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Governance for Emerging Autonomous Driving Development in China

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ABSTRACT

Academicians have realized that the opportunities and challenges of autonomous driving (AD) coexist, thus the governance of this revolutionary technology is vital to enhance the benefits of AD whilst avoid its risks. In this article, we attempt to response to this question and take the AD development in China as an example to examine the governance situation of it. The positions and responsibilities of important stakeholders (the government and firms) for developing AD in Chinese special administrative system environment are studied at first. Then, the regulatory relationship between them is discussed through investigating relevant policy documents, firm websites and media reports. The investigation shows that, thus far, the legislative process on AD governance is relatively lagging. The government's responses in most instances are relatively conservative, and focus on creating normative documents to better regulate AD. There is therefore a comparative lack of commitment to the AD's legitimacy. In contrast, enterprises are the pioneers of AD development. They actively explore the future of automation technology and the formulation of policies via extensive alliances sharing the risks and uncertainties of this innovation. To address this governance issue, strategies ranging from supplying transportation infrastructure, investing in AD through government-led industrial funds to reaching public-private partnership have been adopted. However, it is not clear whether this enterprise-led industrial development direction is consistent with the government's management goals, although these industry lobbies are actively promoting effective policy making.

Keywords: Revolutionary Technology; Autonomous Driving Development, Stakeholders, Governance Situation.

INTRODUCTION

Autonomous driving (AD) have a revolutionary impact on both future transportation and society *(1)*. Since Google released its first fleet of autonomous vehicles (AVs) in 2010 *(2)*, the research progress on AD has accelerated significantly worldwide. At present, the research on AD mainly focuses on two issues:

(a) How to ensure the technical reliability of AV *(3)*?

(b) How to evaluate the possible impact of AD on society? (see *(4)* for details).

For the first issue, many literatures have defined the safety challenges that the automation technology faced and have proposed corresponding solutions *(5-7)*. For the second issue, scholars have drawn various conclusions which suggest the uncertain future of AD. For example, when it comes to economy development, self-driving mobility can reduce safety and time costs significantly *(8)*, whilst create a situation that jobs in the transportation and logistics sectors are likely to be replaced due to the introduction of AD *(9, 10)*; when it comes to environment issues, AVs can be conductive to energy saving in the long term, whilst lead to increased energy use because of longer travel distances and induced trips by underserved populations such as disabled, and elderly *(11,12)*.

Therefore, according to the current research achievements, the impact of AD on the future society is unpredictable, and appropriate governance strategies can help enhance the potential benefits of AVs whilst avoid negative or unexpected scenarios *(13)*. However, the research on this governance challenge to date is very limited. There are some works highlighting the importance of AD's governance and providing some regulatory strategies for future development in view of the potential risks of AD *(13-15)*. But there is no country-specific literature describing the current governance situation of AD, which is the foundation for putting forward reliable measures.

This paper tries to fill this gap. China, aiming at building its strength in transportation, is taken as an example, whose innovative development mode for AD has important practical significance for the AD's development in the global scope. Before discussing the position and responsibility allocation of stakeholders in developing AD, we briefly introduce the special political environment under Chinese administrative system reform. Then based on the consideration of the regulatory relationship among stakeholders in supporting AD, the management and governance situation for AD in China is examined.

Aiming at investigating the above-mentioned problems, the research scope is limited to the following aspects:

- First, there are many stakeholders in the AD industry, including the government, enterprises, the users, etc. Among them, the government and enterprises are the research objects of this paper, because the innovation activities of enterprises reflect the industry and market development, and the legislative environment formed by the government has a significant impact on enterprises *(16,17)*. In addition, the users involved mainly include those who own AVs and the labor market related to driving. The acceptance degree of car owners and the employment problems resulting from AD will affect the future development process and direction of it. But this impact will be in the distant future, as Milakis et al. *(4)* defined it as the "third-order" stage of AD.

In view of the fact that AD in China are at the road test stage and not commercialized, and the market penetration is low, the implications of users on AD is not within the scope of this study.

- Second, it is worth noting that the policy documents of national governments are mainly examined in this research. The reasons are as follows:
  (a) China's AD industry has just realized the AVs production of SAE Level 2 *(18)* and the main policies are guidance documents which are usually issued by the national government;
  (b) Although the AD industry is under the dual regulation of the national government and local governments, the national government centralizes the power of local governments, resulting in consistent policies of these two level governments. Therefore the concern for government at the national level is limited but reasonable.

