A Study of the Factors Influencing the Sales of Intelligent Connected Cars

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Abstract. Cars are becoming more sophisticated and connected as big data technology advances. A growing number of respondents are now purchasing intelligent connected cars, particularly in the late 2020 pandemic, when sales of these vehicles have surged in China. However, there are still many respondents who are hesitant to choose intelligent connected cars, through field research and questionnaires in Beijing, China, this paper analyses the variables influencing respondents' purchase of intelligent connected cars from the respondents' perspective and evaluates the effectiveness of policies and actions of intelligent connected car manufacturers. The research demonstrates that respondents' purchase intentions for intelligent connected devices are positively correlated with policy, quality (function and performance), data security, social responsibility, and price, with data security having the greatest influence. Based on the findings of the investigation, this article concludes with management recommendations for data security of intelligent connected cars based on the research findings. For instance, both management and technical measures should be stressed, and a data security management model should be established.

Keywords: intelligent connected cars · questionnaire survey · social responsibility · data security

1 Introduction

Four distinct features, namely electrification, intelligence, networking, and co-sharing, have become an unavoidable trend in the growth of the automotive industry due to the rapid advancement of science and technology [1]. The process of moving from sensation to cognition, followed by judgment and thought, is what is commonly referred to as intelligence. The eventual result of this process is what is referred to as "knowledge," which includes innovations and original findings. Additionally, "ability" may be used to describe the act of accomplishing one or more things on one's respective initiative. "Intelligence" is the result of combining "knowledge" with "ability" [10]. The notion of intelligence used in this paper refers to relates to managerial practices and technological techniques that actively gather and analyse outside data, train and learn from preexisting models, and make decisions automatically and continuously in response to changes in the external environment in order to complete one or more tasks. The use of

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extremely intelligent technologies, such as AI control, cutting-edge sensor technology, 5G connectivity, and intelligent linked technology, in cars is referred to as automotive intelligence.

Data security in this article refers to the technology, measures, and management practices that protect data from unauthorized access, use, modification, destruction, or leakage. Data security is a comprehensive concept that ensures the confidentiality, integrity, and availability of data during transmission, storage, and processing. Protecting data security means ensuring that data is not destroyed, stolen, or tampered with by hackers, viruses, spyware, social engineering, and other forms of malicious attacks, as well as protecting data from accidental damage, hardware failures, natural disasters, and other unforeseen incidents [2]. Data security also includes ensuring that data complies with applicable laws and regulations and taking appropriate security measures to protect users' privacy and rights when necessary. The definition of data security for intelligent connected vehicles refers to the protection of data generated, transmitted, stored, and processed by connected vehicles, ensuring that this data is not accessed, used, modified, destroyed, or leaked by unauthorized parties. This includes protecting data from cyber-attacks, hacking, malware, spyware, and other malicious activities that can compromise the confidentiality, integrity, and availability of data.

Data security for intelligent connected vehicles also involves protecting personal information, such as the driver's identity, location, and driving behaviour, to prevent data misuse and abuse [3]. This requires implementing appropriate technical and organizational measures, such as data encryption, access control, and authentication, to safeguard data during transmission, storage, and processing.

Furthermore, data security for intelligent connected vehicles involves complying with relevant laws and regulations related to data protection and privacy, such as the General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA) and adhering to industry standards and best practices to ensure the highest levels of data security.

As society and the economy have advanced, so has respondents' readiness to purchase intelligent cars [4]. The demand for private car sales has been expanding significantly as China's residents' income grows and urbanization continues to spread quickly throughout the nation. China's cumulative automobile production and sales in 2021 were 26.082 million and 26.275 million respectively, with long-term growth at a high level. The Traffic Management Bureau of China's Ministry of Public Security estimates that by the end of 2021, there will be 395 million motor vehicles in China, including 302 million cars. Nevertheless, China's per-1,000-person automobile ownership rate is still low, and the World Bank reports that China's per-1,000-person automobile ownership rate will be 209 in 2021, which is much lower than the level of developed countries such as 837 in the United States, 591 in Japan, and 589 in Germany, and China's car market will continue to rise steadily over the ensuing years [11]. With the advancement and application of automotive intelligence, people's perceptions of the car have expanded beyond just being a mode of transportation. Instead, they now hope that it can provide more intelligent, more convenient, and richer in-vehicle services, turning it into a mobile ecosystem [12], a mobile office, or a cozy place to unwind. While respondents

are interested in the ease that intelligent automobiles bring to their lives and jobs, they also express concerns about the security of their personal data.

