Measurement of China ADAS Industry Competitiveness based on Grounded Theory

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Abstract. As a rapidly emerging industry in recent years, the market size of China ADAS industry has reached 87.8 billion yuan in 2020, up 108.5% from 42.11 billion yuan in 2019, and will become a rapid growth point for the future automotive industry. This paper innovatively adopts the rooting theory combined with Porter diamond model, completing the open coding, categorization, recoding and aggregation for ADAS industry, constructing the ADAS industry competitiveness measurement model. After the information and data of the current situation of China's ADAS industry are used as input to complete the industry competitiveness measurement, the results show that the competitiveness is unbalanced in factors Innovation and Production, significantly leading in factors Demand and Related Industry, and not significantly performing in factor Support & Opportunity. Overall, China ADAS industry competitiveness is unbalanced, but can occupy a more advantageous position in the competition globally, with some significant lagging segments, such as Technology Development and Human Resource, that need to be adjusted.

Keywords: ADAS; Industry Competitiveness; Grounded Theory; Porter Diamond Model.

1. Introduction

In recent years, the automotive industry has been in the process of transformation of electrification, intelligence, networking and sharing, and a large number of new car-making forces represented by Tesla, Nio, Lixiang and Xiaopeng have emerged to take a temporary lead in the track of new energy and automatic driving. Traditional Automakers also started to transform themselves as soon as possible to contend the lead in the future new era of the automobile market. This process is an excellent opportunity for rapidly developing China's automobile industry in the new track and transforming its current status, which is dominated by developed countries like Europe and North America.

ADAS refers to an Advanced Driving Assistance System, which uses a variety of sensors installed in the car to sense and collect data from the surrounding environment at all times during the driving process, combined with map data, to carry out systematic computing and analysis, so that the driver can be aware of possible hazards in advance. ADAS is a kind of pre-landing product for future fully automatic driving technology and is also an important part of the trend of car intelligence. Therefore, all major manufacturers are now making continuous efforts in the field of ADAS, and from previously being equipped only with high-end products to being widely popular now, the market scale is expanding rapidly. According to statistics, the market scale of ADAS in China is 87.8 billion yuan in 2020, which is 108.5% higher than 42.11 billion yuan in 2019, and the field of driver assistance will become a rapid growth point for the future automobile industry.

Therefore, this paper measures the competitiveness of China ADAS industry based on the passenger car segment with the grounded theory combined with Porter diamond model, and makes relevant suggestions for the sustainable optimization and rapid development of the industry chain in the future.

2. Background of China ADAS industry

The global ADAS industry is currently growing rapidly. In a research report by McKinsey, Ondrej notes that by 2030, the revenue of the automatic driving chip market is expected to reach about $29 billion per year, which will be significantly higher compared to $11 billion in 2019. And most of this demand is expected to come from automatic vehicles at L2 or higher levels, which will account for 85% of the market demand by 2030. [1] Zhao, Jin, et al, in their study, expect that the China ADAS market will enter a period of rapid expansion in the next 2-3 years, and the demand for ADAS in the China automotive market will maintain a continuous growth trend with a CAGR of about 27.8% in the next three years starting from 2019. [2] Liang Weiqiang and Hong Fubin point out that the growth rate of the ADAS market will only stabilize after the mass production of high-level automatic vehicles by 2025 in their study. [3] And national ministries and commissions have launched a number of policies and specifications to vigorously promote the implementation of assisted driving technology on the ground.

The future development of the ADAS industry is more secure than the development of the L4-level automatic driving technology industry. In her study, Zhu Lin points out that if the development of L4-level automatic driving technology is slow, these companies will have difficulty surviving due to the lack of products, but ADAS has sufficient product support. [4]

Therefore, in the trend of ADAS industry development, there is an urgent need to measure the current ADAS industry competitiveness comprehensively and scientifically for further targeted improvement.

3. Relevant experience literature

3.1. Grounded Theory

The core and fundamental methodological principle of classical grounded theory are to avoid any subjective and preconceived assumptions from researchers. Let the data speak for themselves, let the research questions and the final theoretical results emerge naturally from the social progress and the research process conducted on it through the existing literature, the perspectives of the researchers themselves and their subjects, historical information, or personal experiences. In their paper, Jia Xudong and Tan Xinhui point out that their emphasis on conceptualization and abstraction facilitates the excavation of the essence of management phenomena and their laws to construct a normative theory. [5] Fei Xiaodong, in his study on grounded theory, points out that problem formulation and shaping should explain what really happens in real life rather than describe what should happen. Not paying too much attention to the strictness of research methods while ignoring the relevance. [6] Lai Lei and Jiang Nongjuan, in their study of the shared bicycle business model based on grounded theory, used the 3-stage coding of grounded theory to gradually refine 12 sub-categories and further construct 3 main categories, and gave specific countermeasures and suggestions around the core category of "value creation". [7]

3.2. Porter Diamond Model

Guo Jingfu points out in his research on industry competitiveness that the study of industry competitiveness should be based on the accurate judgment of weak links. A set of scientific and reasonable competitiveness evaluation index systems and systematic evaluation methods should be established to evaluate industry competitiveness to ensure the improvement with a target. [8] Wang Ying, in her study, points out that there are many paradigms for the analysis of industry competitiveness measurement, all of which are based on Porter diamond model to improve and innovate. She also summarizes the analysis paradigm of Porter diamond model developed so far. [9] Rui Mingjie, on the other hand, in his research, combines the development trend of the times and adds a core to Porter diamond model - knowledge absorption and innovation ability, with which the industry can develop its own sustainable competitiveness. [10]

