediction of relevant institutions, the price of hydrogen fuel cell vehicles is expected to fall to the same level as that of traditional fuel vehicles by 2035. Based on this, the preliminary estimation of single vehicle price is made: starting from the converted average price of single vehicle of 1.63 million yuan in 2021, the annual average price will be reduced by 11.63% until it falls near the average price of single vehicle of various vehicle types in the current automobile industry in 2035. Considering the sales proportion structure of commercial vehicles in the future, the final converted average price of single vehicle is 371000 yuan, which is basically equivalent to the average price of 369700 yuan in 2035, which is shown in Table 3.

Table 3: Estimation of average selling price of each vehicle.

Year	(n)	Volume	Price	Reduction ratio
2018	0	-	-	-
2019	1	20	163.00	0.00%
2020	2	40	163.00	0.00%
2021	3	160	163.00	0.00%
2022	4	288	163.00	0.00%
2023	5	827	163.00	0.00%
2024	6	1487	144.04	11.63%
2025	7	2993	127.29	11.63%
2026	8	5244	112.49	11.63%
2027	9	9044	99.40	11.63%
2028	10	15405	87.84	11.63%
2029	11	25977	77.63	11.63%
2030	12	36203	68.60	11.63%
2031	13	55499	60.62	11.63%
2032	14	66599	53.57	11.63%
2033	15	73259	47.34	11.63%
2034	16	80585	41.84	11.63%
2035	17	88644	36.97	11.63%
2036	18	97508	36.97	0.00%
2037	19	107259	36.97	0.00%
2038	20	117985	36.97	0.00%

3.4 Profit estimation

Considering that the single vehicle profit is closely related to the vehicle price and brand, the paper adopts "the average profit corresponding to the selling price of 10000 yuan" as the estimation index, also known as the Profit Coefficient (PC) (Unit: 10000 yuan). By analysing the main revenue, sales volume, net profit and other indicators of mainstream listed vehicle enterprises in recent three years, the average price and average profit of each vehicle enterprise are calculated; On this basis, the average profit corresponding to the selling price per 10000 yuan is obtained. Finally, the PC of all the investigated vehicle enterprises are calculated to be 0.044. This average value is used as the reference benchmark for the profit estimation of hydrogen fuel cell vehicles for example car enterprises.

The empirical study show that the PC of each vehicle enterprise are between 0.0024-0.1493, while from the perspective of privately controlled enterprises, the PC is generally higher than that of state-controlled enterprises. The example enterprise is privately held, and its PC is predicted with reference to private enterprises. Considering the following factors such as the improvement of production and operation, cost control rate and the price reduction of raw materials, the PC will be further improved. Based on this, the following estimates are made: (1) 2019-2020 is the year of initial production and demonstration application, and the PC is taken as the industry average value of 0.044; (2) From 2021 to 2030, the enterprise will increase the profit margin by controlling costs, reducing rates, strengthening management, using talents and improving technologies; It is predicted that the PC will increase at an average rate of 10% per year, and reach the highest value of 0.1141 in 2030; (3) Then, from 2031 to 2038, with the continuous decline of the average price of single vehicle, the

increasingly fierce competition in the industry, large-scale mass production, the increase of labour cost and other factors, its PC decreased year by year at a rate of about 10% per year, and finally decreased to 0.0749 in 2038, which was above the medium level of the industry.

4. INCOME PREDICTION AND ANALYSIS

Suppose that the example enterprise invested 5 billion yuan for the first time, including 2 billion free funds and 3 billion funds from bank loans. The annual interest rate is 4.9%, which is paid by means of annual interest repayment and one-time principal repayment. Therefore, 147 million yuan of interest will be paid at the end of each year. It is assumed that the investment in fixed assets will be 2 billion yuan in 2020 and 2029 (the initial and medium-term of the project), so as to facilitate the calculation of the net cash flow (NCF). The cumulative depreciation average life method is adopted, and its calculation formula is: Annual depreciation rate = (1 - estimated net salvage value) / estimated service life * 100%. It is adopted that the service life of machine equipment in the industry is 10 years, the net salvage value is 5%, the annual depreciation rate is 9.5% and the year 2018 is set as the base year (n = 0).