The respondents in Beijing, China were chosen for this study as the study's subject and a questionnaire was utilized to collect descriptive research data on the respondents' willingness to purchase intelligent connected cars and its influencing factors. In this study, the term "purchase willingness" refers to the potential of respondents' willingness to buy intelligent cars. Respondents' opinions and attitudes regarding a commodity or service shape their readiness to buy, which is then affected by extrinsic influencing factors. A buyer's subjective inclination to select a particular commodity can also be included as part of their purchasing intention, which has been proven to be a reliable predictor of consumer behaviour [13].

2 Questionnaire Analysis

2.1 Questionnaire Design

This study was carried out using field research and questionnaires. To find out the desire and worries of respondents in Beijing regarding the acquisition of intelligent connected cars, the Beijing V company conducted a field survey of 420 persons. The author uses Questionnaire Star in a multi-dimensional way to develop the questionnaire thoroughly while adhering to a methodical, practical, and rigorous philosophy throughout the entire procedure. Basic information about the respondents, their knowledge of intelligent connected cars, their willingness to purchase intelligent connected cars, and what are the main deterrents to purchasing intelligent connected cars, like what are the worries about the intelligent connected cars, are all included in the questionnaire's content [14].

Policy, quality (function and performance), data security, social responsibility, and price are the five factors used to measure and score the degree of willingness to purchase. On a 4-point Likert scale, 1 denotes no influence/unwillingness, 2 indicates uncertainty/wait-and-see, 3 means influence/willingness, and 4 denotes absolute influence/willingness. There were 420 copies circulated in all, and 405 copies were validly collected. All respondents in this paper were from Beijing, China, of which 218 were male and 187 were female. Of these, 86.91% were over 28 and financially independent; 81.23% had a bachelor's degree or above. Mature age and higher education background mean that the respondents exhibit generally reasonable consumption tendencies. In addition, the balanced ratio of males and females who are economically independent ensures that this questionnaire provides accurate feedback on the demands of the respondents. Through an in-depth study of the questionnaire, the author can more fully investigate the elements influencing respondents' willingness to purchase intelligent cars.

2.2 Empirical Analysis

In order to guarantee the reliability and validity of this questionnaire, this paper adopts IBM SPSS to conduct confirmatory factor analysis on five aspects: policy, quality (function and performance), data security, social responsibility, and price and conducts reliability and validity analysis. The findings indicate that t each dimension's and the scale's

Table 1. Reliability analysis.

Aspect	Cronbach alpha	The number of items
Policy	0.730	4
Quality (function and performance)	0.707	4
Data Security	0.729	4
Social Responsibility	0.735	4
Price	0.731	4
Overall	0.882	4

Table 2. Validity analysis.

Fitting index	Chi-square freedom ratio	CFI	NNFI	TLI	IFI	SRMR
Actual value	2.37	0.927	0.906	0.906	0.928	0.056
Standard value	<3	>0.9	>0.9	>0.9	>0.9	<0.1

overall Cronbach alpha value exceed 0.7, the load of all questions on a single dimension is higher than 0.5, and each metric reaches an appropriate level. This shows that the "Questionnaire on Influencing Factors of Intelligent Connected Vehicle Purchase Intention" has strong reliability and validity, indicating that the survey's results may accurately and faithfully capture the respondents' intentions to acquire intelligent connected vehicles in Beijing. See Tables 1 and 2 for details.

3 Data Analysis

3.1 Descriptive Statistical Analysis

Among the respondents of this survey, men account for 53.83% while women make up 46.17%. The age distribution of all respondents displays a normal distribution, with 13.09% under the age of 28 and 15.06% over the age of 50. In terms of whether they currently own a traditional fuel vehicle, 53.09% of respondents do, while 46.91% do not; in terms of educational background, respondents with a junior college degree or below account for 18.77%, respondents with a bachelor's degree account for 40.00%, while those with master's degree and above account for 41.23%. The vast majority of respondents (71.8%) are between 29 and 50 years old, which is also the primary target customer group of intelligent connected vehicles. Overall, 45.93% of the respondents express their willingness to purchase intelligent connected vehicles, 22.96% are unwilling to make a decision, and the remaining 31.11% hold a wait-and-see attitude.

