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Comparative Analysis of the Autonomous Vehicle Industry in the USA and China

Index

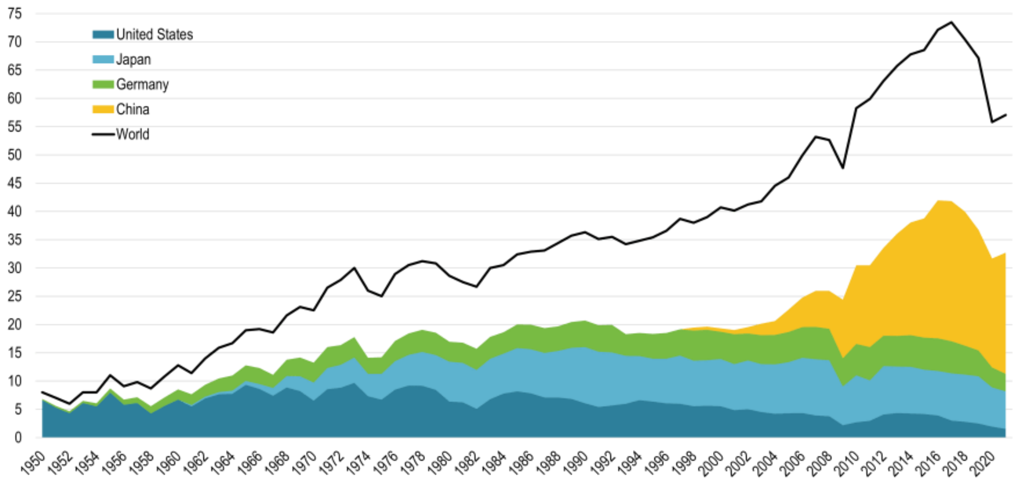
1. The Automotive Market in the USA and China

1.1 Market Size and Growth

The automotive market in the USA and China has an immense significance on the worldwide stage. The USA, with its legacy of pioneering automotive giants and advanced technological capabilities, has long been a leader in vehicle production and innovation. Meanwhile, China has rapidly emerged as the world's largest automotive market, driven by strong domestic demand and significant investments in electric vehicle technologies (also called EV).

The following is a figure from the *International Organization of Motor Vehicle Manufacturers*. (**figure 1.A**) representing Automobile Production across countries including China and the U.S. from 1950 to 2022. It highlights the important shifts in the automotive market over time, particularly between the United States and China. In 1950, the U.S. dominated global car production, holding over 80% of the market. However, by 2021, this share had drastically decreased to only 2.7%, indicating a loss of competitiveness in the U.S. car manufacturing system. Although the U.S. remains the world's largest car market, it is now saturated, with a focus on replacement sales and intense competition between manufacturers (this is also demonstrated further in the part 1.2.B of this essay thanks to the Herfindahl–Hirschman Index). Conversely, China experienced a very rapid growth in car production, reaching 37.5% of global production in 2021.

Figure 1.A: Automobile Production, Selected Countries, 1950-2022



Source: International Organization of Motor Vehicle Manufacturers

A. Vehicle registrations

Vehicle registrations are steadily increasing in both China and the USA. However, China maintains a larger automotive market, with total vehicle registrations reaching 311 million, compared to 283 million in the USA **[1]**. Nevertheless, vehicle registrations include all vehicles currently registered and in use, taking into account both new and older vehicles. This metric gives insights on the general car consumer behavior but not precisely regarding new cars being purchased.

B. Vehicle sales

Hence, studying new vehicles sold in each country separately is also a relevant key to understand the automotive market in a country. According to a report of ACEA *"Economic and Market Report: Global and EU auto industry, Full year 2023"* **[2]**, China registered 22,320,061 new cars in 2023 and 21,354,717 in 2022 whereas the USA registered only 12,327,829 new cars in 2023 and 10,773,065 in 2022.

C. Vehicle production

Car production in each country is also interesting to be compared since a new car registered in USA can have been produced in China for instance. The same report by ACEA *(using S&P GLOBAL MOBILITY sources)* **[2]** demonstrates that in 2022, China was the most important car producer with 23,237,924 units produced when only 7,033,378 units have been produced in the same year in USA. This point reflects China's domination in the automotive industry introduced in the introduction (**figure 1**).

D. Employment contribution and GDP contribution

Overall, the automobile industry has historically contributed to 3 to 3.5 per cent of the overall Gross Domestic Product in the United States and directly employed over 1.7 million people **[3]** whereas this industry contributes to 10 per cent of the China's GDP according to the report *"China Automotive Industry Trends to Watch 2023"* from EqualOcean Intelligence **[4]** which demonstrates clearly the considerably higher importance of this sector in China. This trend can be explained by the recent sudden growth of the Electronic Vehicles industry in China that also led to a massive automotive-related employment growth (it indeed reaching over 4 million people in 2023) **[5]**.

1.2 Industry Players and Market Dynamics

A. Key automotive manufacturers

China and the US have historical differences in their relation with the automotive industry. The USA is the birthplace of the modern automotive industry led by Henry Ford's introduction of mass production with the Model T in 1908 and recently challenged by Tesla, whereas China's automotive industry witnessed a later but faster growth thanks to companies such as BYD and Geely focusing on Electric Vehicles.

B. Market concentration and competition

Comparing Market concentration and competitiveness in both countries is a key to understand market dynamics differences. The following quantitative comparison (**figure 1.B)** of the automotive market in the two regions is relying on the data provided by the website *"goodcarbadcar.net"* **[7]** in the figures called *"2022 Best Selling Automakers in China"* and *"2022 Best Selling Automakers in the U.S"*.