In this study, China's administrative system reform which exerts an influence on AD industry regulation is outlined in the next section. With respect to the positions and responsibilities of the government and enterprises for developing AD, this paper mainly describes its different attitudes and governance entities. Then, specific sections present and analyze some examples of stakeholders' regulation and their mutual relationship. The conclusion summarizes the current governance situation of China's AD promotion and proposes the future research directions.

CHINESE ADMINISTRATIVE SYSTEM CONTEXT

The industry development is influenced by the structure of the state administrative system *(19)*. The main connotation of the national administrative system structure includes the definition of government functions, the relationship between government and firms, etc. Chinese traditional administrative system structure is relatively centralized, namely, the government has a strong decision-making power, as well as a large number of public resources *(20)*. Thus, the traditional government plays an omnipotent role involving owners, operators, managers and distributors, who allocates resources and manages the development of enterprises through directive plans, thus controlling the industry economy *(21)*.

However, this centralized regulatory mode can inhibit the independent innovation power of enterprises, and fail to meet the growing industry development demands. Recognizing the deficiencies of the government's overall control on enterprises, Chinese government has practiced gradual improvement and reconstruction of its functions undergoing six administrative reforms in the past 30 years. The initial attempt was to guide market participants to innovate actively with policies, such as the implementation of industrial park policy and the foreign investment introduction policy *(22)*. But these policies have not changed the dominant position of the government in the previous government-enterprise relationship. With the continuous reforms of the administrative system, the government is increasingly aware that enterprises are the main body of the socialist economy. And thus the government should not regard itself as the manager of the firms, but should regard the firms as the creator of social wealth, the practitioner of social harmony and stability, as well as the government service object. The connotation of government's role shift involves:

(a) The scope of its role: from omnipotent government to limited government, affirming the subject pluralism of state governance, namely, government, industry, society and other subjects in the management of national and social public affairs.

(b) The regulatory mode: the government, sets up government supervisory bodies to supervise and control the activities of market participants instead of managing firms by administrative means such as issuing orders, in order to prevent and remedy market failure.

In contemporary society, the concept of government functions has undergone tremendous changes. The most advantageous evidence is the "Program for Deepening the Reform of Party and State Institutions" *(23)* issued by the Communist Party of China (CPC) Central Committee in 2018, which highlights the position of the market in the resource allocation process. Meanwhile, service government, is the main trend of development of China's administrative reform. Furthermore, Chen Baoshing (Member of CPC Central Committee) said: "One of the most important relationship which is necessary to appropriately deal with in establishing a service government is the relationship between the government and the firms. Descriptively, the government is expected to control state-owned capital and investment instead of regulating the firms all around. All firms' activities will happen according to the market law" *(24)*.

GOVERNANCE SITUATION IN THE ADVENT OF AD

The comprehensive reform of China's administrative system has led to a shift of the power balance from government hierarchies to a broader decision-making network involving more stakeholders. Therefore, in terms of the governance issues on an emerging technology, i.e. AD, the government tends to disperse the responsibilities to various interest groups, typically enterprises. Relying on this mechanism, in order to explore the development prospects of AD in China, the basic and core issues are: (a) what the unique positions of different stakeholders (i.e. government and enterprises) are in supporting the AD's development and (b) how the responsibilities are allocated among them.

Challenges of Government

Although the government is aware of the limitations of its capabilities *(25)*, it is generally accepted that the government plays a decisive role in the management of AD's development and the shaping of markets associated with it *(26-28)*.When the innovation of AD supports the government's key functions, the government is expected to participate in the development of it and influence the main ways of its diffusion (just like the government tries to achieve its emission targets through supporting large-scale use of electric vehicles via financial subsidies *(29)*). Its traditional incentive policies include legislation, sponsoring the development, cooperation with enterprises, and even self-development of new technologies (e.g. defense technology). These incentives can be categorized as government interventions to support a certain industry, which can be problematic: they may reflect interests of the lobbying groups, focus on technological leaps with insufficient market evaluation, or cause promises which are difficult to withdraw *(30)*. In addition, government interventions may also lead to some controversial criticisms, accusing the government of inefficiency and "ill-conceived" acts

in a situation where large amounts of investments do not seem to get a good return. If the government does not intervene, such inaction will also cause public discontent, believing that it is negligent in achieving social well-being *(31)*. Thus, it is a challenging task for the government to master the regulatory balance for AD to ensure that the government is able to realize its own functions well while encouraging the firms' innovation power for self-driving development.