3.2 Variance Analysis

The influence of each respondent's willingness to purchase intelligent connected cars is depicted in Fig. 1. They are divided into three groups: 22.96% of respondents are not willing to choose an intelligent connected car, 45.93% of them are very willing or willing to do so, and 31.11% of them hold a wait-and-see attitude. In addition, those who take a wait-and-see attitude are concerned about the data security of an intelligent connected car.

The effect of various genders on the intention to intelligent connected cars is depicted in Fig. 2. In contrast to 14.32% of men and 18.77% of women, who choose to wait and see, as well as 13.33% of men and 13.83% of women who are reluctant to choose intelligent connected cars, 26.17% of men and 13.58% of women are willing or very willing to choose intelligent connected cars. The analysis of the data reveals that nearly half of the male respondents are very willing or willing to select an intelligent connected car. However, when it comes to intelligent connected cars, female respondents are more cautious and apprehensive. 41% of the female respondents hold a wait-and-see attitude, which means that female respondents are more concerned about the security of private data.

The effect of various ages on the intention to buy an intelligent connected car is depicted in Fig. 3. As illustrated in Fig. 2, the younger generation is represented by those between the ages of 18 and 28, the middle-aged group is represented by those

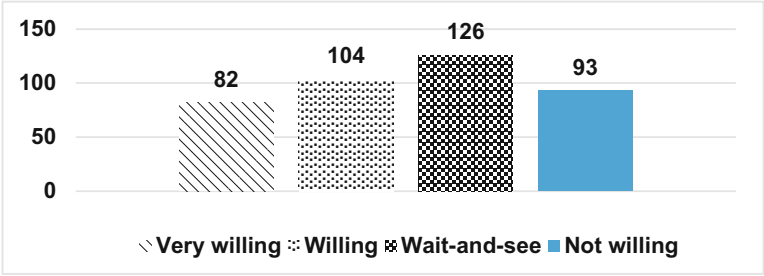

Fig. 1. All respondents' willingness to buy the intelligent connected car.

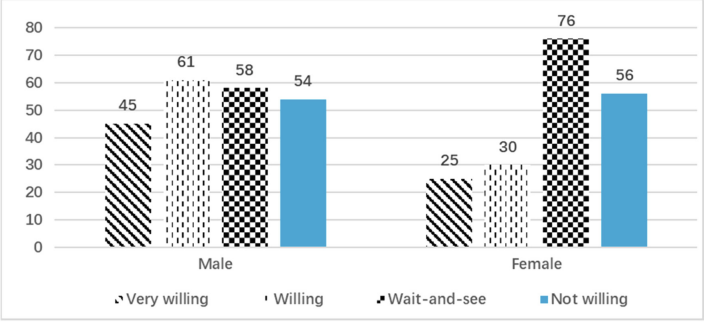

Fig. 2. Effect of gender on willingness to buy the intelligent connected car.

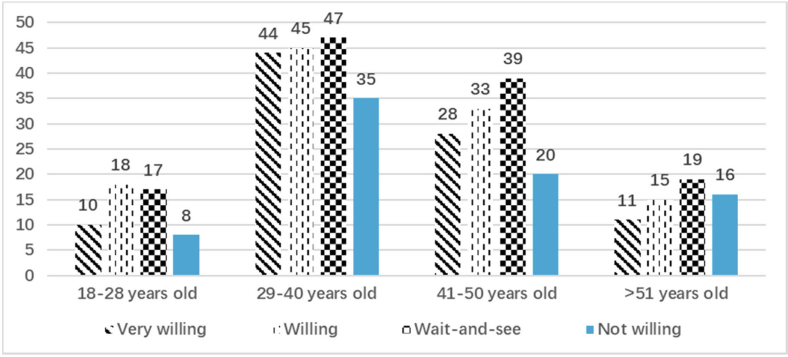

Fig. 3. Effect of age on willingness to buy the intelligent connected car.