Herfindahl – Hirschman index:

$$HH = \sum_{i=1}^{N} S_i^2$$

Concentration ratios:

$$C_n = \sum_{i=1}^{n} S_i$$

	USA	**China**
C4	0,444	0,468
C5	0,528	0,543
C6	0,585	0,616
HH	**0,065**	**0,086**

Figure 1.B: Concentration ratio and Herfindahl – Hirschman index in USA and China

The table shows that China's automotive market is more concentrated than the USAs, as reflected by higher concentration ratios (C4, C5, C6) and a higher Herfindahl–Hirschman Index (0.086 vs. 0.065). This indicates that a few firms dominate the Chinese market, while the USA has a more competitive environment with market share spread more evenly across firms. These differences highlight the dominance of key players in China compared to the USA's more diversified and mature market. Hence, new actors in China could face more important entry barriers.

C. The presence of new actors

The automotive industry, whether in China or the USA, is seeing the emergence of new players challenging existing manufacturers. In 2009, Alphabet (Google's parent company) founded the company *Waymo* in California. This company specializes in autonomous driving, aiming to establish itself as a key player in this rapidly growing sector. Similarly, the Chinese tech giant Baidu launched Apollo in 2017 to compete with Google's autonomous vehicle initiative.

Nevertheless, some key structural differences between the two companies deserve to be stressed. While most of Waymo's funds are coming from private investments (Alphabet, Chrysler, Qualcomm), Apollo beneficiates from considerable Chinese government investments. Additionally, Apollo takes advantage of numerous partnerships with Chinese automakers such as Geely, BYD, and Chery, whereas Waymo is not specifically collaborating with American automotive companies since they are mainly collaborating with Hyundai, a South Korean firm and Jaguar Land Rover (). The way that these two companies are funded and organized exemplify well the typical differences in Chinese and American industrial model that will be explored further in the following sections.

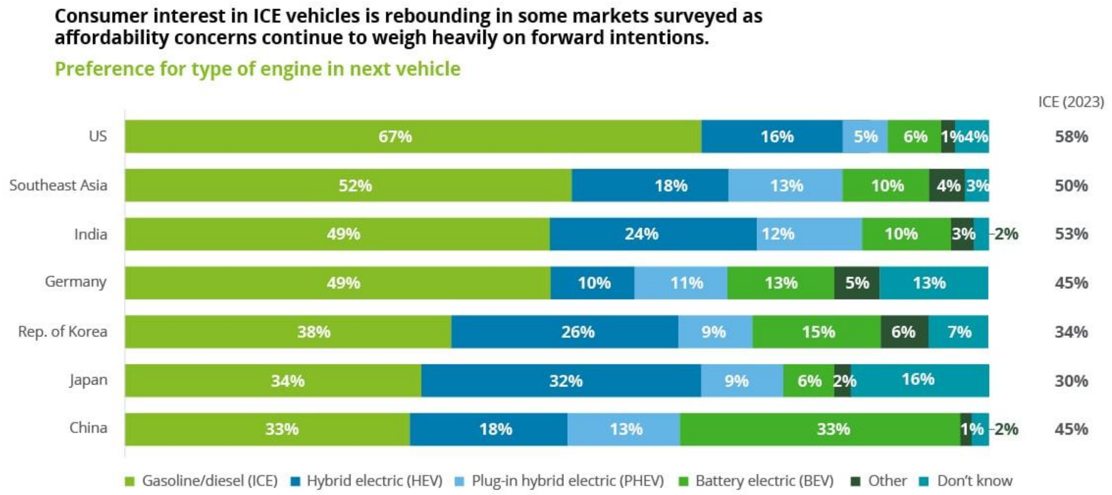
1.3 Consumer Preferences and demand differences.

A. Differences in car ownership culture

General trends regarding automobile consumer behavior are still closely linked with culture and historical differences between China and USA. In the United States, this is characterized by a preference for large vehicles like SUVs and trucks, often used for personal freedom and long commutes. In China, cars are seen more as a status symbol, with a growing demand for EVs and compact vehicles suited for urban environments. It reflects dense Chinese cities and government incentives on EVs ownership.

B. Adoption of new technologies vehicles in Chinese and U.S. markets

A survey held in the end of 2023 by Deloitte **[6]** demonstrates the greater importance of prices for American consumers than for Chinese ones to choose what car to buy (see **figure 1.C**). Indeed, Chinese consumers choices are mostly driven by the performance of the vehicle. Regarding the type of engine, only 27 per cent of Americans have a preference for a non-ICE (non - Intern combustion Engine), whereas 54 per cent of consumers in China have a preference for a vehicle that doesn't have an Intern combustion Engine. Furthermore, Chinese consumers are considerably more willing to pay for more connectivity in a vehicle (60% "yes") than Americans (25% yes). These differences in new technologies acceptance stand as a key to understand consumer preferences and thus the likeliness for the autonomous vehicles market to develop in each country.



<u>Figure 1.C</u>: Preferences for type of engine in next purchased vehicles across countries

Source : Deloitte Survey 2023 [link]

2. Innovation management for Automotive vehicles in the U.S and in China

2.1 Technological Foundations of Autonomous Vehicles

a. Presentation of the technology of autonomous driving

Autonomous vehicles or self-driving vehicles are often classified based on 6 different levels (0 to 5) indicating how much a human has to be involved to drive the car. This definition has been defined by SEA international in 2014 **[1]**. In this part, the term Autonomous Vehicles (AVs) will refer to Level 4 or Level 5 vehicles. Level 4 vehicles can be driverless in defined use cases while Level 5 vehicles are constantly driverless which make it possible to not have either pedals nor steering wheel. Self-driving technology is a competency enhancing innovation since its diffusion in the market would not make Level 0-1 vehicles obsolete. Additionally, this innovation is a component innovation which makes the incremental development of autonomous vehicles possible.

b. Sub-technologies enabling autonomous driving

Autonomous driving (AD) is an innovation driven by a Science-push enabled by key sub-technologies recent improvements. Compute power and driving data retrieval technics have significantly improved recently which enabled the use of more precise Machine Learning models to provide efficient understanding of their environment to autonomous vehicles. Furthermore, sensors technologies improvements allow the system to take into account a larger environment detecting further items in a more precise way through the improvement of cameras, LIDARs (Light Detection and Ranging) and Radars. The development of faster communication protocols such as 5G technologies enables better *Vehicle to Infrastructure* or *Vehicle to everything* communication (so called "V2X" communication) is also crucial to enable Level 4+ self-driving vehicles. Overall, Self-driving is a component innovation technology relying on the basic unchanged car architecture. This type of innovation encourages an incremental innovation processus that is less threatening for the investors unlike architectural innovation that represent more risks. Overall, new consensuses are still being explored through basic research conducted on key technologies for autonomous vehicles, such as new methods for object detection studied in this scientific paper giving solutions to enhance Object referring thanks to LLMs and neuromorphic methods: *"Object Referring in Videos with Language and Human Gaze"* **[11].** The following **figure 2.G** from a McKinsey report on AVs **[7]** confirms the specific need of basic researches in Computer vision software that is the main bottleneck of self-driving technologies.