Aspiration of Firms

Generally, the government will make policy decisions on emerging automation technology to support its key functions, whilst it can be expected that enterprises will enhance their competitiveness in a rising industry relevant with AD by participating in the development and innovation process of it (i.e. occupying the automation fields and acquiring new AV users). What's more, firms' participation may also include the implementation of management functions or social responsibilities clearly authorized by the government, and involve the fields where the government has not intervened (or neglected by the government) *(32-34)*. However, firms and governments have different management motivations. For example, in the traditional industry economy, the actions of private firms are motivated by market profits, which means that there will be inadequate investment in some areas where the uncertain risks are too high and the predicted profits are insufficient *(35-37)*. And companies are thought to respond positively only when critical technologies and market uncertainties are reduced by the government *(38)*.

However, in the field of the AD development, it is interesting that this may not be the case. The true story is that enterprises show a strong aspiration to support AD actively exploring the development boundary of it. Take Baidu as an example, for the information security of AD, it actively jointly established information security research laboratory with relevant enterprises, universities and research and development institutions; for the insurance of self-driving testing, it has signed cooperation agreements with many insurance companies to ensure the customer safety; for the judgment of accident liability, it has developed an Event Data Recorder (EDR) for AD system to provide reliable evidence for accident analysis, etc. This aspiration will be further confirmed in the next section, as it is of great significance for us to understand the unique efforts of the enterprises in the high-risk self-driving industry.

Governance Entities for AD Development in China

For the development of AD, the specific stakeholders and the current responsibility allocation of them are summarized as follows and are also shown in **Figure 1** according to relevant policies, company websites and news reports.

On the one hand, the main regulatory bodies on the side of the national government are the Ministry of Industry and Information Technology (MIIT), the Ministry of Public Security (MPS) and the Ministry of Transport (MOT). The MIIT plays a leading role in these aspects:

(a) Formulation and implementation of the plans, industrial policies and standards relevant to the intelligent transport industry (which contains the concept of AD);

(b) Management of industry daily operation;

(c) Promotion for the development and innovation of key technologies (e.g. intelligent chips, intelligent algorithms, etc.) and equipments (e.g. intelligent sensors, integrated circuits, operating systems, etc.) of AD;

(d) Advancement of the research and development and standard-setting of information technology in the AD industry, and guaranteeing the national information security.

The MPS and MOT are the main bodies of policy implementation. The former is responsible for allocating sufficient resources of the transport institutions in accordance with the development strategy of intelligent transport industry issued by MIIT, specific matters involve:

(a) Managing the daily operation of AD (currently mainly refer to the road test management, safety assessment, investigation of safety accidents, judgement of the accident liability, etc.);

(b) Security supervision of public information network;

(c) Safety education of relevant enterprises and related personnel, etc.

And the MOT is responsible for implementing relevant policies and regulations, focusing on managing the practical traffic organization behavior, its main tasks include:

(a) Regulation of the AD market, involving the implementation and supervision of relevant policies, systems and technical standards;

(b) Safety production of the industry (for example, understanding and promoting the research and development status of automation technology in major AD enterprises and scientific research institutions in China) and emergency management;

(c) Transportation statistics for the self-driving industry, and guiding the industry to value the targets of environmental protection, energy conservation and emission reduction.

On the other hand, the active organizations belonging to the social side are mainly private firms, including internet firms and vehicle manufacturing firms. Although vehicle manufacturing firms have major advantages, such as (a) systematic understanding of vehicle dynamics; (b) a large number of road test data; (c) decades of industry experience; (d) powerful strength in safety, reliability and manufacturing of automobile products, they lack of advanced core technology and team for promoting intelligent driving algorithm, and the strategic acuity to new technologies. These two flaws are exactly the unique advantages of the internet firms. For internet companies, they are very clear that the ultimate carrier of AD technology is the vehicle, so in order to make the driverless system closer to the actual product, actually, in the development of AVs, they adopt a cooperative relationship to solve the problems of research and development of AD technology as well as its commercial operation.