between the ages of 29 and 40, and between the ages of 41 and 50, major consumer groups with a particular level of economic purchasing power, and the middle-aged and elderly groups are represented by those between the ages of 51 and over. Among them, respondents between the ages of 18 and 40 have a strong purchase intention, which is also consistent with the fact that the younger generation favours new things and enjoys the cool features of intelligent connected cars; respondents between the ages of 29 and 40 have the highest proportion of choosing not to buy the intelligent cars, and respondents between the ages of 41 and 50 have the highest proportion of respondents choosing to wait and see since they are worried about the data security of intelligent connected cars. It is worth noting that neither the young group aged 29–40 nor the middle-aged group, aged 41–50 prefer to wait and see. The reason is that they are concerned about the data security of intelligent connected cars.

Figure 4 demonstrates the impact of respondents' ownership of a fuel vehicle on the criteria for selecting an intelligent connected car. According to the study findings, respondents who do not possess a fuel-powered car are more likely to adopt a wait-and-see attitude. Those who already possess a fuel-powered vehicle are more definite and more divided, with 25.19% of respondents saying they would be hesitant to choose an intelligent connected vehicle, and 44.20% saying they would be willing or very willing to choose an intelligent connected car. This has a lot to do with traffic restrictions and vehicle license plate controls in Beijing, China.

Figure 5 depicts how respondents' educational backgrounds impacted their intention to purchase. Those with a bachelor's degree or higher are more conservative than those with a post-secondary degree or below, and 22.18% of them do not prefer intelligent connected cars. And the questionnaire reveals that these individuals are concerned about the data security of intelligent connected cars. Compared to 30.86% who hold a wait-and-see attitude, 49.14% of respondents are willing or very willing to choose intelligent connected cars.

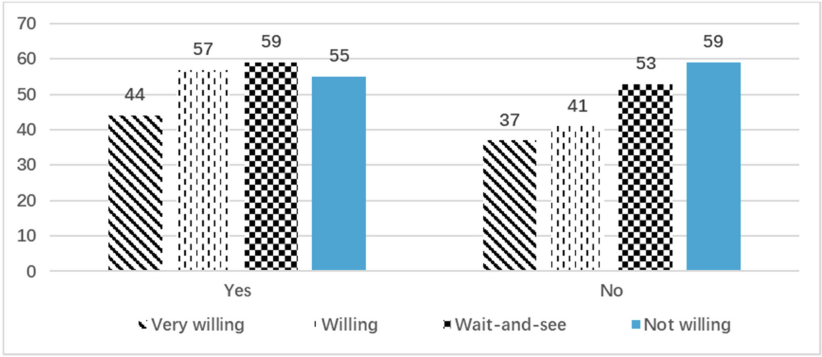

Fig. 4. Effect of whether or not to own a fuel car on willingness to buy the intelligent connected car.

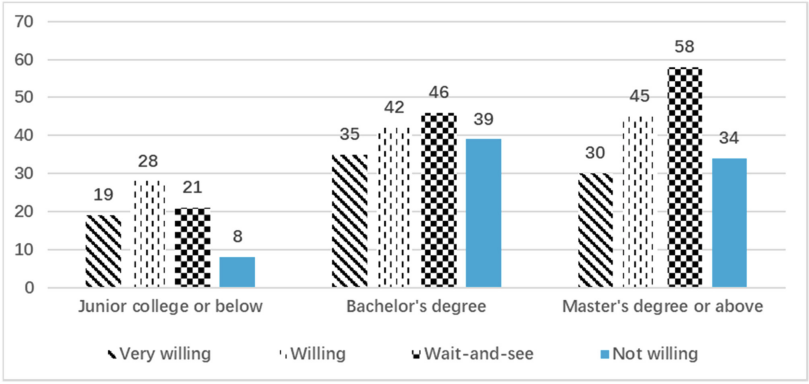

Fig. 5. Effect of education on the willingness to buy the intelligent connected car.

3.3 Correlation Analysis

According to research using correlation analysis (see Table 3), respondents' purchasing intention (T0) for intelligent connected vehicles is positively correlated with the degree of influence of policies (T1), the degree of influence of quality (function and performance) (T2), and the degree of influence of data security (T3), the degree of influence of social responsibility (T4), and the degree of influence of price (T5). That is, the respondents' readiness to purchase intelligent connected cars increases with the level of data security; on the other hand, their willingness to do so decreases with the level of data security protection. It is worth noting that although the five factors listed above are favourably correlated with respondents' desire to select intelligent connected cars, this does not imply that they have a major impact on respondents' readiness to purchase intelligent connected vehicles. The conclusion must be drawn through linear regression analysis.

