

# Driverless Industry: Current State, Business Model, Challenges and Prospects

Haozhe Chen<sup>1, a, \*, †</sup>, Le Li<sup>2, b, \*, †</sup>, Peiqi Wang<sup>3, c, \*, †</sup>

<sup>1</sup>Fisher College of Business, The Ohio State University, Columbus 43210, Ohio, United States;

<sup>2</sup>Mater Dei High School, Santa Ana 92707, United States;

<sup>3</sup>Beijing-Dublin International College, Beijing University of Technology, Beijing 100124, China.

\*Corresponding author: <sup>a</sup>Chen.11329@osu.edu, <sup>b</sup>lil.22@stu.materdei.org,  
<sup>c</sup>peiqiw@emails.bjut.edu.cn

†These authors contributed equally.

**Abstract.** Digital transformation in the automotive industry promotes the emergence of autonomous vehicles, having a significant impact on people's daily life and microeconomic environment. This paper presents the current situation of the self-driving industry, its prospects, and the potential value chain in the future. Being the bellwether in the self-driving industry, Waymo has had the largest driverless taxi service in the world. Although there are many obstacles in the process of autonomous vehicles being the mainstream, its future is still promising. We predict the changes in the value chain mainly come from driverless technology and its convenience. This research could enable autonomous vehicle manufacturers to know which aspects should be developed into core competencies.

**Keywords:** Autonomous Vehicles; Waymo; Value Chain; Challenges and Prospects.

## 1. Introduction

Driverless technology has received an increasing attention, with many large companies investing in it and many countries are focusing on developing industries related to it. This shows that this is an emerging industry that is beneficial to both business and society. There is no doubt that such a much-anticipated industry will change the existing business model, but the driverless industry also faces difficult challenges.

An autonomous vehicle, also known as a self-driving car or driverless car, is a vehicle that can detect its surroundings and move safely with little or no human input [1]. Since self-driving technology can be traced back to the 1920s, there have been numerous researches on it on far, including focusing on core technologies, application fields, advantages and drawbacks to society, and so forth. However, there are few articles systematically explaining the difference among current autonomous driving technology development companies and illustrating the impact of autonomous technology on the business model of future companies from a management perspective. This paper would mainly illustrate the leading company in the self-driving industry – Waymo, the prospect of business model, and potential challenges of the driverless industry.

The rest of this paper is organized as follows. Section 2 presents the history of autonomous vehicles. section 3 reports the current state of autonomous vehicle companies. Section 4 predicts the effect of self-driving technology on the future value chain. Section 5 describes the challenges and prospects of the autonomous vehicles industry. Finally, section 6 concludes.

## 2. History of Autonomous Vehicles

Since vehicles were first invented, scientists have been thinking about how to remove people from the driver's seat. One of the first demonstrations is the radio-controlled car on New York City streets in 1925. There is another car needed behind to send radio signals to the transmitting antennae installed in the driverless car in front [2]. During the period of 1920 and 1980, various car companies and Universities had made many efforts to pioneer autonomous vehicles.

The first truly autonomous cars appeared in the 1980s. A vision-driven Mercedes-Benz robotic van, designed by Ernst Dickmanns of Bundeswehr University Munich in Germany, can perform autonomously over 20km with a speed of 96 km/h on an empty highway. Since then, many large companies and research organizations have developed functional self-driving vehicles. In 1989, the robotic van was capable of recognizing obstacles and, in the 1990s, could make lane changes independently. In the 2000s, the US government funded 3 military efforts, Demo I, Demo II, and Demo III. Demo III demonstrated that unmanned ground vehicles could drive through a mock urban environment [3].

The first self-driving vehicle applied for commercial sale was the Induct Technology's Navia shuttle in 2014 [4]. The purpose of it is to shuttle people around large industrial sites, airports, university campuses, theme parks, pedestrianized city centers, and hospital complexes. In 2014, SAE International, an automotive standardization body, released a classification system consisting of six levels, ranging from fully manual to fully automated systems [5]. In 2019, the first regulation, regulation (EU) 2019/2144, applies from 2022 in the European Union for automated vehicles.