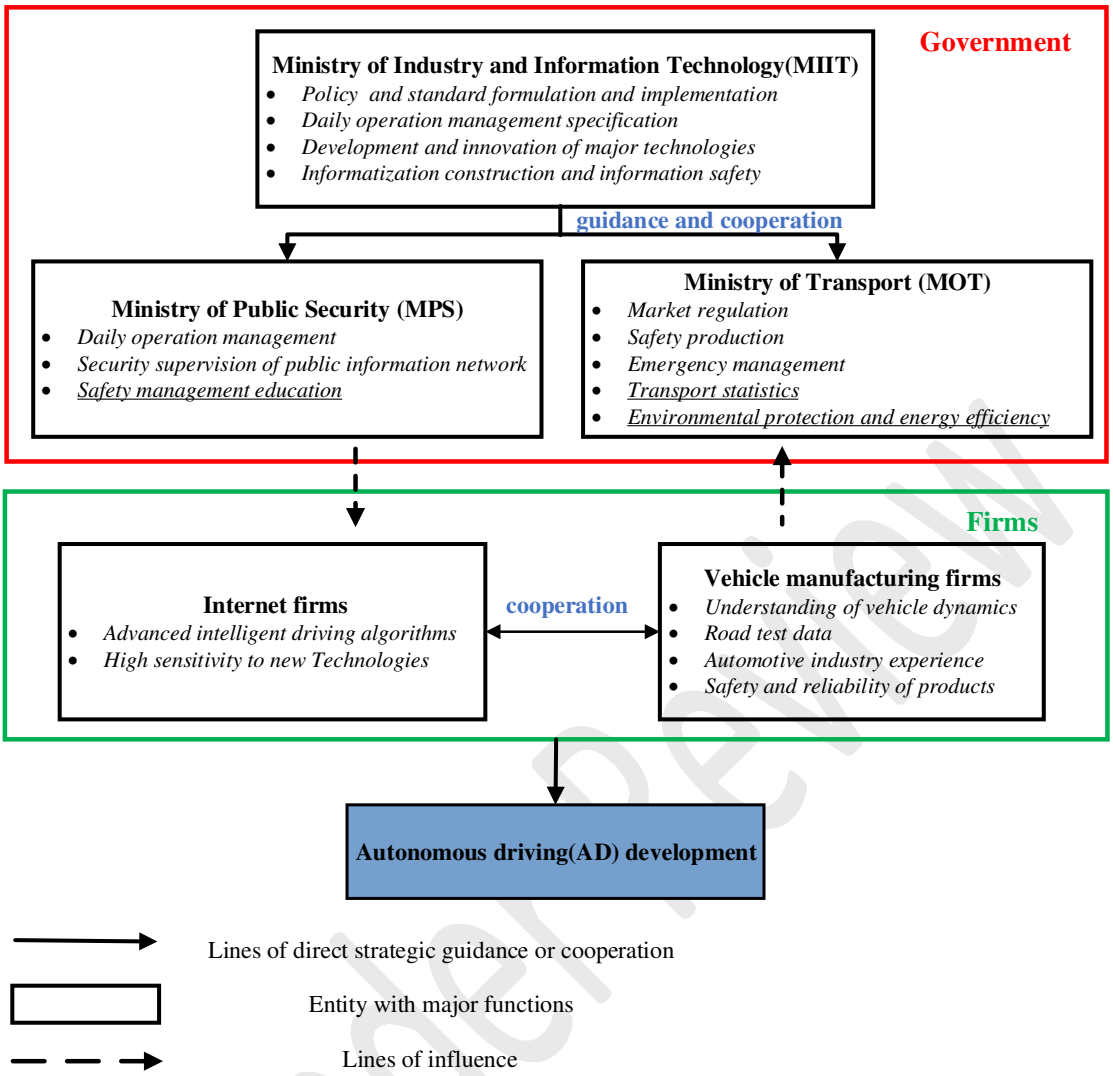

Figure 1 Functions of AD related entities and their mutual relationship

Source: Authors' summary and compilation based on related information from government websites of China.

Note: The underlined part is the responsibility related to AD development that departments should be assigned according to the administrative system, but has not been paid attention to at present.