Table 3. Pearson correlation coefficient.

	T0	T1	T2	T3	T4	T5
T0	1					
T1	.734**	1				
T2	.854**	.342**	1			
T3	.894**	.642**	.653**	1		
T4	.709**	.555**	.518**	.686**	1	
T5	.769**	.518**	.610**	.557**	.315**	1

** At the 0.01 level, the correlation is significant.

3.4 Research on the Influencing Factors

This paper conducts multiple linear regression analysis through IBM SPSS(see Table 4), regards the respondents' willingness to purchase intelligent connected cars (T0) as the dependent variable, and takes the degree of influence of policies (T1), the degree of influence of quality (function and performance) (T2), the degree of influence of data security (T3), the degree of influence of social responsibility (T4), as well as the degree of influence of price (T5) as independent variables. The research findings are displayed in Table 5, where the VIF value of each factor is lower than 10, indicating that there is no multicollinearity between the factors. The value of R^2 is 0.993, and the adjusted value of R^2 is 0.992, indicating a good model-matching effect. T0 is influenced by independent factors T1, T2, T3, T4, and T5, all of which have a favourable effect. It suggests that respondents are more likely to purchase intelligently connected automobiles if the policy, quality, data security, social responsibility, and price are all better. If they want to increase the sales of intelligent connected cars, they must start from the aspects of data security, quality (function and performance), social responsibility, price, policy, etc., especially data security.

3.5 Research on the Influencing Factors

On November 7, 2022, the "5th Global Automotive Development Trends Forum" was held in Shanghai, China, and Chen Tao, Deputy General Manager of the China Automotive Engineering Research Institute (CAERI), delivered a speech on "Security Challenges and Reflections on the Development of Intelligent Connected Cars", focusing on data security of intelligent connected cars:

- **The challenge of security**
- Exaggerated publicity, the safety risks associated with the non-standard use;
- Network and data security systems are not yet mature;
- Industry-wide efforts are needed to put the Cyber Security Law and the Data Security Law into practice.

Table 4. Results of regression analysis.

Model	Unnormalized coefficient		Normalized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			tolerance	VIF
Constants	0.04	0.03		1.33	0.19		
Policy	0.10	0.01	0.13	7.00	0.00	0.19	5.18
Quality (function and performance)	0.17	0.01	0.24	18.68	0.00	0.38	2.61
Data Security	0.35	0.01	0.41	34.71	0.00	0.47	2.15
Social Responsibility	0.07	0.01	0.09	5.30	0.00	0.22	4.61
Price	0.30	0.01	0.35	34.90	0.00	0.63	1.58

Note: $R^2 = 0.993$, adjusted $R^2 = 0.992$, ** at the 0.01 level, the correlation is significant.

Table 5. Highlights of automotive data security-related regulation and industry standards issued by various countries.

Order	Level	EU	US	PRC
1	National level	GDPR	Nevada Data Privacy Act	Cyber Security Law / Data Security Law
2	Company level	GDPR	Nevada Data Privacy Act	Cyber Security Law / Data Security Law
3	Personal level	GDPR	CCPA	Personal Information Protection Law
4	Technical level	Partially dependent on other countries, such as the US.	Technologically advanced	Rapid development, catching up with Europe and the US
Overall summary		Put human rights protection first [16]	Market Oriented [16]	Relatively systematically on the national, company, and personal levels, stress company accountability

- **Suggestions**
- Regulatory level: strengthen the use of the link of supervision, static to dynamic change, proactive innovation to enhance security;
- Enterprise level: strengthen the research and development of security technology and build a security management system;

Fig. 6. J.D. Power and the Global Times jointly launched the survey results

- Industry level: create a good, sustainable, cooperative multi-party win-win ecology and the building of a data security management platform;