3.3. The Measurement of Industry Competitiveness

Vladimír H, in his study on the competitiveness indicators of the Slovak automotive industry, measures the industry concentration through the Herfindahl index to explain the competitiveness of the industry in the Slovak economic context. However, the limitation of this research method is that it does not allow a scientific evaluation of multinational enterprises [11]. A study by Wang Long et al. on the measurement of the international competitiveness of the Chinese automotive industry, split the objectives into a total of 6 parts: environmental, technological, parts, production, sales and service competitiveness [12]. In his dissertation, Zhang Chuankun proposed an evaluation system with 4 primary indicators of policy, environmental, production and technology, and also 9 corresponding secondary indicators for measuring the industry competitiveness of new energy vehicles. [13] Li Ying and GAO Chang, in their study on measuring the competitiveness of the Chinese new energy automotive industry, proposed an evaluation system with 4 primary indicators of R&D, production, sales, and value-added services and their corresponding 14 secondary indicators from the perspective of value chain [14].

4. Research path

Since the ADAS industry is limited by its attributes of a new industry, it is difficult to collect enough industrial data to support the quantitative analysis of the industry competitiveness model during the research process. Therefore, in this paper, we establish the competitiveness model of the ADAS industry by using the grounded theory to code and categorize the literature related to China ADAS industry, and further combining the theories of Porter diamond model to reorganize the categories presenting common features and internal linkages, to measure the competitiveness of China ADAS industry based on the obtained information and data and identify the strengths and weaknesses of the development. Finally, propose targeted countermeasures and suggestions.

5. Data acquisition and encoding

5.1. Open Coding

In this paper, a total of 124 pieces of literature related to the ADAS industry were searched on the web, and the content of the articles was deeply understood by a research participant and avoided preconceived understanding and orientation. The key information of the literature was labeled, and a total of 339 labels of 118 types were obtained. And then further conceptualization and categorization of the label contents layer by layer, a total of 16 initial categories were summarized:

Table 1. Open Cording Categorization.

Initial concept group (partial)	Category
sensors, high precision maps, autonomous driving chips, semiconductors, GPUs, millimeter wave radar, lidar, short wave infrared sensing technology, cameras, semiconductors	Related Product
improve safety, enhance intelligence, practicality and comfort to be improved	Product Features
test complexity enhancement, test time compression, sensor virtual testing, electromagnetic radiation immunity testing, open road testing, closed road testing, controller virtual testing, in-loop testing, simulation testing, virtual driving scenario simulation	Technical Testing
impact on driver interference, timing of manual takeover, effectiveness of use by different people, driving experience	Using Safety
core technology R&D, R&D investment enhancement, patent application enhancement, patent applicant dispersion, LIDAR solution, vision solution, self-driving chip R&D, millimeter wave radar R&D, camera calibration, self-test calibration, deep learning, image recognition technology, neural network algorithm	Technology Development
increasingly stringent security regulations, security protocols and standards, technical testing standards, data and information security	Safety Standard

distance monitoring, side object detection, blind spot monitoring BSD, pedestrian warning system PDS/PCW, forward collision warning FCW, lane departure warning LDW, driver attention monitoring, adaptive cruise control ACC, automatic emergency braking AEB, lane merge assist LCA, automatic parking, lane keeping LKA	Technical Features
market size expansion, market revenue enhancement, technology price to be further reduced	Market Demand
expansion of industry chain scale, lower price of assembled models, higher assembly rate, lower production cost, expanded production input, production line process management innovation	Production Assembly
Lack practitioners, single knowledge structure of personnel	Human Resource
automotive industry new four trend, autonomous driving technology route, automotive electronics market development	Development Opportunities
increased market acceptance, influence on consumer purchase decision, high consumer dependence, low acceptance on urban roads, good technology promotion trend, intelligent degree mark	Acceptance
Sunny Optical, Crystal Optech, OFILM, SMIC, OMNIVISION, Mobileye, Renesas Electronics, NXP, Texas Instruments, Nvidia, Tesla, Bertram, Trinova-tech, Tongyu Automobile, NASN, Horizon, Huawei, Black Sesame, Bosch, Continental, ZF, Waymo, Here, Baidu, Ali, Wanji Technology, Desay SV, Hasco Auto, Hesai Technology, RoboSense, Didi autonomous driving, Tencent, SONY, Denso, Panasonic, Valeo, Fujitsu	Related Companies
Top-level design support, higher investment and financing amount	Top-level Support
5G technology, smart grid technology, auto insurance pricing, auto insurance model innovation	Supporting Industries

5.2. Selective Coding

From the above table, we can see that the 16 categories obtained are not completely independent of each other. In this paper, after reorganizing and refining the categories with common features and internal connections, we got 4 main categories: R&D, Production, Market and Opportunity. After looking at the core of each category from the 4 main perspectives of Innovation, Production, Profitability and Application, the core category is "Value Enhancement", in which R&D is the core, Production is the foundation, Market is the result, and Opportunity is the necessary condition.

5.3. Saturation Test

After the coding was completed, this paper again searched more papers related to the ADAS industry to test the reliability and validity of this grounded theory study for the criterion of obtaining new categories. The results showed that no new categories were generated and the currently obtained categories were saturated.