A RESPONSE TO AD: INNOAVATIVE RELATIONSHIP BETWEEN GOVERNMENT AND FIRMS

The regulatory relationship between the government and firms has always attracted social controversy *(39-41)*.When it comes to the government-firm relationship in AD's regulation, some academicians believe that the government should realize its own functions (for instance, safety, traffic congestion, social equity and civil well-being) in public affairs relevant with AD by regulating enterprises behavior *(42)*. Others argue that AD, as a fusion of information technology (IT) and the automobile industry, has great potential in its development scenarios *(43,44)*, and recommend less regulation to enable as many solutions as possible to emerge in various scenarios. Actually, it is necessary to create a balanced regulation

relationship between government and firms, because too much regulation may hinder the ability of the market sector to participate and innovate, while too little regulation may lead to results that are not in the public interests *(45)*.

As mentioned above, the government used to regard itself as the regulator of enterprises, but now has realized that it should change its previous management-oriented relationship with enterprises into a service-oriented relationship. In this context, the new governance relationship of government and enterprises for the promotion of AD should be paid attention to, which will determine the self-driving development process in China. And this issue will be illustrated based on the analysis of related policy documents, firm websites and media reports.

The Lagging Policies and the Progressive Enterprises

Interestingly, in the development of AD, there is an innovation compared with the traditional regulatory manner of government and firms. As explained in the previous section, our traditional perception is that firms only invest heavily in some high-risk industries after the government determines its position. However, the situation in China seems to be different in the AD's rising stage.

As seen in **Figure 2**, policies published by the government is mainly geared to low-level intelligent networking vehicles. What's more, the rank of the laws specialized for AVs is relatively limited and is mainly at the Ministries' level, lack of amendment for superior law.

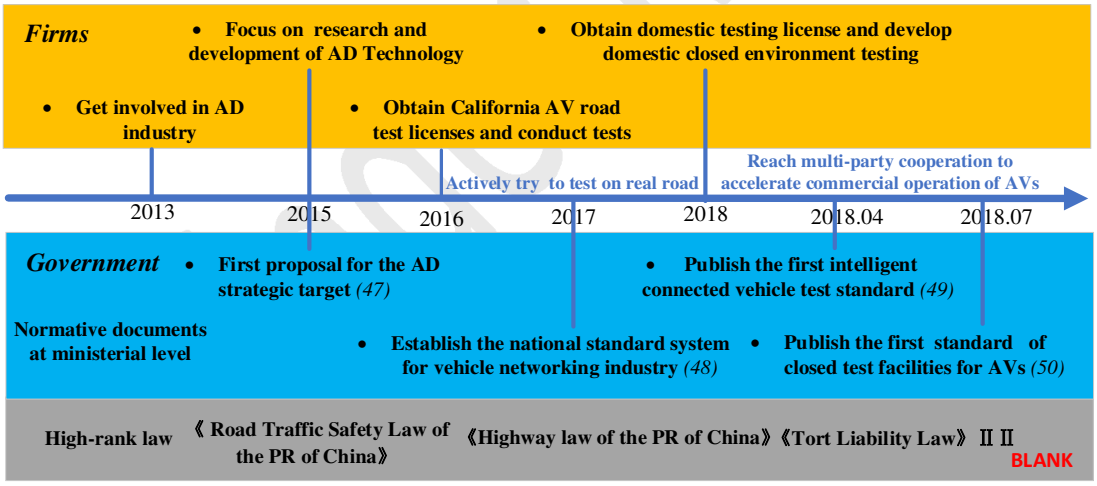

Figure 2 Time series diagram of firms' efforts and government's policy decisions

Source: compiled by the author from various policy documents and company reports.

Note: With respect to the AD related enterprises, we investigate the self-driving development process of representative enterprises in China, including Baidu, Tencent, NIO, SAIC, Dongfeng, Geely, etc. In terms of the government side, it is worth noting that:(a) statistics is mainly concentrate on the publication of representative innovative policies at the national level (there is no list of local governments who actively develop AD, such as Beijing, Shanghai, etc.); (b) the national standard system of vehicle networking industry formulated in 2017 focuses on Advanced Driving Assistance System (ADAS), which not directly aim at promoting the field of AD; (c) The difference between intelligent connected vehicle and the AV is that the

former is the initial stage of intelligent vehicle technology, while AV is the highest stage of intelligent vehicle. Consequently, the legislative progress is lagging, which may lead to the contradiction between AD usage and the high rank law. For example, The Road Traffic Safety Law of the People's Republic of China claims that" the driver's license must be obtained in accordance with the law to be able to drive a motor vehicle *(46)*". This means that it is not clear whether the AD system can replace a human driver to control the vehicle on the road. Moreover, the law also stipulates that drivers should not have behavior such as answering phones and watching TV, which hinders safe driving *(46)*. But this regulation contradicts the commercial purpose of providing leisure and entertainment for AD users to a certain extent.