According to Fig. 6 and the results of the "2022 Chinese Consumer Survey on Data Security and Personal Privacy Awareness and Concerns of Smart Connected Vehicles" jointly sponsored by J.D. Power and the Global Times, Chinese consumers have little confidence in the ability of smart car manufacturers to properly protect sensitive personal information at this stage. About 30% of the respondents said they are relatively informed or extremely confident, while more than 40% said they are not confident at all or are not confident enough:

4 Conclusion and Suggestions

According to the research findings presented in this paper, respondents' willingness to purchase intelligent connected cars is positively correlated with criteria such as data security, quality (function and performance), social responsibility, policy, and price factors. Data security is the main element among them that has an impact on respondents' purchasing intention, followed by quality (function and performance) and price factors [5]. Additionally, respondents with a wait-and-see attitude express concerns about the data security of intelligent connected vehicles, confirming that respondents' intentions to purchase intelligent connected vehicles are significantly influenced by the degree of data security management. This study provides the following suggestions for relevant car companies and institutions.

4.1 Data Security Management

Currently, respondents' top concern is the data security of intelligent connected cars. A conventional automobile had roughly 10 million lines of code ten years ago. Today, "there are at least 100 ECU units on the intelligent connected car, running 60 million lines of code", and the code for driverless cars will reach more than 100 million lines [15]. An

intelligent connected car collects at least 10TB of data every day, much of it pertaining to the travel trajectory, behaviour habits, hobbies, voice, video, etc. of drivers and passengers. The technologies and services provided by intelligently connected automobiles are more extensive and complicated, and they require an increasing amount of software and onboard applications. When confronted with hundreds of millions of lines of code, implicit loopholes are inevitable, and criminals have opportunities to take advantage of them. A series of sensitive data leaks from more than 100 auto factories, a rash of keyless car theft cases in Europe, and security flaws in some BMW and Mercedes-Benz models are just a few of the recent data security incidents involving intelligent connected cars that have surfaced one after another. The female car owner in the right protection incident at the Shanghai Auto Show in China in April 2021 felt that Tesla had breached her right to personal privacy by disclosing her information to the public and media without her consent. Due to violations of the "Cyber Security Law of the People's Republic of China", the "Didi Chuxing" APP was banned on July 4, 2021 by the Chinese Cyberspace Administration. As illustrated in Figs. 7 and 8, numerous have successively issued and implemented regulations and standards pertaining to information security and data security as a result of the frequent occurrence of data security vulnerabilities in intelligent connected vehicles.

In this paper, the regulations of the EU, the US and China are sorted out through comparative analysis. Following a comparative investigation, the author finds that the emphasis of these regulations and standards varies depending on the nation, as shown in Table 5. The largest issue facing the automotive sector is the lack of a unified regulatory standard.

Additionally, there is a legislative gap on a global scale. The laws and regulations frequently lag behind the pace of technological advancement and cannot address the new challenges brought about by the era of intelligent connected vehicles [6]. This necessitates that automakers have a forward-looking vision so as to avoid the risk of having their corporate strategies reversed by compliance concerns following the implementation of new laws or standards.

Nowadays, data security management has become a core competitive advantage in intelligent connected vehicle enterprises, and the rapid development of the industry has brought about a huge demand for relevant manpower. "Bo Ying, the director of the

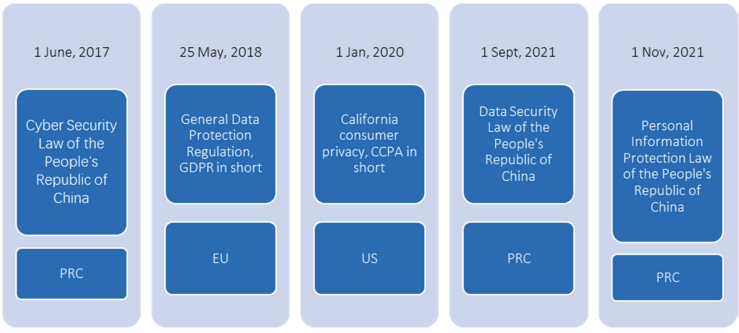

Fig. 7. Data security regulations issued and implemented successively by various countries.