6. China ADAS industry competitiveness

6.1. ADAS Industry Competitiveness Measurement Model

In order to conduct a focused analysis of the competitiveness of China ADAS industry, this paper will use the categories obtained by grounded theory, combined with Porter diamond model and the industry competitiveness-measurement-related theories, recode and integrated to obtain the ADAS industry competitiveness measurement model with five factors of Innovation, Production, Demand, Related industries, Support and Opportunities as the first level indicators and the corresponding label data. Among them, the core still corresponds to the core category "value enhancement", Innovation is the core, Production is the foundation, Demand is the result, Related Industries and Support & Opportunity are the necessary conditions. While ensuring the reliability, validity and saturation of the categories obtained from the grounded theory, the analysis can be carried out in a more intuitive and targeted way.

Meanwhile, this paper further analyzes the label contents and the corresponding key information of the papers, and marks "(+)" after the labels which showed significantly ahead; and marks "(-)" after the labels which showed significantly behind.

Table 2. ADAS industry competitiveness measurement Model.

Tier 1	**Tier 2**	**Information and Data**
Innovation	Technology Development	core technology R&D(-), R&D investment enhancement, patent application enhancement, patent applicant dispersion, LIDAR solutions, vision solutions, autonomous driving chip R&D, millimeter wave radar R&D(-), camera calibration, self-test calibration, deep learning, image recognition technology, neural network algorithms
	Technology Function	Decision-making and early warning categories: distance monitoring, side object detection, blind spot monitoring BSD, pedestrian warning system PDS/PCW, forward collision warning FCW, lane departure warning LDW, driver attention monitoring Assisted driving: adaptive cruise control ACC, automatic emergency braking AEB, lane merge assist LCA, automatic parking, lane keeping LKA
	Technology Applications	impact on driver interference, timing of manual takeover, effectiveness of use by different people, driving experience
	Technology Testing	test complexity enhancement, test time compression, sensor virtual testing, electromagnetic radiation immunity testing, open road testing, closed road testing, controller virtual testing, In-the-Loop testing, Software-In-the-Loop, Hardware-In-the-Loop, simulation testing, virtual driving scenario simulation
	Safety Standard	increasingly stringent security regulations, security protocols and standards, technical testing standards, data and information security
Production	Production and Assembly	expansion of industry chain scale, lower price of assembled models (+), higher assembly rate (+), lower production cost, expanded production input, production line process management innovation
	Production Materials	sensors, high precision maps, autonomous driving chips, semiconductors, GPUs, millimeter wave radar, lidar, short wave infrared sensing technology, cameras, semiconductor
	Human Resource	lack practitioners (-), single knowledge structure of personnel
Demand	Market Demand	market size expansion (+), market revenue enhancement (+), technology price to be further reduced
	Product Feature	improve safety, enhance intelligence, practicality and comfort to be improved
	Acceptance Perspective	increased market acceptance (+), influencing consumer car purchase decisions, high consumer dependence, low acceptance on urban roads, good trend in technology diffusion, sign of intelligence
Related Industry	Upstream Industry	**Decision level-chip** **Overseas:** Mobileye, Renesas Electronics, NXP, Texas Instruments, Nvidia, Tesla **China:** Horizon, Huawei, Black Sesame **Execution Level - Wireline** **Overseas:** Bosch, Continental, ZF **China:** Bertram, Trinova-tech, Tongyu Automobile, NASN **Perception layer - high precision map.** **Overseas:** Waymo, Here **China:** Baidu, Ali, Didi autonomous driving, Tencent **Perceptual layer - sensors** **Overseas:** Bosch, Valeo, SONY, Waymo **China:** Wanji Technology, Desay SV, Hasco Auto, Hesai Technology, Huawei, RoboSense **Perception layer - camera** **Overseas:** Bosch, Denso, Panasonic, Valeo, Fujitsu **China:** Sunny Optical, Crystal Optech, OFILM, SMIC, OMNIVISION
	Supporting Industry	5G technology (+), smart grid technology, auto insurance pricing, auto insurance model innovation
Support and Opportunity	Top-level Supporting	Top-level design support, higher investment and financing amount
	Development Opportunities	automotive industry new four trend, autonomous driving technology route, automotive electronics market development

6.2. Measurement of China ADAS industry Competitiveness

6.2.1. Innovation factor

In Technology Development, ADAS is widely regarded as an early form of automatic driving technology, so the development of the two technologies has been difficult to completely separate. There are two main types of automatic driving solutions in the industry: the one is camera-lead and radar-assisted programs, represented by Tesla, Mobileye. And the other one is led by Laser radars and assisted by cameras, sensors like millimeter-wave radars, etc. It can be seen that China ADAS industry is more oriented towards the latter, and is also a more mainstream developing orientation in the industry today.

According to Rolanberg's research data, the overall rate of R&D and the percentage of automatic driving patents have increased in China ADAS industry over the five years from 2016 to 2020, helping the ADAS market thrive. As a result of the early initiation of foreign research, there is a gap between the current level of core technology in China and abroad. Such as millimeter radar, Chinese companies are currently concentrated in the traditional 24GHz, strictly not yet reaching millimeter frequencies. But the world's mainstream high-end millimeter radar has been concentrated in the 77GHZ and 79GHZ bands. While there are also pioneering areas in China, such as Horizon, Huawei, etc. have stood in the front of the automatic driving chips area.