Despite the lagging effect of the policy-making, enterprises are still optimistic about AD's prospects, as Baidu believe that the future of transportation should be composed of AD, and China's AD industry will have the ability and opportunity to stand at the forefront of the world in 3-5 years. Guided by this confidence, firms are leading the way of the research and development of AD, and they are actively conducting AV safety tests and promoting the commercial operation process of AVs. **Figure 3** shows the changing trend of the investment amount as well as the investment number in AD industry from 2013 (the time that AD started to develop in China) to 2018 (the time that legal closed road test of AD has realized in China). We can learn from these data that in 2013-2015, when the government has not paid attention to the self-driving industry, the investment amount in it has displayed a slow growth trend; And in 2015-2018, it shows a sharp growth, thanks to the national strategic objectives issued for AD and the promulgation of relevant policies (see **Figure 2**). It is worth noting that under the condition that the number change of investment is flat (2016-2018), the amount of investment is increasing steeply, which suggests that the amount involved in each investment is increasing year by year.

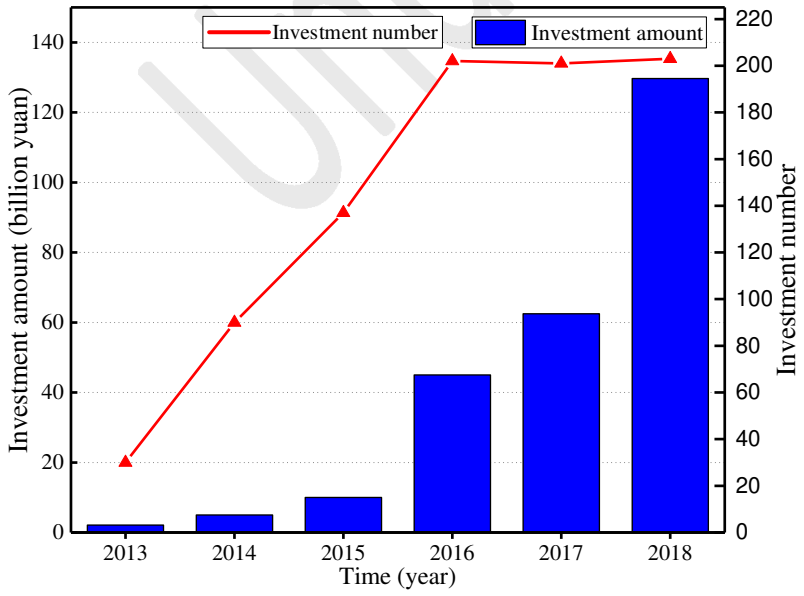

Figure 3 The changing trend of the investment amount and the investment number in AD industry from 2013 to 2018

Source: compiled by the author from various news resources.

Enterprise Alliances and Policy-making Progress

Faced with the technical difficulties of AD and the lack of industry standards, firms are increasingly aware that individual efforts are weak to build an AV that is safe enough to make profits in the future. Based on this consideration, cooperation alliance has been regarded as a preferred pathway to defray costs, share risk and exchange resources and signals which convey industry recognition *(51)*. Baidu is considered as a valuable partner relying on its cutting-edge technology resources. A major alliance of enterprises integrated by it is a representative case, which involves various types of AD-related firms including suppliers of components and solutions (e.g. sensors, high precision maps, V2X technology and AI algorithms), vehicle manufacturing enterprises, AD start-ups, mobility service companies, university institutes and government agencies. The 145 companies cooperated with Baidu Apollo *(52)* are categorized according to the above different compositions, as shown in **Figure 4**. We can know that the AD's cooperative platform built by Baidu covers the main elements of AD, and specifically focuses on components and solution suppliers, and vehicle manufacturing enterprises.