4.1 Prediction by NPV

Combined with the above forecast data, we calculate the annual net profit, and then calculate the NCF of each year in the investment period. According to the formula (1), taking the benchmark return on investment of 8.9% as the discount rate, the NPV of each year can be calculated, as shown in Table 4 (10% market share after 2030).

Table 4: Estimation of NCF and NPV.

Year	NCF	Present value	NPV
2018	0	514700.00	-514700.00
2019	143.44	-13366.91	-528066.91
2020	-180713.12	164777.52	-692844.42
2021	20262.27	4306.94	-688537.49
2022	21495.83	4832.04	-683705.44
2023	26895.80	7962.89	-675742.55
2024	32796.30	10849.82	-664892.73
2025	45998.96	17231.96	-647660.77
2026	64981.02	25420.32	-622240.45
2027	96085.17	37782.82	-584457.63
2028	146634.49	56244.43	-528213.19
2029	28218.66	5292.09	-522921.10
2030	302431.06	103431.35	-419489.76
2031	364570.73	115490.21	-303999.54
2032	348811.33	101274.68	-202724.86
2033	307539.73	81510.17	-121214.69
2034	271432.73	65619.84	-55594.86
2035	264382.28	58602.18	3007.32
2036	288920.51	59101.45	62108.77
2037	315912.56	59613.33	121722.10
2038	345603.82	60137.34	181859.43

It can be seen from Table 4 that when n=16 (2034), NPV<0, indicating that the return rate during the investment period is less than the benchmark return rate; when n=17 (2035), NPV is greater than 0, and there is excess return, and the return value is 30 million yuan, indicating that the project is economically feasible; when n=20 (2038), the income is 1.818 billion yuan. Therefore, in order to make a profit, the project needs at least 17 years, far exceeding the average investment payback period of 9 years in the automotive industry. In fact, Tesla also achieved its first profit after 17 years of its establishment.

4.2 Prediction by IIR

According to the formulas (2) and (3), assuming that the investment period is 17 years, the internal rate of return is calculated by the interpolation method. Let i_{big} = 8.94%, at this time, NPV (1) = -109.26<0; Let i_{small} = 8.938%, at this time, NPV (2) = 46.16, which is greater than 0; we can obtain i*=8.9385%>8.9% (benchmark yield). Therefore, if the investment period is 17 years, the project is OK, but the yield is very low.

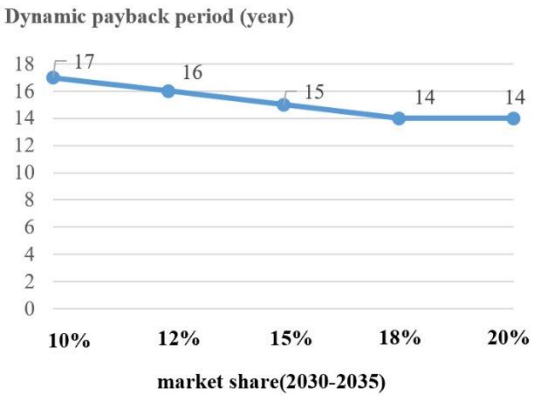

Figure 1: DPPI of the example enterprise under different market shares.

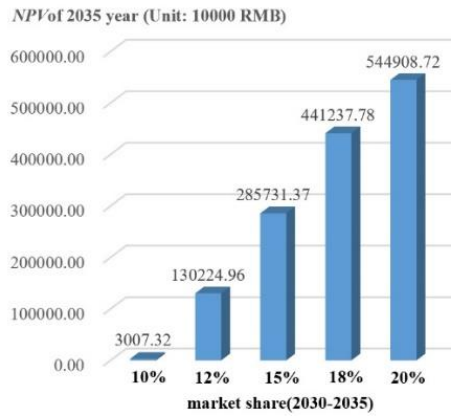

Figure 2: NPV of the example enterprise under different market shares.

4.3 Prediction by DPPI

According to the formulas (4) and (5), combined with the NPV of each year in Table 4, we calculate the cumulative NPV and DPPI P_t as follows:

$$P_t = k - 1 + \frac{|\sum_{i=0}^{k-1} NPV(i)|}{NPV(k)} = 17 - 1 + \frac{|-55594.86|}{58602.18} = 16.95(year)$$

From the above analysis and calculation, assuming that other conditions remain unchanged, the market share plays a decisive role in the DPPI and NPV. We calculated the DPPI and NPV of the example enterprise under different market shares in detail (assuming that the market share is stable at a fixed value after 2030), as shown in Figure 1 and Figure 2. If the market share of the example enterprise can be increased to 18% from 2030, the DPPI is 14 years, that is, the investment can be recovered in 2032. At this time, the NPV equals to 736 million yuan. Addition, the NPV can reach 4.412 billion yuan in 2035 and 7.611 billion yuan in 2038.