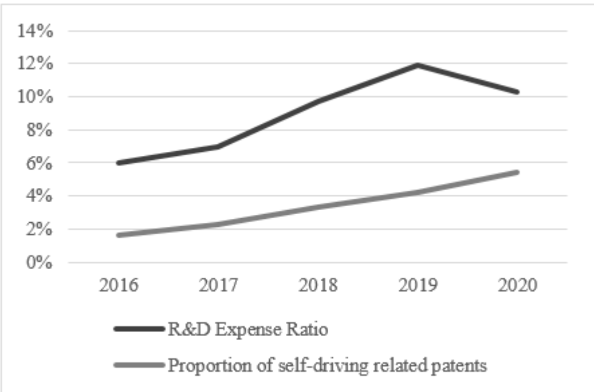

Fig 1. Development trend of China ADAS industry R&D efforts.

In Technology Function, the capabilities of ADAS currently fall into two main categories: Decision warning, after detection of actions or hidden hazards that endanger the safety of the vehicle traveling, promptly inform the driver by icons or beeping cues, to win more response time, such as distance monitoring, side-object probing, blind area monitoring BSD, pedestrian warning system PDS/PCW, pre-collision warning FCW, lane warning LDWs, driver attention monitoring, etc. Another category is a relatively high level of application that can intervene in driving behavior to adjust vehicle status or hedges, such as adaptive cruise ACC, automatic emergency braking AEB, side-car assisted LCA, auto parking, lane retention LKA, etc.

In Technology Applications, due to the capabilities of ADAS technology involving alerting and even partially replacing the role of the driver, the core of technology development should be the ability to guarantee effectiveness, reliability, and safety in a variety of scenarios. As and require extensive consideration of the impact on driver interference in the use process, the dependency on drivers, the timing of driver takeover of higher-order driving aids, and driving experience of drivers. Companies, both domestic and abroad, are exploring and are beginning to emerge in a program that uses interactive lights, sounds and odors to create new ways to communicate with drivers.

In Technology Testing, ADAS testing sessions are more integrated and have more pieces under test, which enhances testing costs and compresses testing time due to faster market iterations, thus putting higher requirements on the openness and flexibility of the testing system. The common solution for domestic and overseas is to incorporate more simulation testing, virtual testing, and front-loading testing process. ADAS testing technologies include three main parts: road, sensor, and data collection. And it is divided into three main kinds: Recording the original sensor data in road testing to verify the function and train the algorithm. Virtual simulation testing with a digital twin, which uses virtual scenarios restored with the real environment to perform in various test sessions, including hazards and special conditions. Hardware-In-the-Loop (HIL) and Software-In-the-Loop (SIL), based on NI PXI real-time controller to run simulation models, can adapt to higher dynamic characteristics and higher precision model application requirements to effectively reduce the time and cost of development. At present, the core manufacturers of virtual simulation testing and HIL/SIL testing are still mainly located overseas. There are several domestic companies in rapid development such as Dongfeng Motor Group Co., Jingwei Hirain, etc.

In Safety Standard, due to ADAS having changed the way cars are driven and the improvement in safety, all countries are pushing forward to revise their car safety standards and ADAS testing standards. China is at the forefront, C-NCAP has regarded active safety as a scoring item, with a weight of 15%, and requires that all subsequent new cars should be equipped with ADAS systems. The relevant departments in China have also released a large number of guidance documents on the testing of automatic driving vehicles.

According to further analysis of the labels and corresponding papers, the industry competitiveness shows a significant behind in the technology development, mainly focusing on the core technology R&D and millimeter wave radar R&D parts: According to the data of Zhongke Longgang, as shown in Figure 2, by 2019, there is only one domestic company Baidu among the top ten Chinese ADAS patent application enterprises, which means core technology R&D is significantly behind. According to the data in Liu Yi's degree dissertation, Germany's Mercedes-Benz started the research and development of millimeter wave radar in 76 GHz band in 1997, and Germany's Hella started the research and development of 24 GHz band in 2004, while Chinese enterprises did not start the R&D of millimeter wave radar in 24 GHz and 77 GHz band until 2015, which means Chinese ADAS technology is still in the primary stage [15].

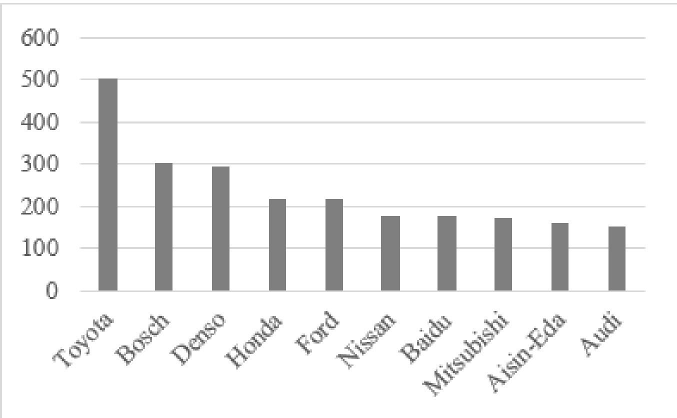

Fig 2. Top 10 ADAS Patent Application Companies in China (as of 2019).

Overall, the industry competitiveness of factor Innovation is unbalanced, with Technology Development behind except few relatively leading parts; Technology Application, Technology Testing and Safety Standard have not shown obvious performance.