### 3. The Current Situation of Autonomous Vehicle Companies

Human has had three industrial revolutions, each of which has been accompanied by the great transfer of global industries and the great adjustment of the international structure. The fourth industry revolution (5G internet + artificial intelligence (AI) + self-driving cars etc.) has begun in recent years. Different countries and companies are competing in various dimensions in these industries, especially in the driverless industry. Competition among autonomous vehicle companies has been fierce over the past few years. Many companies have invested millions or even billions of dollars in autonomous driving technology, such as Waymo, Cruise, Uber, Baidu, etc. This race between various tech companies will decide who will be the winners in the driverless industry.

Autonomous-vehicle research costs billions of dollars, and there is very little short-term return for the research. Over the last few years, a group of 30 firms has invested at least \$16 billion in the development of driverless cars, and so far, they have little revenue. However, billions more will probably be needed to develop the driverless technology to primetime. Based on the calculations, Waymo, Cruise, and Uber, these three companies spent half of the \$16 billion [6]. For others, Baidu, Apple, Ford, and Toyota spent most of the rest. Only a few companies have enough capital to afford this long-lasting spending, particularly Apple, Toyota, and Alphabet.

To gain a better understanding of the current state of self-driving companies, we must start with the leading company Waymo. Waymo has been viewed as the clear leader in the self-driving industry. The massive financial support from Waymo's parent company Alphabet is an imperative key to its success. In March 2020, Waymo raised \$2.25 billion in its first external funding round. Later in June 2021, Waymo raised \$2.5 billion in the second external funding round [7]. Waymo has the largest driverless taxi service in the world, which allows it to gain much more driver data and operational experience than other companies. This advantage enables Waymo to further upgrade its software and maintain its leadership position. Many other companies follow the same strategy as Waymo, namely, to build and operate a robotaxi fleet, such as Cruise LLC (US), AutoX (China), Baidu (China), Tesla (US). These companies are developing new technology, adopting expansion strategies, and embarking on collaborations. Table 1 presents the major developments of 5 major autonomous vehicles companies.

**Table 1.** Major Developments of Self-Driving car Companies

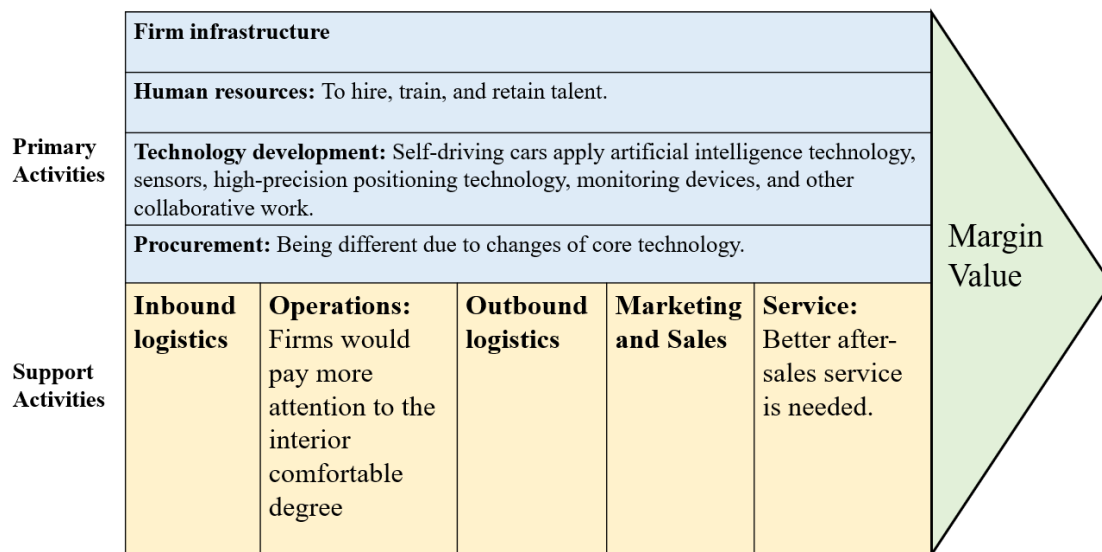
Self-Driving Car Companies	Major developments
Apple	Establish a transportation network for employees; has 70 autonomous cars on the road in California currently. Former engineers from Waymo and NASA were hired in 2018 to lead the Titan project. Obtained a number of autonomous driving patents.
Baidu	Built “android of autonomous driving” to support developing autonomous driving technology. 3m autonomous kilometers traveled in urban areas. Opening of an AI research laboratory in Silicon Valley
Tesla	Launch of Autopilot, its semi-autonomous driver-assist technology in 2014. Autopilot Hardware 3 launched in April 2019. Announced that all Tesla cars on the road would be capable of receiving autonomous technology by a software update.
Uber	Hired 40 engineers Carnegie Mellon Robotics Laboratory to work on autonomous driving technology for Uber. Conducted limited testing on the streets of San Francisco in 2020. Sold autonomous unit ATG to Aurora innovation in Dec 2020.
Ford	Expects to deploy autonomous cars by 2022. Acquired Argo at \$1B Partnership with Domino's, Postmates, and Walmart on self-delivered pilot projects [8].