5. CONCLUSIONS

The reason why the example enterprise enter the commercial vehicles field of hydrogen fuel cell with a long DPPI is directly related to their market reputation, market share, R&D cost, sales and so on. Give some warnings: (1) for general vehicle enterprises to enter the field of CV-HFC, they should be cautious. Their DPPI is long and the risk is high; (2) For high-quality automobile enterprises with strong strength, they have great advantages in market share, capital strength, product competitiveness and brand awareness and their DPPI will be shortened to a great extent, but it is also significantly greater than the average DPPI of the automobile industry (n=9); (3) If automobile enterprises want to enter this field and make profits as soon as possible, they need to make efforts in expanding market share, improving product competitiveness and net profit, and need to continue to invest in R & D for a long time to continuously reduce operating costs. The study provides real and detailed income data analysis and prediction support for relevant enterprises when investing in hydrogen fuel cell vehicles, which is conducive to enterprises to analyse the risk sources of income, so as to make up for their shortcomings, make accurate efforts and ensure the benefits of investment.

ACKNOWLEDGEMENTS

Our thanks to the anonymous reviewers for their insightful comments. The study is supported by National Natural Science Foundation of China under Grant 61803073.

REFERENCES

[1] Dusseault, B., Pasquier, P. (2021). Usage of the net present value-at-risk to design ground-coupled heat pump systems under uncertain scenarios. Renewable Energy, 173, 953-971.

[2] Fan, Y. (2021). Technological Innovation and Market Cultivation of New Energy Vehicle Industry[C]. *2020 Asia Conference on Geological Research and Environmental Technology*. IOP Publishing.

[3] Gorshkov, A.S., Vatin, N.I., Rymkevich, P.P., et al. (2018). Payback period of investments in energy saving. Magazine of Civil Engineering, 78(2), 65-75.

[4] He, X., Wang, F., Wallington, T.J. et al. (2021). Well-to-wheels emissions, costs, and feedstock potentials for light-duty hydrogen fuel cell vehicles in China in 2017 and 2030. Renewable and Sustainable Energy Reviews, 137, Article number: 110477.

[5] Hazen, G., Magni, C. A. (2021). Average internal rate of return for risky projects. Engineering Economist, 66(2), 90-120.

[6] Khan, U., Yamamoto, T., Sato, H. (2021). An insight into potential early adopters of hydrogen fuel-cell vehicles in Japan. I. J. of Hydrogen Energy, 46(18), 10589-607.

[7] Liu, C., Liu, Y., Zhang, D., Xie, C., et al. (2022). The capital market responses to new energy vehicle (NEV) subsidies: An event study on China. Energy Economics, 105, Article number: 105677.

[8] Mo, L. (2021). Comparative Analysis of Equity Financing Efficiency between Chinese and American New Energy Vehicle Listed Enterprises[C]. *AEECS 2021, 2021 5th International Conference on Advances in Energy, Environment and Chemical Science*. EDP Sciences Press.

[9] Qingyu, Z., Jieshan, M., Bohong, G., et al. (2021). Effect of Consumers' Green Preferences and Governmental Subsidy Policies on New Energy Vehicle Manufacturers: A Game-Theoretical Analysis[C]. *ICEME 2021, The 2021 12th International Conference on E-business, Management and Economics*. ACM Press.

[10] Rezaei, F., Najafi, A. A., Ramezanian, R., et al. (2021). Simulation-based priority rules for the stochastic resource-constrained net present value and risk problem. Computers and Industrial Engineering, 160, Article number: 107607.

[11] Wang, P., Xue, Q., Yang, J., et al. (2022). Energy Security Planning for Hydrogen Fuel Cell Vehicles in Large-Scale Events: A Case Study of Beijing 2022 Winter Olympics. Automotive Innovation, 5(2), 209-220.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (http://creativecommons.org/licenses/by-nc/4.0/), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.