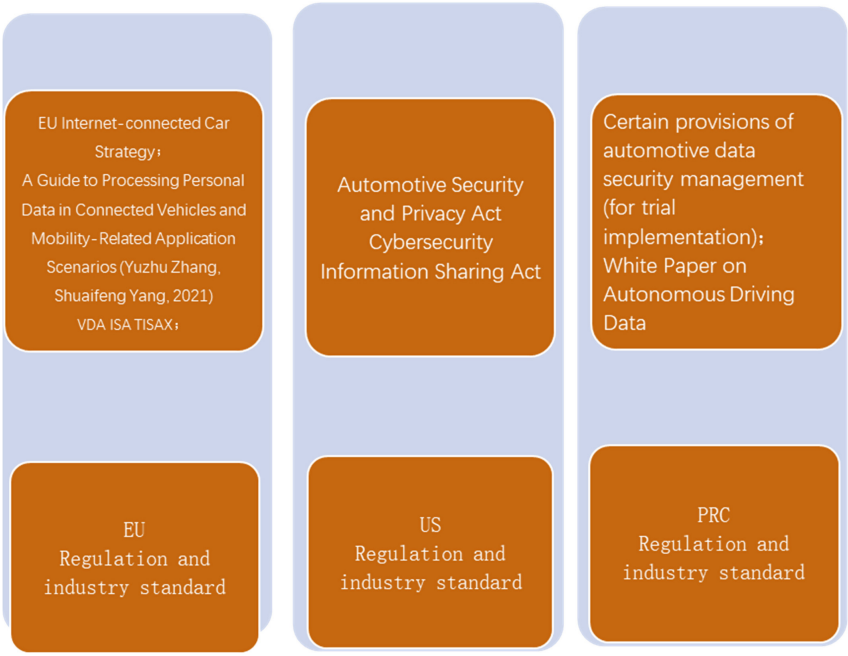

Fig. 8. Automotive data security-related regulations and industry standards successively issued by various countries.

Talent Department of the China Automotive Engineering Society, pointed out in a public occasion that the current demand for intelligent connected talents by automakers is in an explosive growth stage. By 2025, the demand for talents will reach 92,000 to 116,000, but the total supply is seriously insufficient, and the net talent gap is up to 37,000 people." In order to stand undefeated in the competition for data security management talents, intelligent connected vehicle enterprises must pay high costs for external recruitment or invest time in internal training [7]. Data security management manpower includes both technical and managerial talents. Technical personnel include encryption algorithm engineers, server maintenance personnel, IT personnel, technical audit personnel, etc. Management personnel include DPO (Data Protection Officer) personnel, data security management system personnel, process audit personnel, data quality personnel, etc. Even with no cost spared for human resources investment, there is no 100% security for intelligent connected vehicle enterprises because security is relative. This is also a major challenge faced by intelligent, connected vehicle enterprises.

This study investigates a solution for the data security issue of intelligent connected cars by putting equal emphasis on management and technical means, and by creating a company-level data lifecycle management model by using the PDCA loop method, which is tightly integrated with the company's product lifecycle [8]. In accordance with the different data security requirements of each project, this paper performs appropriate tailoring (equivalent to OTA patching), applies the company-level data management model to each project, and adopts PDCA at the project level to continuously optimize and

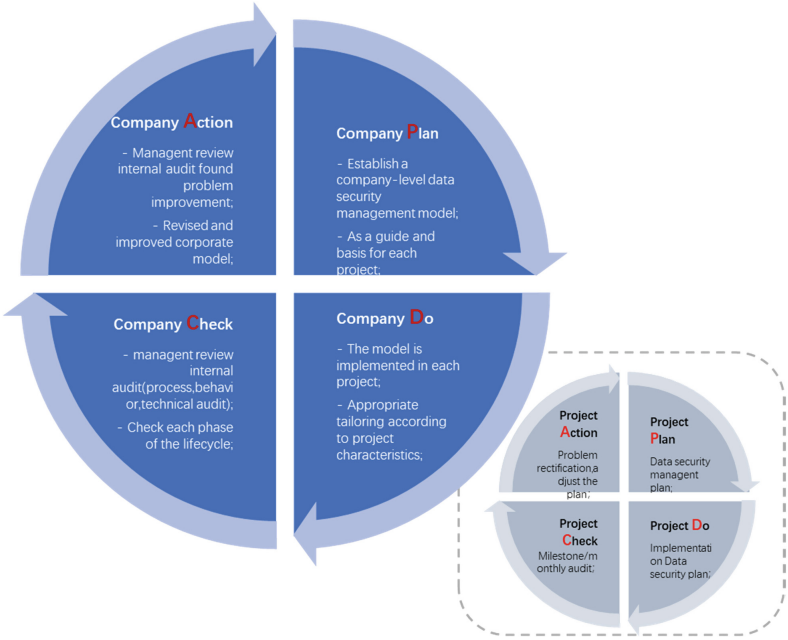

Fig. 9. PDCA-style data lifecycle management model.