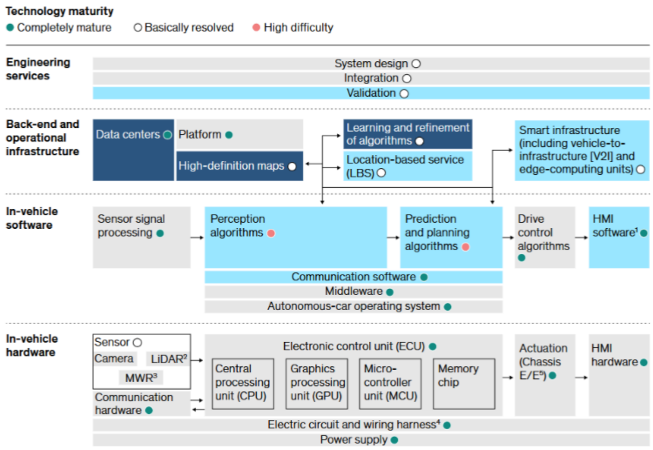


Figure 2.G: technologies required to build autonomous vehicles and they level of maturity
Source : 2025 Global Automotive Consumer Study

c. Diffusion stage

Even though ground-breaking progresses have been made in this field, Level 4 and 5 AV technology's development stage is still considered as emerging. Indeed, even though numerous pilot projects are taking place in specific limited areas to test AV, the diffusion of the technology is still at a beginning stage, barely adopted by early adopters but struggles to cross the Chasm to reach by the early majority on the Roger's innovation diffusion pattern. **[2]** This is due to the lack of optimal software solution, of sufficient proof of usefulness provided by the early adopters to the potential early majority and to the lack of clear governmental regulations as explained in the third part of the project.

d. Value appropriation of the firms

In the USA and in China, the main players have different elements of value appropriation from technologies. Indeed, some will emphasize on very Tacit and Complex knowledges which enhances their competitiveness thanks to less easily imitable and transferable technology knowledge. This is for example the case of Nvidia that focuses on Hardware and AI computing. Conversely, others such as the Chinese firm Baidu invest on more numerous and broader technological innovations (mainly in *Vehicle to everything* "V2X" communication) in the field of Autonomous Driving, but with a lower competitive impact. These trends are measured thanks to patent production in each company showing their competitive positioning in a report from LexisNexis *"Driving Toward Tomorrow: A Deep Dive into Autonomous Vehicle Innovation"* **[3]** providing the **figure 2.A** bellow.

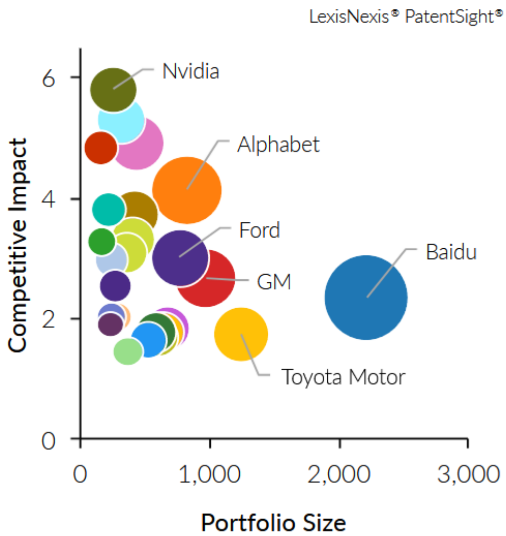


Figure 2.A: Competitive positioning of the top 25 players in the field of Autonomous Driving in terms of patent portfolio Competitive Impact and Portfolio Size

Additionally, the figure shows the intermediate position adopted by Alphabet (Google's children company), with a competitive impact between Nvidia and Baidu as well as a number of patents produced in the Autonomous Driving between Baidu's and Nvidia's figures.

2.2 An ecosystem for innovation in Autonomous Vehicles

Developing and commercializing autonomous driving technologies requires a lot of complementary resources. Enormous data resources are needed to train the newest deep neural networks to understand the surrounding of the vehicle and make it behave as expected. These data resources have to be annotated and adapted to the type of captor giving information to the software (Visible light camera, LIDAR, Radar, event cameras, thermal cameras).

A. Data

According to the paper *"A Survey on Autonomous Driving Datasets: Data Statistic, Annotation, and Outlook" (April 2024)* **[4]**, today, 20.9% of the annotated datasets in the world are owned by USA companies when Chinese own around 8 % of them **(figure 2.B)**. Since newest deep learning algorithms used in autonomous cars are more and more depending on data quantity, this is a clear advantage for the development of the AV in the US.