6.2.2. Production factor

In Production and Assembly, the assembly volume of ADAS is growing rapidly around the world, especially in the Chinese market, and the average price of ADAS-equipped motor vehicles continues to drop. According to relevant data from Zuosi Automotive Research Institute, as shown in Figure 3, the average price has dropped from RMB 314,800 in 2016 to RMB 209,200 in 2020, while the assembly rate has increased from 2.24% in 2016 to 25.81% in 2020, which the growth rate reached more than 10 times. The growth was more rapid after 2018, indicating that ADAS has developed to the stage of large-scale popularization in the Chinese market. According to forecasts, there is still a huge improvement space in the assembly volume of ADAS before fully automatic driving is fully adapted to the market. [4]

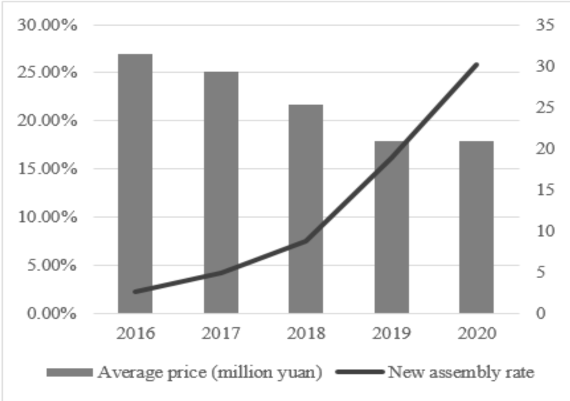

Fig 3. The average price and new assembly rate of Chinese ADAS-equipped motor vehicles

After further analyzing the ADAS assembly rate of new motor vehicles in China, we found that the proportion of L2 level is increasing from 29% (in 2016) to 50% (in 2020). In the future, high-level ADAS will become the mainstream in the Chinese Market.

In Production Materials, there are many upstream industries in the ADAS industry, such as vehicle cameras, sensors, chips, etc. The production capacity of these industries is closely related to the production and assembly of ADAS. Since the outbreak of Covid-19 in 2020, the global chip industry has been affected continuously. There is a serious shortage of automotive-grade chips, which has seriously affected the production capacity of complete vehicles for a long time. In 2022, the uncertainty and endless of Covid-19 cause a huge impact on parts production and vehicle Production in the automobile industry both in China and the global market. With the prospect of the domestic epidemic situation still unclear and foreign epidemic prevention generally back to normal, how to ensure the supply meets the lowest expectation and maintains its market position under the influence of Covid-19 is a common problem faced by various domestic industries.

In Human Resource, according to the estimation of the national ministries and commissions in the "Manufacturing Talent Development Planning Guide", the gap in manufacturing talent in China will be 1.03 million in 2025, and the single knowledge structure will also be a problem. It is foreseeable that the shortage of human resources in the ADAS industry will be further affected.

According to further analysis of labels and corresponding papers, The part of Production and Assembly is in a leading position in industry competitiveness, mainly in the part where the average price of ADAS-equipped motor vehicles has been reduced and the new assembly rate has increased: Figure 4 shows the ADAS assembly rates of Chinese new passenger cars from the pricing perspective. Chinese self-owned brands’ assembly rate has a significant advantage, accounting for 100% of RMB 0-100,000, and 97% of RMB 100,000-150,000. Joint-venture brands only show advantages in RMB 200,000-250,000. Figure 5 shows the ADAS assembly rates of Chinese new passenger cars from different countries in the Chinese market. The assembly rate of Chinese self-owned brands is significantly higher than others, and the overall rates from different countries are on a growth trend.

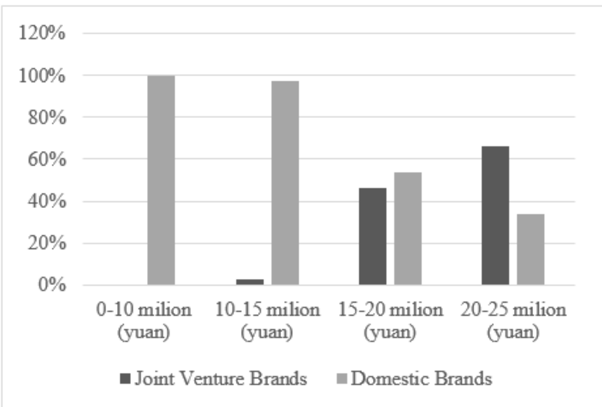

Fig 4. The ADAS Assembly Rates of 2022 Chinese New Passenger Cars

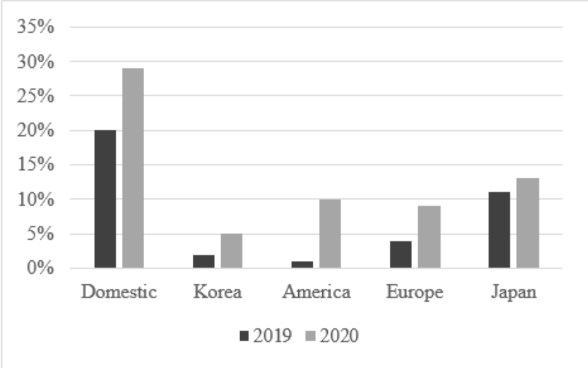

Fig 5. The ADAS Assembly Rates of Chinese New Passenger Cars from Different Countries

Human Resources is the key lag behind in industry competitiveness which is mainly concentrated in the small number of employees. According to the data of the "China Automobile Industry Yearbook", the number of employees in the Chinese automobile industry reached its peak in 2016, reaching 610,000 employees. It keeps stable from 2017 to 2020, with nearly 550,000 employees, which accounts for nearly 15% of the number of employees in the manufacturing industry, far below the level of 30% in world-class countries.

Overall, the industry competitiveness of factor Production is unbalanced, with Production and Assembly ahead, Human Resource behind, and Production Materials not showing obvious performance.