There is also a collaboration between technology and autonomous vehicle companies, tech companies must collaborate with each other to reduce the significant risks and costs associated with technology. Through partnerships with technology companies, auto manufacturers can better understand the key technologies that are changing the industry and speed up the learning process to remain competitive in the fast-changing environment. Tech companies are also encouraged to work together with auto manufacturers to see how they can complement each other's strengths [9]. For instance, Waymo has worked with OEMs such as Fiat and Jaguar to provide an autonomous platform that is based on Intel computing hardware. The company installed the system on Pacifica hybrid cars and Jaguar I-pace SUVs to turn them into autonomous vehicles, next gave them to Lyft to operate, delivered them to Avis for maintenance, finally restore data from there [10].

#### **4. Potential Business Model Change if Driverless Technology Becomes Mainstream in the Future**

The rise of self-driving technology not only change customers' lifestyle but also affect business models in different industries, among which the automotive industry is the most affected. This part mainly analyzes how driverless technology would change the traditional automobile manufacturing industry from the perspective of the value chain.

The value chain is a series of activities the firm uses to implement its business-level strategy. There are two aspects of the value chain: primary activities and support activities. Figure 1 presents changes in the future value chain of the automotive industry.



**Fig 1.** Value Chain

**4.1 Primary Activities**

The value chains of present car manufacturing companies tend to be similar except for some diversification in several steps. In terms of primary activities, the future automobile manufacturing industry would have analogous inbound and outbound logistics, and marketing and sales.

Since self-driving technology would diminish the necessity for drivers to focus on road conditions when driving cars, for people, the automobile would generally become a space to take a rest during the trip. Hence, considering automotive design, one of the segments of operation, firms would pay more attention to the interior comfortable degree. Besides, firms need to provide better after-sales service than it already is. According to the Deloitte study, if the original equipment manufacturer (OEMs) offered a guarantee for accidents due to technological failure, around 59% of drivers would be more likely to use autonomous vehicles [11]. Because, at least up to now, there is no authoritative evaluation showing that self-driving cars are safer than traditional cars, no one would make a deal if they cannot receive a warranty for undertaking extra uncertainty.

**4.2 Support Activities**

The crucial matter of autonomous driving is technology development. Drivers do not need to interfere with driving, while the computer would automatically operate the automobiles. One preeminent technology is Cellular vehicle-to-everything (C-V2X), enabling the vehicle to connect with other vehicles and road facilities, such as signal lights, through the network, and connect the single intelligent automobile to the whole network so that the vehicle can make timely feedback according to external information during driving [12]. However, in addition to technical progress, the impact of this technology on the future of mobility also depends to a large extent on customer acceptance and favorable regulations. Autonomous vehicles can be accepted once they are evidently safe, so developing reliable autonomous driving technology is the key to participate in future mobility markets.