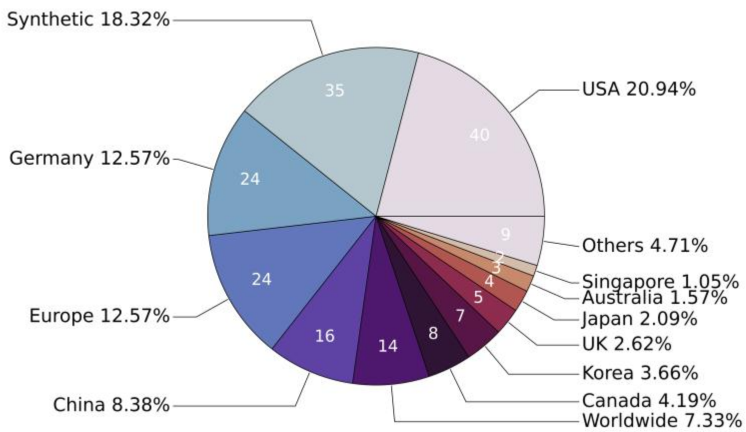


Figure 2.B: The distribution of datasets around the world. This figure illustrates the distribution of data collection locations of the datasets.
source: A Survey on Autonomous Driving Datasets: Data Statistic, Annotation, and Outlook" (April 2024)

B. Infrastructure on the road

Infrastructure on the road are also primordial to reach Level 4+ self-driving vehicles. Indeed, such a vehicle needs an area where 5G is available in order to use V2X communication with other vehicles, signalization, and internet (illustrated by **figure 2.C**). This report from *"5GAA Automotive Association"* **[5]** emphasis on key challenges to enable real-time data exchange for safety and efficiency. They include low penetration rates in the market (as mentioned in the previous paragraph) reducing effectiveness, the need for standardized protocols to ensure cooperation between all kind of self-driving vehicle, limited interfaces for pedestrian safety, and the necessity of interference-free frequencies to maintain reliability. Even though in 2020 the KPMG report "2020 Autonomous Vehicles Readiness index" **[6]** placed China as the 16th most ready country for AV infrastructures while they ranked the USA on the 9th place, China's centralized effort made them able to recently progress faster than the USA on infrastructures thanks to their strong government creating less uncertainty than the American democracy regarding autonomous vehicles policies.

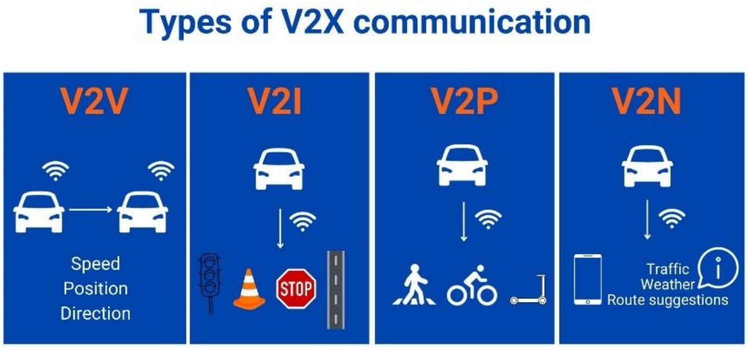


Figure 2.C: V2X technology use cases
Source: Asiapolicy.org : "De-risking Global Supply Chains: Looking Beyond Material Flows"

C. Talents

The technology and innovation environment for AV is strongly dependent on the Talents and working force disponible in each country. Partnerships, joint ventures and other local or international cooperations are solutions to build a better technology and innovation environment. However, independent R&D initiatives and competing for talent attraction is still a main priority to create an innovative ecosystem. *"From sci-fi to reality: Autonomous driving in China"* report from McKinsey **[7]** underlines the increasing demand of talents by China from 2021 to 2025 in key technology domains for Avs as shown in the **figure 2.E.**

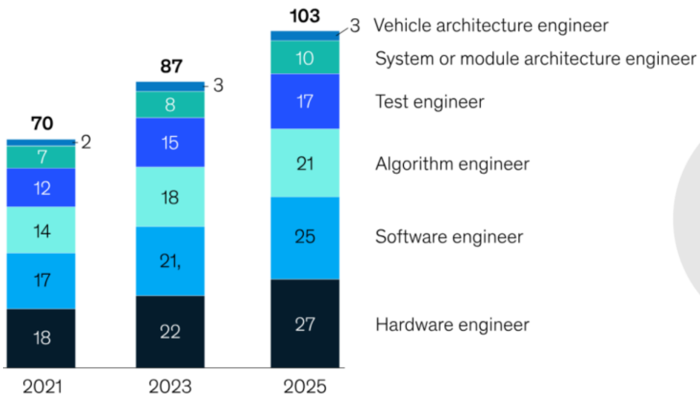


Figure 2.E: China's talent demand forecast for intelligent and connected vehicles

Source: McKinsey article 2023

D. Regulations and policies

Although this concept cannot be defined as complementary resources since they are not in the hands of the firms, as demonstrated by the previous example, regulation and policies are major factors to allow an efficient development and adoption of the AV technology. A well-coordinated policy on Autonomous Vehicles industry is necessary to provide good conditions to lunch test programs, avoid uncertainty regarding regulations modifications in the future regarding autonomous vehicles, and give incentives for their adoption to the customers. In line with the importance of this subject, the question of policies and regulations is thoroughly addressed in the third part of this article. The report from KPMG *"2020 Autonomous Vehicles Readiness Index"* **[6]** places the USA on the 6th position regarding policy and legislations, whereas China is ranked 21st regarding this precise type complementary resource. This is mainly due to their score of 0.00 on the "Data sharing environment" metric that the KPMG study used, when the US have a score of 0. 771 (**figure 2.I**). The lack of an efficient Data sharing environment leads to issues regarding the need for highly precise digital maps to enable AV technologies of Level 4+. Even though the position of the United States is pretty high on the ranking, the authors of the report still consider that *"While state and city work can be more agile and tailored to local circumstances, it can lead to less standardization."* And *"Other countries are working to update road infrastructure and use AVs in public transport, but the US performs relatively poorly on infrastructure and is more focused on private vehicles and taxis."*. Conversely, the authors underline the fast progress of China on this regard with a better environment for standardization: *"Chinese government made it easier to test AVs on public roads, allowing this to take place in more cities and with fewer control"*.