6.2.3. Demand factor

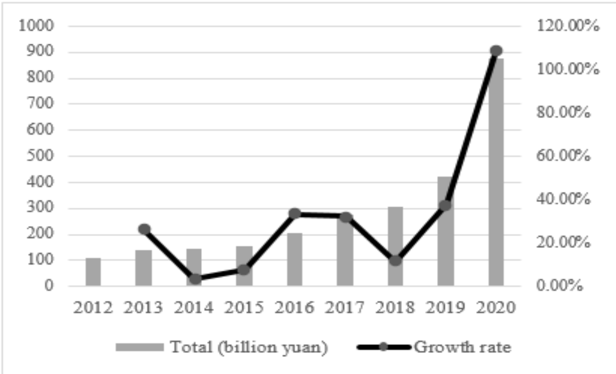

Fig 6. China ADAS Market Size.

In Market Demand, the total market value of China ADAS industry has continued to increase since 2012 as shown in Figure 6, from 11.03 billion RMB in 2012 to 87.80 billion RMB in 2020, especially the growth rate is rapidly accelerating since 2018. According to forecasts, China ADAS technology market size will continue to expand and reach a stable level until the mass production of high-level automatic driving cars.

In Product Feature, consumer demand in the Chinese market is mainly focused on improving the safety and intelligence of vehicles, among which improving safety is the most numerous label in this study, indicating that safety is the core requirement of ADAS: such as eliminating potential safety hazards, reducing the number of collisions, eliminating blind spots in vision, etc. However, the practicability and comfort in the product use process need to be improved as well.

In Acceptance Perspective, ADAS has become one of the indicators to measure the degree of car intelligence. The trend of technology promotion is favorable and begins to affect the car purchase decisions of consumers, and it is easy to make consumers dependent on their driving habits.

According to further analysis of labels and corresponding papers, Market Demand and Acceptance Perspective show a significant lead in industry competitiveness, mainly concentrated in the market scale expansion, market revenue growth, and market acceptance adoption. According to Technavio’s research report, the global ADAS market will grow US$18.99 billion from 2020 to 2025, of which the market growth in the Asia-Pacific region will account for 37%. China and Japan will be the key countries in the ADAS market [16], leading significantly in global in terms of market expansion and market revenue growth. According to Deloitte’s research on the market acceptance of ADAS, the Chinese market has higher enthusiasm for autonomous driving technology, with the highest degree of acceptance and the most confidence in safety than other regions in the world, and it is the only one that believes emerging enterprises will bring automatic driving vehicles to the market completely. [17]

Overall, the industry competitiveness of factor Demand is significantly ahead, including Market Demand and Acceptance Perspective ahead, and Product Feature has not shown obvious performance.

6.2.4. Related Industry

In Upstream Industry, it is mainly composed of four core layers: the decision-making layer, execution layer, perception layer and transmission layer. Among them, the transmission layer is to provide signal transmission for automatic driving including communication equipment and communication services and links to technology such as the Internet of Vehicles. The perception layer is to perceive external environment status and changes to provide data for the decision-making layer, which includes cameras, sensors and high-precision maps. The execution layer is mainly to execute instructions for the vehicle based on decisions like electrically controlled vehicle wire control systems. The decision-making layer analyzes the perceived environmental data and provides instructions to the execution layer, generally including hardware platform, software and operating system.

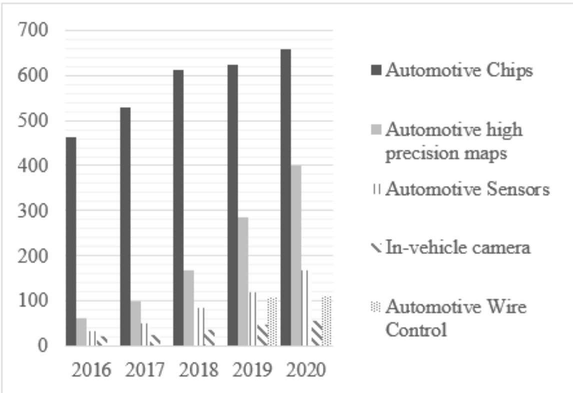

Fig 7. China ADAS Technology Related Industry Market Size / (billion yuan).

According to statistics, as shown in Figure 7, the market scale of upstream industries, such as automotive chips, high-precision maps, sensors, onboard cameras, and wire control systems, has continued to grow in China from 2016 to 2020 and has maintained a reasonable growth rate, and the automotive chip market size is already impressive. According to the forecast, there is still enormous room for the market scale of upstream industries to grow in the future. The present global market size is uneven, from 2016 to 2020, China's automotive chip and automotive sensor already accounted for about 20% of the world's total, and the automotive camera market accounted for only about 5%, while the overall proportion is rising.

In Supporting Industry, the development of the ADAS industry will affect industries such as 5G technology, intelligent connected vehicles, and auto insurance. At present, China's 5G technology is leading the world, and the intelligent connected automobile industry is developing rapidly, which can provide strong support for the development of China ADAS industry.

According to further analysis of labels and related essays, the Supporting Industry shows a significant lead in industry competitiveness, mainly in 5G technology. According to research by Sudan, Yan Kun, and others, China accounted for as high as 31.49% of global patent applications for 5G+autonomous driving technology, ranking first in the world, followed by the United States at 20.48%. [18]

Overall, the industry competitiveness of factor Related Industry is significantly ahead, including Supporting Industry ahead, and Upstream Industry has not shown obvious performance.