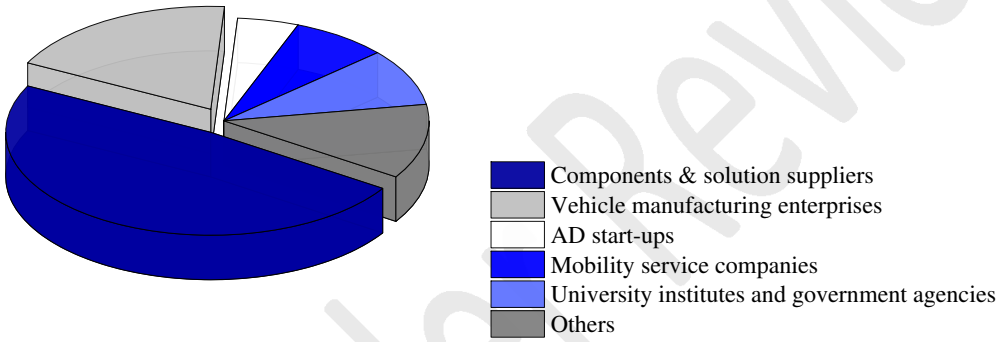

Figure 4 Enterprise alliance components of Baidu Apollo (2017-)

Source: compiled by author from Baidu company website.

Moreover, these alliances that established in recent years attempt to motivate the government to accelerate the policy-making process *(53)*, which corresponds to the positive role orientation of the AD enterprises. For example, in 2017, driven by Baidu and its alliance partners, Beijing issued the first local government-level test management standard for AVs in China *(54)*; In 2018, Alibaba Group, Highway Institute of MOT, FAW Group and other institutions jointly established a "2038 Premier League" to promote the development of technology and standards related to AD in V2X (Vehicle to Everything) technology, vehicle-road coordination and other fields; In 2019, Baidu launched the White Paper "Safety First for Automated Driving" with 11 enterprises, such as APTV, BMW, Audi, etc. This document expounds the research and development, testing and verification framework for the safety of AVs and tend to prompt the government to set up a unified industry standard.

Government New Roles: Participant and Service Provider

These two types of innovative relationship between government and enterprises has developed uniquely but not surprisingly, because they seem to correspond to Chinese

administrative institution reform, descriptively, all respond to the requirements of industry and market self-regulation emphasized in the reform. Moreover, in terms of the government function changes in the reform, the fact is that since 2017, governments are not only involved in self-driving governance as a regulator but also have sought new roles (i.e. industry participants and service provider) to develop AD. In this way, the government is willing and able to negotiate and conclude cooperation relationship with potential service partners. The specific practice includes the following three aspects:

- Since 2015, MIIT has taken the lead with some local governments in building AD test bases in several provinces and municipalities to serve the testing demands of local AD enterprises. At present, 14 cities in China have completed the test base construction of AVs, as shown in **Figure 5**. In addition, MOT, as the main body of daily operation supervision for AD, has certified three closed test bases, namely, Research Institute of Highway Ministry of Transport (a research institution directly under the state ministry), Chongqing Vehicle Test and Research Institute (a vehicle product quality inspection institution at the local government level), and Chang'an University (the only comprehensive automobiles performance test field among China's universities), which are displayed in **Figure 5**. Relying on these three institutions, the official AD certification system can be constructed at three levels from national government, local government to local university.