Policy and legislation pillar scores breakdown by variable

	Position	AV Regulations	Government-funded AV Pilots	AV-focused agency	Future orientation of government	Efficiency of legal system in challenging regulations	Government readiness for change	Data-sharing environment	Pillar 1 score (unadjusted)
6	United States	0.857	0.929	0.714	0.763	0.792	0.634	0.771	**5.461**
21	China	0.786	0.929	0.643	0.490	0.535	0.561	0.000	**3.944**

Figure 2.I: Policy and legislation pillar scores breakdown by variable from the KPMG 2020 index report on autonomous vehicles readiness.
Source: KPMG index of readiness on automotive vehicles 2022

E. Conclusions regarding the technological ecosystem readiness in China and USA according to KPMG index of 2022

The same report from KPMG **[6]** ranks the United States as the 2nd most ready country regarding technologies and innovations for autonomous vehicles when China is only reaching the 20th place. Regarding this index, in 2020 The United States significantly outperforms China in several key areas. The most significant differences are on their *availability for the latest technology* (USA scored 0.931 and China scored 0.023 which makes a difference of 0,908); and on their *Assessment of cloud computing, AI and IoT* (China scored 0. 446 and the USA scored 1.0 which makes a difference of 0.554). However, the two countries have the same *industry partnership score*. Finally, China overpasses the USA only on their market share of electric cars with a score of 0.103 for China and 0.033 for the US. The scores are summed up in the **figure 1.D** bellow.

	Position	Industry partnerships	AV technology firm headquarters	AV-related patents	Industry investments in AV	Availability of the latest technologies	Innovation capability	Cybersecurity	Assessment of cloud computing, AI and IoT	Market share of electric cars	Pillar 2 score (unadjusted)
2	**United States**	1.000	0.122	0.298	0.370	0.931	0.939	0.989	1.000	0.033	**5.681**
20	**China**	1.000	0.002	0.045	0.014	0.023	0.503	0.777	0.446	0.103	**2.913**

Figure 1.D: Technology and innovation pillar scores breakdown by variable from the KPMG 2020 index report on autonomous vehicles readiness.
Source : KPMG index of readiness on automotive vehicles 2022

2.3 Technology adoption and acceptance

Autonomous driving is representing a new discontinuity in the S-curve of vehicles. So far, the technologies performances and improvements are lower on these new technologies than on classic cars but its forecasts overcome it. Indeed, this period is witnessing turbulence and uncertainty about technology and business models. Autonomous driving didn't fulfil the initial market of classic driving cars yet and is still struggling to reach the early majority on the Roger's innovation diffusion pattern **[2]** as explained before which leads us to study the adoption and acceptance possibilities of this technology.

A. Adoption influence factors

Main adoption influence factors for autonomous vehicles can be analyzed thanks to Unified Theory of Acceptance and Use of Technology methodology (UATUA) developed by Venkatesh in 2003. The scientific paper published in Nature *"Using the Extended Unified Theory of Acceptance and Use of Technology to explore how to increase users' intention to take a robotaxi"* **[10]** utilizes the *UTAUT* framework that evaluates technology adoption based on factors such as *performance expectancy*, *effort expectancy*, *social influence*, and *facilitating conditions*, providing insights into public support for autonomy. In the end, this study highlights that the willingness to adopt AVs is mainly driven by perceived personal benefits, societal impacts, and alignment with cultural or political values. However, significant barriers remain, such as regulatory constraints, trust issues with autonomous systems, concerns about equitable access (for urban and rural people with low and higher incomes).

B. Consumers' readiness for Autonomous driving market penetration

Overall, China's market keeps a better market penetration potential. As The *December 2021 McKinsey Center for Future Mobility survey* **[8]** shows, Chinese consumers are more likely than American consumers to embrace autonomous driving, more enthusiastic about autonomous functionalities, and more willing to pay all of which has culminated in a high interest in purchasing L4 pilot vehicles (**figure 2.F**). Knowing that electronic vehicles (EV) have more potential to accommodate autonomous functionalities, these differences can be explained by the high penetration of this new energy vehicles technology in the Chinese market lately with a penetration rate exceeding 20% in 2021 according to this the 2021 survey quoted above **[8]**.

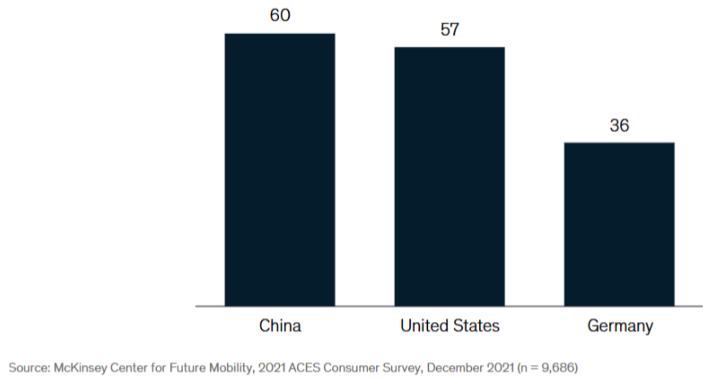


Figure 2.F: Likelihood of buying an L4 advanced highway pilot for $9,999 or less, % of respondents
Source: McKinsey report(2022) From sci-fi to reality: Autonomous driving in China

This observation is counterbalanced by the 2024 report from McKinsey *"McKinsey China Auto Consumer Insights 2024"* **[8]** showing a willingness to pay that has declined since 2021, even though interest in this technology remains similar. This trend is explained by both the aggressive pricing strategies of OEMs (Original Equipment Manufacturer) on Level 3 autonomous vehicles featuring autonomous driving equipment and robot-taxis development in demonstration zones in main Chinese cities such as Beijing and Shanghai. Nevertheless, even though in 2023 the willingness to pay for additional Autonomous-driving equipment has decreased in China (**figure 2.G**), It stays higher than the willingness of Americans to pay for his type of technologies as *2023 Alix Partners ADAS consumer Survey demonstrates through the diagram **figure 2.H*** **[9]**