It is predicted that the future car company is an attractive vocation for digital and research talents, as high-tech features are central to the driverless industry. Therefore, the human resource management departments need to devote a great deal of attention to hire, train, and retain talent.

Since the change of core technology of automobile manufacturing, the procurement of required raw materials can be a little different from that of the current automobile market. In the future, as mobility become a commodity, the profit margin has declined and OEMs are focusing on process improvement and cost-efficiency. It is essential for a firm to maintain communication and operation with all of these suppliers for smooth procurement. Therefore, in the future, car production will retain

the core business, but OEM would increase the proportion of other business models to gain more market share [11].

## 5. Challenges and Prospects of the Driverless Industry

At present, the driverless industry is still in an initial stage of development, which means that security is still a serious problem [13]. Boston Consulting Group in 2016 published a report shows that 45% of people want to be controlled at all times, and even 50% of people wouldn't feel safe about driverless cars. Driverless cars usually use three techniques to navigate: Light detection and Ranging (LiDAR), cameras and radars [14]. These three techniques could vary inaccurate in unusual weathers like heavy rain and snow [13]. In addition, people also do not show big confidence in the security of driverless car, in 2018, a woman in Phoenix, Arizona was killed by part of Uber's driverless car test fleet. At the time of tragedy, there was an emergency backup driver is sitting behind the wheel and still, the accident happens. This indicates the even someone can control during the auto drive, however, they may let their guard down because of long hours of auto driving. Another major challenge can also be noticed is business ethics and legal issue. There is no doubt Uber would be responsible for this accident, but assuming that driverless car is in the daily driving instead of the testing phase and there is an accident. It is already hard to judge who should be responsible in a normal car accident, not to mention driverless car which is not precisely defined for drivers. The question of who is legally responsible becomes more complicated when driverless vehicles is equipped with manual driving devices such as wheels brakes and throttle just like the driverless car that hit and killed a woman in the 2018 Uber test drone. There is another challenge that ordinary cars encounter that would be even worse in a driverless car and that is being hacked. With the development of technology, the system on each car is like a little computer, which can record driving records, listen to radio and video, but the advanced system comes with a risk of hacking [15]. According to New York Times, security researchers use a laptop that caused a Jeep Cherokee to lose power, switch the radio stations, and control the windshield and Air condition from 10 miles away in 2015. Driverless cars will face more serious consequences if they are being hacked: leakage of personal information, travel times, driving habits, etc. Moreover, most driverless cars are electric, once they are hacked and disconnected, they will face the risk of death in a car accident. The last key challenge facing driverless cars is the standard of market permission to be on the roads. It is well known that the launch of a brand new motor vehicle in the U.S. will take a significant amount of time to meet a series of environmental standards, followed by stability and safety testing before it can be passed. And the driverless car industry will be even more complicated to pass this situation. A driverless car company needs to prove that its product can drive itself, and it needs to deal with extreme situations such as pedestrians or cars running red lights. But the driverless industry is still far from mature, and the U.S. Department of Transportation has no specific standards for driverless cars. Therefore, for the government to develop an objective, the practical standard is a very critical issue, as far as the question is concerned, the standard for driverless cars on the road is still in its infancy. These Four challenges, if not effectively addressed, will have a significant impact on the public's confidence in driverless car, leading to a loss of sales and the reduction of government investments for the driverless industry [16].