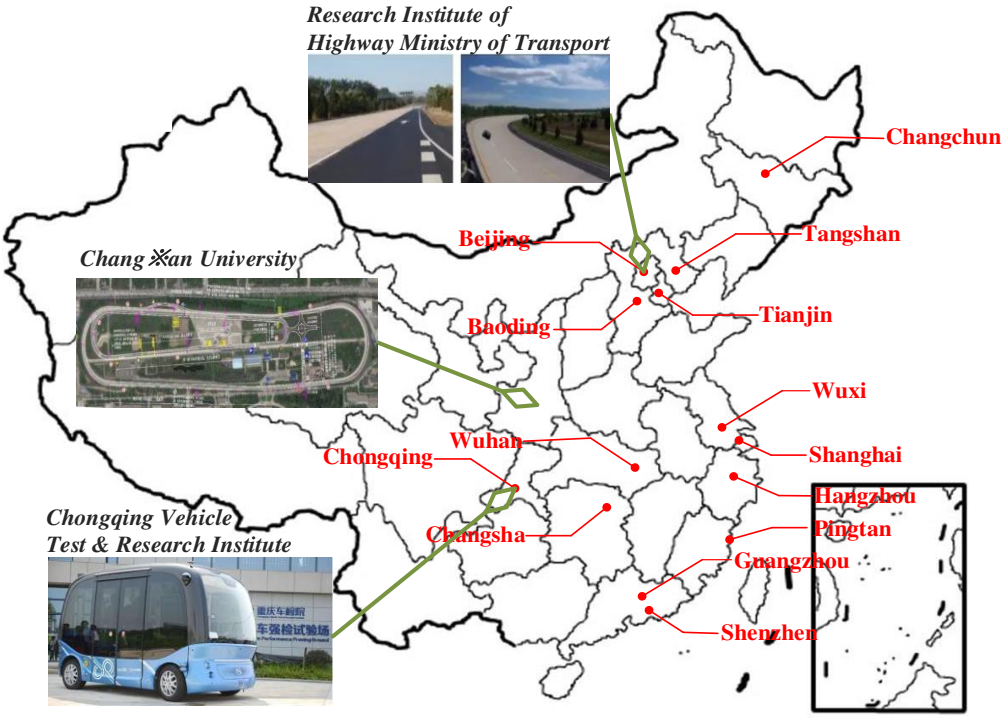

Figure 5 Geographical distribution of AD test bases in China

Source: compiled by the author from news reports, government and university websites.

- The government often participates in the AD industry by investing in AD companies through industrial funds led by government or state-owned enterprises. For example,

Shanghai International Automobile City Group (wholly state-owned group) launched "Star Program" in 2017, investing 200 million specialized funds to support 100 self-driving related venture projects; Chongqing industry-guiding fund owned by Chongqing government, also join with many private funds and set up a fund of 700 million yuan for the intelligent vehicle industry.

- Furthermore, a public-private partnership was reached by the government and enterprises to build smart cities and relieve urban traffic pressure, at the same time, stimulate regional economy. The typical examples are that Xiongan New Area government signed a strategic cooperation agreement with Baidu Company in December 2017; Changsha Municipal People's Government, Hunan Xiangjiang New Area Management Committee and Baidu Company also jointly signed a strategic cooperation agreement in October, 2018. And this trend seems to grow due to the change of government's role orientation from omnipotent government to limited government resulting from the deepening institutional reform.

CONCLUSIONS

Despite the rise of AD in recent years, there is a comparison between the rapid advancement of the industry by the self-driving enterprises and the backward process of the government's policy-making. Therefore, the urgent issue is the AD's regulation problem. Aiming at responding to this problem, we attempt to clarify the regulatory status of AD's development, considering the specific development pattern of the government and enterprises. Through the investigation of relevant policy documents, firm websites and media reports, the following results are obtained in this paper.

First, in developing AD, it seems that it is problematic for government's interventions or non-interventions, while for enterprises, they have strong aspiration in supporting AD.

Second, in terms of the governance entities involved in AD's development, it is summarized that the main regulatory bodies of the national government are the MIIT, the MPS and the MOT, among them, the MIIT play a leading role. And they regulate the AD development mainly by issuing normative documents currently. At the same time, internet firms and vehicle manufacturing firms also have a contribution for promoting AD, who have their own unique advantages.

Third, there is an innovative development pattern between government and enterprises for improving the progress of AD. Three representative trends are:

- Enterprises, who have great ambitions for developing AD, actively implement investment and research and development in a lagging legislation environment;
- Whilst the government takes a relatively conservative attitude in the legislation and regulation of AD, enterprises actively promote the formulation process of relevant policies through establishing a large alliance of enterprises;
- Adapting to the administrative system reform, government shifts its role of a regulator to a participant and service provider, by the way of building AD test bases for AD firms, investing in the firms through industrial funds led by government or state-owned enterprises and establishing public-private partnership.

This status quo of the role relationship between the government and enterprises implies

the government's rulemaking reticence and enterprises' proactive advancement in AD industry. And the situation may lead to an emerging risk that the government can be induced by enterprises to formulate policies beneficial to the interests of enterprises, and the results may be inconsistent with the government's political targets *(45)*. With the closing commercialization of AVs, we should aware that it would be an urgent problem than ever about how to create a balanced regulation relationship between government and firms so as to guarantee the social welfare and the bright future of AD.

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AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: Q. Xue, M. Xu, C. Mullen; data collection: Q. Xue.; analysis and interpretation of results: Q. Xue, M. Xu; draft manuscript preparation: Q. Xue, M. Xu. All authors reviewed the results and approved the final version of the manuscript.

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