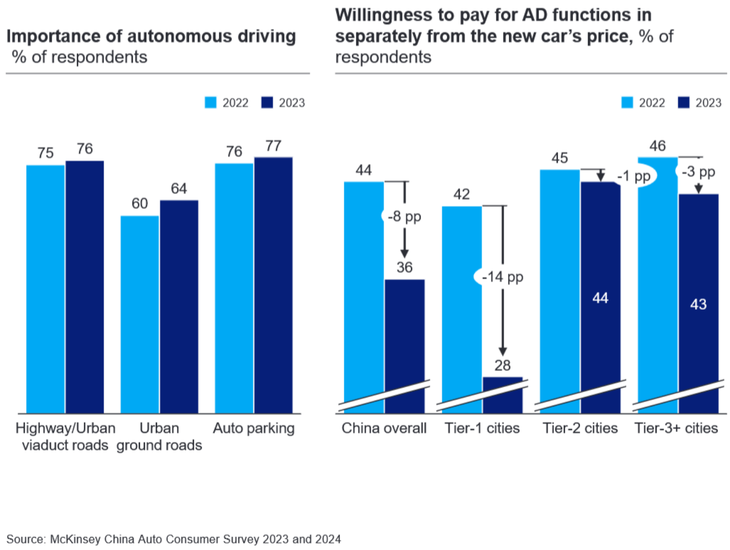
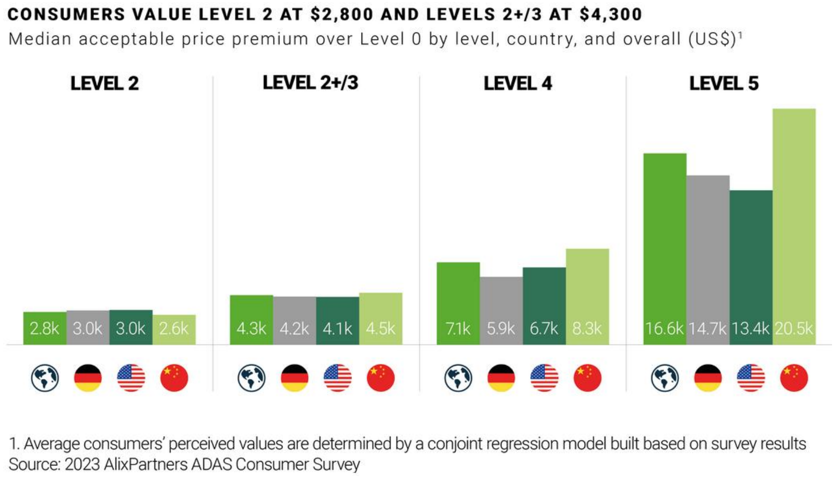


Figure 2.G: Importance of autonomous driving and Willingness to pay for AD functions in separately from the new car's price (2022 – 2023)

Source: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/from-sci-fi-to-reality-autonomous-driving-in-china



<u>Figure 2.H</u>: Average consumers' perceived values of different levels of Autonomous Vehicles.
Source: https://www.alixpartners.com/insights/102ipu3/car-buyers-say-they-trust-adas-systems-regardless-of-negative-experiences/

3. Policies for Automotive vehicles industry in the U.S. and in China

3.1 Geopolitical Dynamics and Tensions Between China and the U.S.

Analyzing how the industrial policies conducted in the U.S and China can have an impact on the Autonomous Vehicles technologies development and to its penetration in the market requires to have an overview of the overall geopolitical situation between the two countries. To do so, let us first clarify the dependence of China on the U.S and the recent trends on their decoupling in technological fields. Then, a discussion about the industrial policies conducted by both countries and their impacts on the previously presented metrics is proposed. And to finish, more specific examples of industrial policies and their results will be analyzed.

A. Dependance and Decoupling

The industrial competition between the USA and China can be analyzed through the concepts of *decoupling* and *dependence*. *Decoupling* is "the process of diverging into two technology ecosystems with an increasing degree of separation" **[4],** in the following study, *Dependance* is determined by measuring how often Chinese patents cite U.S patents.

We will rely on the paper *"Mapping U.S - China decoupling and dependence"* **[4]** published in 2022 to analyze these two concepts. Indeed, on one hand their researches conclude that the decoupling between China and the USA has been declining steadily since 2000 conforming to the effects of the globalization. On the other hand, the paper shows an evolution of China's dependance drastically changing after the Great Recession of 2008 when China started to develop their own R&D and innovative capacity following a *Delinking strategy* which made the country more and more independent on U.S technologies as illustrated in **figure 3.A** bellow.

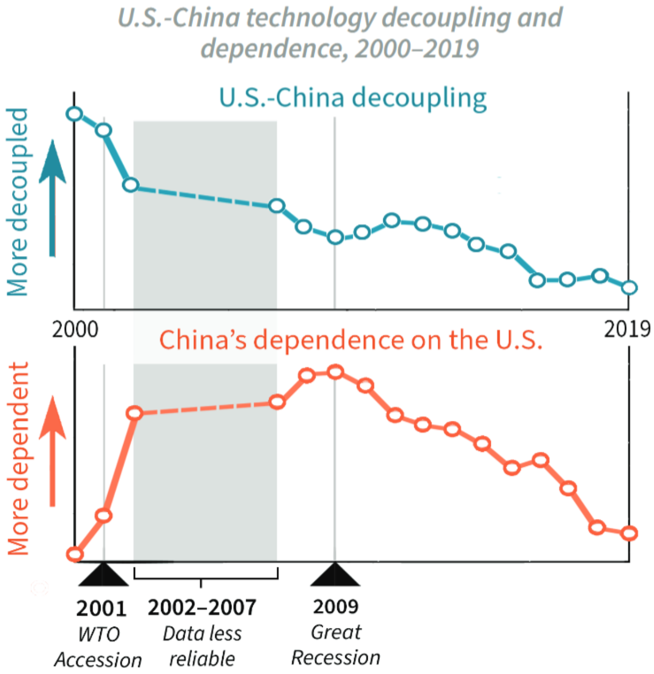


Figure 3.A: U.S – China technology decoupling and dependence from 2000 to 2019

Source: *Stanford paper article "Mapping U.S - China decoupling and dependence"* [[link]]

The paper also highlights that this delinking strategy is particularly effective in emerging high technologies, which show greater decoupling and reduced dependence of China on the U.S. Autonomous vehicles represent one of the key areas China leverages to advance this delinking trend. However, constant tensions between China's desire and ability to progress independently are suggested by the fact that a greater decoupling in a field eventually leads to more dependance of China on the U.S in this same field.