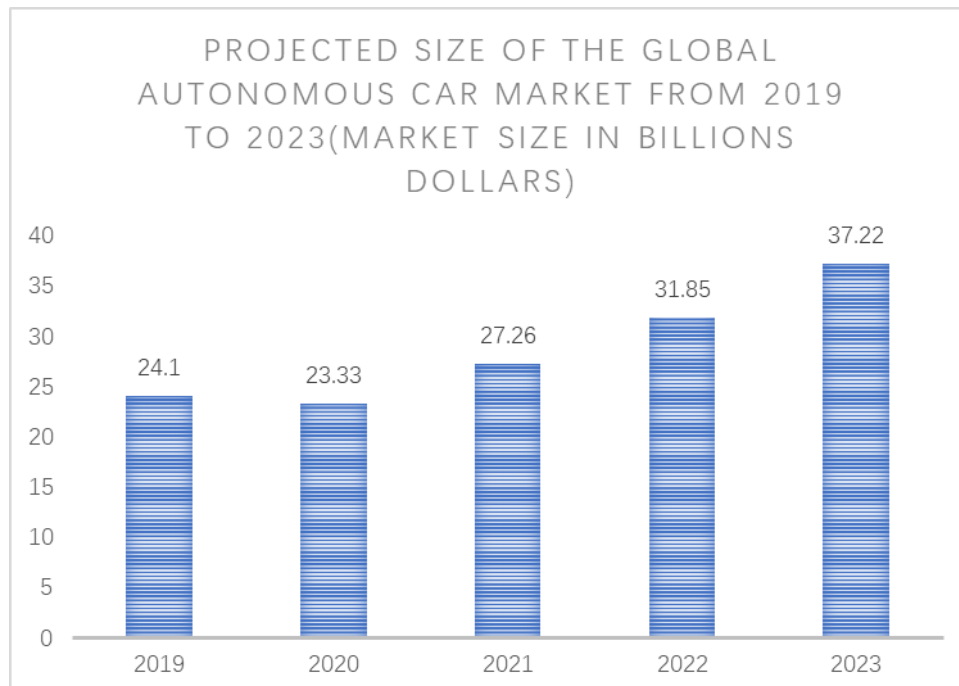


Fig 2. Projected Size of the Global Autonomous Car Market

Although the development of driverless industry is still in its infancy, the future is very promising. In 2016, The U.S. government pledges \$4 billion to fund research and testing of the driverless industry. The U.S. transportation agency was also proposing funds to local government to develop infrastructure to increase the effectiveness of communication between vehicles, thereby increasing the safety of driverless vehicles. According to data, from 2010 to 2016, China's electric car sales rose by 300,000 units, and the United States rose by 400,000 units, although the overall figure is not much, the upward trend is very impressive. Although China and the United States do not represent the world, the two largest markets in the world have expectations for electric vehicles, which can show that driverless industry will be more flourishing in the future [17]. Another phenomenon that can show that the driverless industry will have a good future is that people's idea of a car is slowly changing from owning to using. As urbanization becomes more prevalent, public transportation is becoming more mainstream. In the United States, more than one in five adults do not have a driver's license. In addition, the driverless industry will also be of great help to the disabled community in the future, and promote the development of the agricultural industry, etc.

## 6. Conclusion

Driverless industry is grabbing people's attention. At present, companies in the driverless industry are competing and cooperating with each other, and most of them spend a lot of investment in the driverless industry. But profits are still small. Among them, Waymo has become the leader of the driverless industry with the world's largest unmanned cab industry experience. The driverless industry is also changing the existing business model. When driverless cars become mainstream in the future, the value chain of automakers will change mainly due to the driverless car opportunity and the convenience it brings to people. To have competitive advantages and capture a larger market share, car companies need to focus more on the development and protection of technology. Since the driverless industry is still in its infancy, it faces four major challenges: safety, legal and business ethics issues, and the risk of cyber intrusion, and uncertainty about the standards that the market will allow on the road. While the driverless industry has unresolved challenges, it is still very promising, as evidenced by investments by the U.S. government and local agencies, the rise in sales of electric vehicles in recent years, and the changing perception of the automobile. Although this article is based on a survey of the current driverless industry and literature references, there are still some

shortcomings: because the driverless industry is just starting out, the scale of data is not large enough, and there are still some shortcomings in long-term tracking statistics on sales data and people's perceptions. Moreover, there are not many countries that can afford to invest in driverless industry on a large scale, so the data of the only reference objects are not quite comparable. Future research on the driverless industry can start with long-term sales data on driverless cars and people's long-term perceptions of driverless industry.

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