6.2.5. Support and Opportunity

In Top-level Supporting, the intelligent vehicle industry is a national strategic emerging industry. The official interpretation of "Made in China 2025" in 2016 pointed out that the development of intelligent connected automobile industry is supported. In 2020, the National Development and Reform Commission and ten other ministries and commissions published "Intelligent Vehicle Innovation and Development Strategy." They generally completed the top-level design of China's intelligent vehicle industry, and ADAS is an essential part of it.

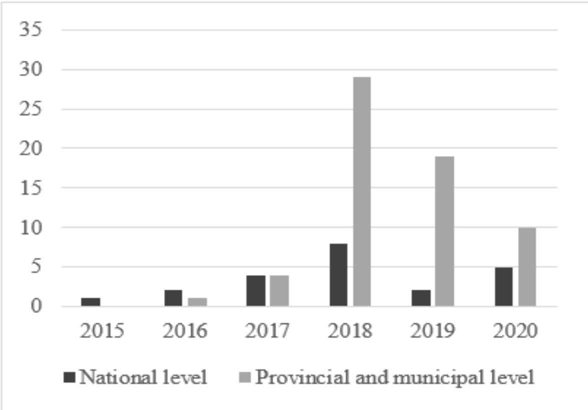

Fig 8. Statistics on the Number of Smart Car-related Policy Documents/(copies).

According to statistics, as shown in Figure 8, China has published 92 policy documents in the past five years, with 29 at the national level, 33 at the provincial level, and 30 at the prefecture level. The peak of the release is 2018, which is also the hottest year for China's automatic driving investment and financing. From the perspective of document types, there are 14 national regulations, 8 national standard guidelines, 26 implementation plans, and 33 road monitoring rules. Many road monitoring rules were issued in 2018, while the implementation plans were mainly published in 2019 and 2020. It shows that the government has dramatically improved its confidence in automatic driving since 2018 and has begun to guide industry development.

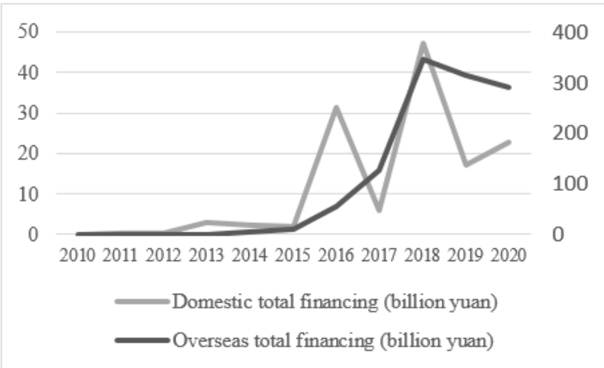

Fig 9. ADAS Industry Total Financing/(Billion).

As shown in Figure 9, the total financing amount of the ADAS industry has increased in recent years, especially since 2018. The growth trend of the domestic total financing amount is relatively flat, with some fluctuations, which have been positive in recent years. The foreign total financing amount has proliferated in the early stage but has begun to decline.

Regarding Development Opportunities, the electrification trend of the automobile industry has promoted automobile components electrification at the same time, providing the primary conditions for ADAS application. In recent years, China's automobile industry has been relying on the trend of new energy vehicles to achieve rapid development, especially in making the automotive electronics market mature and significantly promoting the ADAS assembly rate's increase. The wide application of ADAS has also become the driving force for developing China's automotive electronics market.

Overall, the industry competitiveness of Supporting and Opportunity has no significant performance.

6.3. Countermeasures and Recommendations

According to this paper, the competitiveness of industry shows significant behind in Technology Development of Innovation and Human Resources of Production. So corresponding countermeasures and suggestions are targeted.

The root of industry competitiveness enhancement is to enhance the value creation of enterprises. According to the concept of value chain proposed by Michael Porter, the study of Park S and Park I [19] and the empirical study of Zhang Hui [20], the value creation of enterprises is constituted by activities like a chain, enterprises should seek to move to the forward direction of the global value chain and seize the high value-added segment, which is to seize the strategic segment and the whole value chain.

6.3.1. Countermeasures and suggestions for Technology Development

In Technology Development, the parts that are significantly behind at present are Core Technology R&D and Millimeter Wave Technology R&D. The future market demand for high-level ADAS is much bigger, which will be the high value-added segment in the global value chain in the future. By grasping its core, enterprises' technology development can move forward in the global value chain: Expanding the R&D investment in core technology, exploring the advantages of virtual testing, simulation testing and in-the-loop testing, optimizing the process of technology R&D and technology testing to improve the level of core technology and the rate of technology iteration. Strengthen industrial coupling, give full advantage to the industrial chain of China's automotive electronics market, drive the development of weak areas with advantaged areas, and form an independent ADAS technology ecology.

6.3.2. Countermeasures and suggestions for Human Resource

In Human Resources, the part that is significantly behind at present is the lack of the number of practitioners. The essence is that talent training in the automobile industry does not match the talent demand. While it is difficult for graduates majoring in machinery and automobiles to find employment, the gap in industrial talents continues to expand. Therefore, how efficiently cultivating more talents who can dive into the industry and contribute value is the strategic link for human resources. For R&D talents, domestic colleges and universities should adjust their talent cultivation programs with the development trend of new energy vehicles, intelligent cockpits, and automatic driving to cultivate comprehensive talent in automobile engineering:

Encourage cross-disciplines.

Fully leverage the advantages of traditional engineering.