B. Industrial policies and their consequences

The U.S. have a very large array of tools to affect foreign industry and try to turn it to its advantages thanks to their powerful diplomacy and their leading position in numerous industries. However, China is now threatening their industrial competitiveness in the western world. Indeed, the COVID-19 pandemic and the U.S.-China trade war highlighted the risks of overdependence on Chinese manufacturing for critical goods. This first led to calls for *reshoring ("the process of returning the production and manufacturing of goods back to the company's original country": Industry Organization and Industrial Policy* **[5] (book)**) or diversifying supply chains and General *"decoupling"* policies proposed by the Trump administration. Nevertheless, fully decoupling from China has proven impractical due to its pivotal role in global supply chains. Consequently, the U.S. narrative has shifted to "*de-risking*," acknowledging that severing material flows from China is unfeasible while focusing on managing associated risks **[6]**.

As political tensions are growing between China and the U.S., Washington's concerns about sensitive data that could be accessible by the Chinese government became a major incentive to protectionist restrictions. The Autonomous Vehicles industry is particularly touched by this type of policy as exemplified by the possible trade barriers on Chinese

Software in Self-Driving Vehicles and the worries regarding cybersecurity issues according to this article by Graham Hope **[7]** *"The Commerce Department is understood to be concerned at the potential security risks posed by connected tech in vehicles."*

Yet, overprotective measures led to unintended consequences on both sides. In China, Beijing's hyperfocus on technological self-reliance has meant overinvestment in high-priority sectors, generating oversupply, which has hurt the bottom line of many Chinese companies and generated tensions with trading partners. The article *"How America's War on Chinese Tech Backfired"* from Foreign Affairs **[8]** underlines that *"Many Chinese economists are alarmed by the nationalistic direction of their country's economic policy and skeptical that self-reliance will work. They believe that a return to a more market-friendly approach is necessary."*. On the American side, the restrictions on students pursuing technology degrees in the U.S. deprived the country from many talented students and possible innovative start-ups. Overall, too much security and nationalist policies are going against the flow of globalization and can be called *"Deglobalization"* measures. Thes lead to less innovation, less economic growth and fewer jobs. Therefore, a more adapted model of industrial policies that should be adopted by both countries should be a *"Slowbalization",* which involves to combine domestic wise policies and international alliances as Scott Kennedy suggests in the foreign affairs article **[8]**.

3.2 Governmental regulation landscape on AVs in China and USA

A. The governance and policy framework differences and the Current regulations on AVs in China and the U.S.

According to Norton Rose Fulbright's article *"Autonomous vehicles: The legal landscape in the US"* **[1]** in the U.S., state-level regulations for autonomous vehicles (AVs) are limited, with only seven states and Washington, D.C., passing legislation related to AV testing, while 43 states have yet to regulate the technology. *Steven D. Jansma*, the author of the article explains that this is consequently leading to inconsistencies across states. Indeed, each state has its own certification and approval processes, with testing hubs in states like Arizona and Nevada, while California enforces stricter regulations. Furthermore, states differ in their specific testing requirements, including emergency control protocols and geographical restrictions (Illustrated in the table available on IIHS.org: **[15]** gathering different driving lows on Avs in different states in the U.S). For example, some states require test drivers to be in the driver's seat at all times, while others set geographical categories for testing. However, the article insists one the fact that federal oversight by the National Highway Traffic Safety Administration (NHTSA) is showing signs of flexibility by offering temporary interpretations of existing regulations, such as redefining the term "driver" for Google's self-driving car.

In contrast, China's approach to AV regulations is more centralized. *"China Reveals Self-Driving Vehicles Safety Guidelines"* **[2]**, an article from *IOT world today* explains reveals that the

Chinese government has established clearer and more standardized regulatory frameworks for testing and operational deployment. Indeed, China's regulatory system is evolving through a pragmatic approach where central government sets the agenda, and local governments implement and optimize regulations based on pilot results, as it is detailed in the 2023 McKinsey article *"From sci-fi to reality: Autonomous driving in China"* **[3]**. This system allows for the rapid development of regulations, as demonstrated by Shenzhen's passage of the first law in China regarding autonomous driving, which provides regulatory coverage for testing and accident responsibility. Shenzhen also became the first city to allow self-driving cars on public roads in 2022, marking a significant step forward in the country's AV development.

B. Intellectual Property policies

Secure IP rights have a different effect depending on the technological innovation development of the country of concern. This study **[14]** called *"The link between intellectual property rights, innovation, and growth: A meta-analysis"* shows that in developing countries, low protection rights on IP have good effects on innovation since it makes it simpler to imitate external innovations. This explains a country's rational self-interest to devalue IP protections when it is lower in the technology value chain. However, as countries advance technologically and begin generating world-leading IP, securing this IP becomes more of a concern. Indeed, A robust IP system is essential for fostering innovation by converting ideas into property, enabling safe licensing, and encouraging collaboration. Secure IP rights provide entrepreneurs and investors with the confidence to take risks, leading to market growth and fair competition as evidenced by the last quoted paper **[14]**.

China's Intellectual Property evolved alongside their technological innovation progresses over time in such a way that it enables China to be the country where the most IP are filled (for patents, Utility models, Trademarks, Industrial design and plant varieties) according to the *World Intellectual Property Indicators report of 2023* **[10]**.

Conversely, a series of court decisions and pieces of legislation over the last two decades has weakened IP rights in the United States. For instance, the America Invents Act in 2011 created the Patent Trial and Appeal Board, which invalidates a high percentage of patents, creating uncertainty for innovators. Additionally, from 2010 to 2014, Alice/Mayo Framework legal test restricted patent eligibility for abstract ideas and natural phenomena, invalidating many patents again and discouraging investment in high-tech industries. Overall, this type of decisions resulted in more uncertainty reducing venture capital investments in patent-intensive industries which slowed global competitiveness on these sectors.