improve the data security management strategy of each project in order to overcome the difficulties presented by various regulatory frameworks in each country [9]. In addition, this paper also continuously enhances and optimizes the company-level data lifecycle management model. Meanwhile, the company-level data lifecycle management model is dynamically optimized and updated to address the issue of lagging regulations while each project is continuously enhanced and optimized, with details shown in Fig. 9.

4.2 Quality (Function and Performance)

Respondents also expressed tremendous concern about the quality of intelligent connected vehicles, particularly in terms of function and performance. To ensure that the features and performance of vehicles are completely guaranteed, auto manufacturers must take into account the vehicles' reliability, safety, compatibility, convenience of use, and other aspects. Full and comprehensive testing and verification are needed to ensure that these vehicles can operate safely in a variety of road and weather conditions, such as high temperature, high humidity, extreme cold, and other harsh environments. Additionally, a good user experience and troubleshooting and maintenance functions, that is, perfect after-sales service, are also necessary. In order to enhance the quality of intelligent connected vehicles, this paper gives the following suggestions from the aspect of function and performance.

Based on design and selection, intelligent connected cars should have reliable functions and performance. Sufficient testing and verification should be conducted to assure

the reliability and stability of these functions and performance, including high temperature, cold, durability, etc. Respondents must have confidence that these functions can operate safely under a variety of climatic and traffic conditions. Compatibility and interoperability must be guaranteed concurrently. The various cars and road infrastructure, such as intelligent traffic lights, parking facilities, etc., must be integrated with intelligent connected vehicles. To execute the synergy of intelligent transportation, automakers need to ensure that these systems are compatible with one another and work together. Intelligent connected vehicles should also provide a good user experience, including convenience of use, reliability, and response speed. This calls for effective user interface design and human-machine interaction design, as well as adequate performance and reliability support. In addition, troubleshooting and maintenance also need to be taken into account. Intelligent connected vehicles need to have effective troubleshooting and maintenance functions to guarantee vehicle reliability and stability. This necessitates an effective remote monitoring and inspection system, as well as timely maintenance and maintenance services.

4.3 Others

The price is also one of the key considerations for respondents to consider when purchasing intelligent connected cars. The price of intelligent connected cars is affected by many factors, including technical cost, production scale, competitive landscape, etc. At present, the price of intelligent connected vehicles in the market is relatively high, mainly due to its comparatively high technical cost, production scale, and insufficient market competition. It is advised that the government increase funding for research and development of intelligent connected vehicles to support the industry's growth, such as tax incentives, subsidies, and other measures. This will encourage the industry's healthy development and assist businesses in lowering costs. Businesses involved in intelligent connected vehicles should strengthen their own technological innovation capabilities, improve production efficiency and quality, reduce production costs, enhance product competitiveness, and reduce prices through different market strategies, such as market segmentation and differentiated pricing. Respondents can then select the intelligent connected cars that best suit them by taking into account all aspects of the cost of owning the car, including the price, use cost, maintenance, and other factors.

Enterprises working on intelligent connected cars should be aware of their obligations and roles in the creation and application of these vehicles. The confidence and support of respondents, investors, and employees can be gained through good corporate social responsibility. Also, it might improve the company's reputation and raise the brand value. As intelligent connected vehicle enterprises, they should focus on environmental protection, actively promote the use of clean energy, lessen exhaust emissions and noise pollution, deliver more humanized services, and pay attention to user experience and human-machine interaction design. In order to guarantee that the technical requirements of intelligent vehicles are compliant with international standards, these firms should also actively participate in the formulation and normalization of social and industry norms, as well as the formulation of international standards. Meanwhile, they need to set up a sound compliance management system to meet relevant laws and regulations.

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