Combine electrical engineering, chemical engineering, materials, control, IT/ DT, artificial intelligence, and other disciplines.

For basic technical talents, the "double high plan" should be implemented fully. Improve the vocational education status, increase vocational education investment, improve the vocational education system, and adjust the cultivation plan according to industry needs to cultivate high-quality skilled talents. At the same time, school-enterprise cooperation and industry-university integration should be strengthened. Students can keep up with the industry's technological development frontiers and development trends so they can quickly connect with the industry after graduation.

7. Summary

Based on the grounded theory and Porter diamond model, this paper establishes an ADAS industry competitiveness measurement model, measures and analyzes China ADAS industry competitiveness in 5 dimensions with a total of 16 categories: Innovation, Production, Demand, Related Industries and Support & Opportunity. The study shows that China ADAS industry competitiveness is unbalanced in Innovation and Production, significantly ahead in Demand and Related Industriy, and has not shown obvious performance in Support & Opportunity. Totally, it is as a whole, but able to occupy a more advantageous position in the global competition, with an emergency need to optimize behind segments.

Weaknesses in the competitiveness of China ADAS industry are suggested in this paper. The segment of Innovation significantly behind is core technology R&D and millimeter wave technology R&D. It is suggested to focus on grasping high-level ADAS technology, improving the technology level and technology iteration rate, and strengthening industrial coupling to form an independent ADAS technology ecology. The segment of Production significantly behind is the small number of practitioners. It is suggested to adjust the talent training program by optimizing the cooperation mechanism of talent training in universities and vocational schools to match the talent training and talent demand.

Since the ADAS industry is relatively new, this paper has limited access to research data. It couldn’t measure and analyze the competitiveness of the industry in a more quantitative method and therefore has certain limitations. This paper believes that the ADAS industry is worthy of further in-depth study. As a necessary link in the transition to automatic driving, the ADAS industry has important experimental significance for the development of the automotive industry and is an important growth point for the industry in the future. It has not yet formed a great leading edge overseas and may become a core segment for the future rise of China's automotive industry.

References

[1] Ondrej Burkacky. Automotive Semiconductors for the Autonomous Age [R]. Falkenhausen: McKinsey & Company, 2021.

[2] Zhao Jin, Du Zhibin, Zhang Qingyu, Zhao Pengchao. Analysis of the development trend of China's passenger car ADAS market [J]. Times Automotive, 2019(02):16-19.

[3] Liang Weiqiang, Hong Fubin. Review of ADAS technology and market status [J]. Technology and Innovation, 2021(07):6-9+13. DOI:10.15913/j.cnki.kjycx.2021.07.002.

[4] Zhu, Lin. Who wins first with ADAS and Robotaxi [J]? Operator (Automotive Business Review), 2021(09):266-273.

[5] Jia Xudong, Tan Xinhui. The realistic value of classical rooted theory and its spirit for Chinese management research [J]. Journal of Management, 2010, 7(05):656-665.

[6] Fei Xiaodong. Methodology of rooted theory research: elements, research procedures and criterion [J]. Public Administration Review, 2008(03):23-43+197.

[7] Lai L, Jiang Nongjuan. Research on the design of shared bicycle business model based on rooting theory--Taking Mobike as an example [J]. Contemporary Economic Management, 2017, 39(06):19-22.DOI:10.13253/j.cnki.djjgl.2017.06.004.

[8] Guo Jingfu. Research on industry competitiveness [J]. Economic Forum, 2004(14):32-33.

[9] Wang Ying. Industry competitiveness theory research review [J]. Jianghuai Forum, 2008(02):29-38.

[10] Rui Mingjie. The "new diamond model" of industry competitiveness [J]. Social Science, 2006(04):68-73.

[11] Vladimír Hojdik. Evaluation of Slovak Automotive Industry Competitiveness Based on Market Concentration Indicators [J]. SHS Web of Conferences, 2020, 83

[12] Wang, Long. Research on the International Competitiveness of China's Automotive Industry [D]. Wuhan University of Technology, 2006.

[13] Zhang Chuankun. Research on the assessment of the competitiveness of China's new energy automobile industry and its improvement path [D]. Hefei University of Technology, 2018.

[14] Li Ying, GAO Chang. Research on measuring and improving the competitiveness of China's new energy automobile industry from the perspective of the value chain [J]. Industrial Innovation Research, 2021(16):1-8.

[15] Liu Yi. Optimized design of vehicle-mounted millimeter wave radar antenna system [D]. University of Electronic Science and Technology,2020.DOI:10.27005/d.cnki.gdzku.2020.003904.

[16] Technavio. Automotive Advanced Driver Assistance System (ADAS) Market Size to Grow by USD 18.99 billion | Decline in Sensor Prices to Boost Market Growth | Technavio [R]. Technavio, 2022.

[17] Joseph Vitale, Jr. The Future of Fully Automated Driving - A Survey of Consumer Demand for Advanced Automotive Technologies [R]. Deloitte, 2017.

[18] Sudan, Yan Kun,Li Wenyu.5G+autonomous driving technology patent posture analysis[J].Commu nication Technology,2021,54(08):1937-1941.

[19] Park S, Park I. The Value-added Creation Effect of Industry Position in Global Value Chains: Implications for Asia-Pacific Economies [J]. Asian-Pacific Economic Literature.

[20] Zhang F. Research on global value chain theory and China's industrial development [J].China Industrial Economics, 2004(05):38-46.DOI:10.19581/j.cnki.ciejournal.2004.05.005.