3.3 The governments incentives to strengthen AVs development

A. Government subsidies to customers

Subsidies provided by the government are a powerful tool to make it easier for companies and consumers to adopt a new technology. It can take the form of direct financial support, tax breaks or grants. In China, self-driving vehicles consumer adoption is supported through mainly subsidies on NEVs (New Energy Vehicles) purchases. Indeed, this type of vehicles are already equipped with *Advanced Driver Assistance Systems* (ADAS), hence, making them financially more available to consumers thanks to subsidies improves the market familiarity with self-driving technologies and eventually the overall technology acceptance of AVs in China. As the Chinese Vice Minister of Finance Xu Hongcai said: *"NEVs purchased in 2024 and 2025 will be exempted from purchase tax amounting to as much as 30,000 yuan per vehicle (= 4 098 USD)"* to a Journalist of Global Time **[11]**. In USA as well various subsidies are offered to encourage Electric Vehicles but not particularly vehicles with self-driving functionalities even though EVs are often equipped of ADAS as explained earlier. Moreover, the rebates offered for the purchase of an EV depends on the states. For example, in the state of New York $2,000 are offered under the Drive Clean Rebate program whereas California offers rebates of up to $7,500 through its Clean Vehicle Rebate Project.

In conclusion, either the U.S. nor China offer specific subsidies to AVs users but to EVs consumers which still indirectly enhances autonomous driving technology acceptance.

B. Government investments in R&D and AVs industry actors

In addition to special funds directed to R&D on self-driving and AI technologies, the Chinese government offers direct subsidies and tax rebates to companies in key industries including self-driving vehicles. According to an article of the National Defense University Press written by Gerald J. Krieger (PhD.) in February 2024 **[12]** *"China's advantage is that it can and will heavily fund these sectors, whereas the U.S. Government has outsourced much R&D to the private sector."*. However, The United States is still the largest performer of research and experimental development (R&D), with $806 billion in gross domestic expenditures on R&D in 2021, followed by China, with $668 billion. The evolution of Gross domestic expenditure on R&D is illustrated by the **figure 3.B** bellow provided by "Research and Development: U.S. Trends and International Comparisons report" of the U.S National Science Foundation **[13]**. (The use of current PPP U.S dollars ensures the comparison reflects actual economic capacity rather than currency fluctuations or local price differences.)

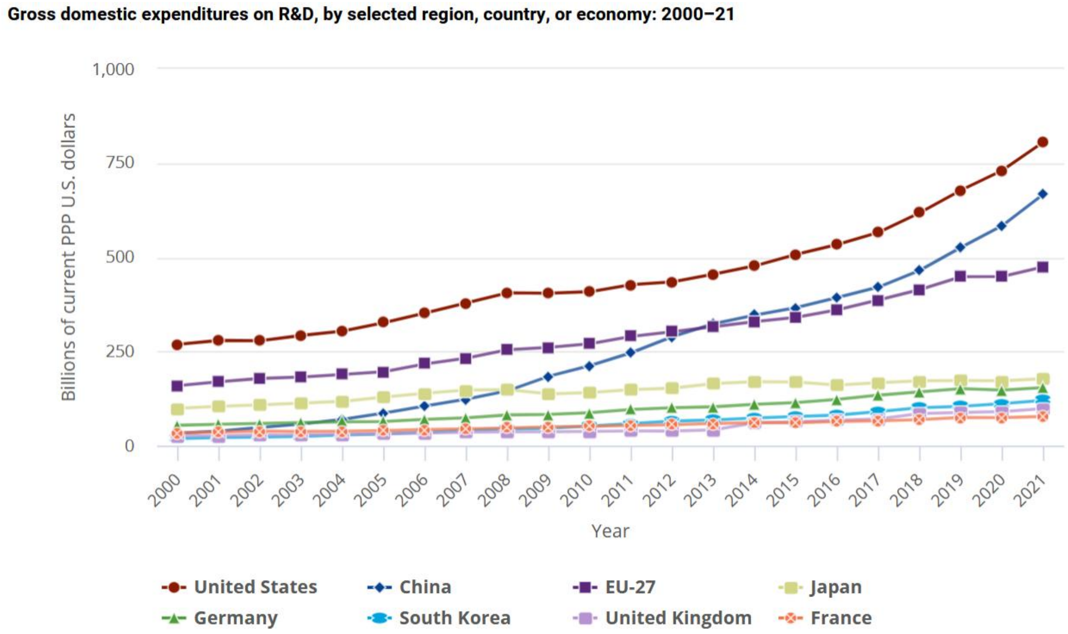


Figure 3.B: Gross domestic expenditures on R&D, by selected region, country, or economy: 2000–21 (PPP = purchasing power parity.)
Source: “Research and Development: U.S. Trends and International Comparisons”

This other table **(Figure 3.C)** from the same report also reveals a clear difference on the share of total R&D funds coming from the *“Rest of the world”* representing 6.7% of them in the U.S but only 0.2 in China. Furthermore, the table demonstrates the higher importance of Governmental R&D in China (with 15.3% of performing R&D in the Government sector) than in the U.S (where only 8.3 % performing R&D coming from the Government sector). This is a major advantage for China, which can then better coordinate its research and innovation on a national level.

(Billions of current U.S. PPP dollars and percent)

Region, country, or economy	GERD (PPP US$billions)	R&D-performing sector: Share of total (percent)				R&D source of funds: Share of total (percent)			
		Business	Government	Higher education	Private nonprofit[a]	Business	Government	Other domestic	Rest of the world
United States[b]	806.0	77.6	8.3	10.4	3.7	67.9	19.9	5.5	6.7
EU-27	474.1	65.6	11.6	22.0	0.8	57.0	30.8	2.4	9.9
China	667.6	76.9	15.3	7.8	NA	78.0	19.0	NA	0.2

Figure 3.C: GERD for selected region, country, or economy, by performing sector and source of funds: 2021
Source: “Research and Development: U.S. Trends and International Comparisons”

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