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Review

Rise of artificial intelligence in the Chinese automotive industry

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ABSTRACT: The integration of artificial intelligence (AI) in the Chinese automotive industry has led to unprecedented growth and innovation, particularly in electric vehicles and autonomous driving technologies. This study examines the impact of AI on China's automotive sector, analyzing key players, government policies, and technological advancements. Through a comprehensive review of the academic literature and industry reports, we explore how Chinese manufacturers are leveraging AI to enhance vehicle performance, safety, and user experience. The research reveals that China's supportive regulatory environment and significant investments in AI have positioned it as a global leader in automotive AI applications. However, challenges remain, including data privacy concerns and the need for international standardization. The study concludes that China's AI-driven automotive revolution is reshaping the global industry, necessitating accelerated AI adoption by Western manufacturers and increased international collaboration.

KEYWORDS: artificial intelligence (AI); automotive industry; autonomous driving; electric vehicles; innovation

1 Introduction

Artificial intelligence (AI) has emerged as a transformative catalyst in various industries, and the automotive sector is no exception. The integration of AI systems in the automotive industry has enabled significant advances in areas such as autonomous driving, optimization of manufacturing processes, and improvement of user experience. China has stood out as a leader in the adoption and development of AI technologies within its automotive industry. Since 2009, the country has maintained its position as the world's largest automobile producer, consolidating a highly advanced and robust supply chain. This leadership is reflected not only in the quantity of vehicles produced but also in the quality and technological innovation they incorporate, especially in the field of artificial intelligence.

The global shift toward software-defined vehicles (SDVs) is reorganizing the automotive industry around data, computers, and continuous over-the-air (OTA) improvement. In China, the government's commitment to promoting environmental protection, renewable energies, and consequently electric vehicles (EVs) has led to a high degree of market penetration of these cars, and dense usage has created large, diverse data streams that accelerate AI learning loops. In particular, the Chinese government's strong support for this sector, through policies that are notably less restrictive than those in Europe, which maintains very stringent regulations, has facilitated the rapid growth of EV deployment, validation, and safety evidence (EUR-Lex, 2018, 2024; IEA, 2025a). Building on established lenses, disruptive and architectural change (Christensen, 1997; Henderson and Clark, 1990), dynamic capabilities (Teece et al., 1997), and technology diffusion (Bass, 1969; Rogers, 2003), this article makes two contributions. First, it links historical growth in EVs, infrastructure, and manufacturing scale to the endogenous formation of AI capabilities (scale → data → model → function). Second, it implements a transparent comparative framework with auditable indicators and reproducible data to position China, Europe, and USA across regulatory enablement, market adoption, charging infrastructure, compute & sensors, ADAS breadth, and safety evidence.

The analysis integrates industry and policy sources with peer-reviewed research; indicators are operationalized in Section 3.1 and visualized in the comparative Table 1 and Fig. 1, while subsequent figures anchor market dynamics. The resulting picture is not a ranking but a structured lens to interpret why regions progress at different speeds and with distinct risk–benefit profiles in AI-enabled mobility (IEA, 2025a; Kusano et al., 2025).

1.1 Objectives of the article

This study pursues three objectives:

√ O1 (Analytical): Articulate a comparative lens that integrates disruption/architecture, dynamic capabilities, and diffusion to explain regional pathways toward AI-enabled EVs (Christensen, 1997; Teece et al., 1997; Rogers, 2003).

√ O2 (Empirical): Construct and apply a reproducible, indicator-based MCDA for China, Europe, and USA (definitions in Table 1; visualization in Fig. 1; data in [Dataset S1]).

√ O3 (Policy/Strategy): Derive implications for regulation and deployment, acknowledging the EU AI Act's high-risk regime and type-approval, U.S. rider-only safety evidence, and China's municipal pilots (EUR-Lex, 2018, 2024; Kusano et al., 2025).

1.2 Methodology and structure of the article

Guided by the workflow in Fig. 2, the study proceeds in six steps. First, we clarify the objective: to assess how AI is integrated into

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Nomenclature

$S_{r,c}$	Normalized score of regions r on criterion c
$x_{r,c}$	Observed value of region r for criterion c
min (x, c)	Minimum observed value of criterion c across all regions
max (x, c)	Maximum observed value of criterion c across all regions
w_c	Weight assigned to criterion c (default $w_c = 1/6$)
I_r	Composite index for region r, calculated as the weighted sum of normalized scores

Table 1 MCDA scores by region (normalized 0–1), 2024–2025

Criterion	China	Europe	USA
Regulatory enablement	0.8	0.6	0.5
Market adoption	0.9	0.5	0.35
Charging infrastructure	0.9	0.65	0.5
Compute & sensors	0.9	0.6	0.7
ADAS breadth	0.9	0.5	0.5
Safety evidence	0.4	0.3	0.8

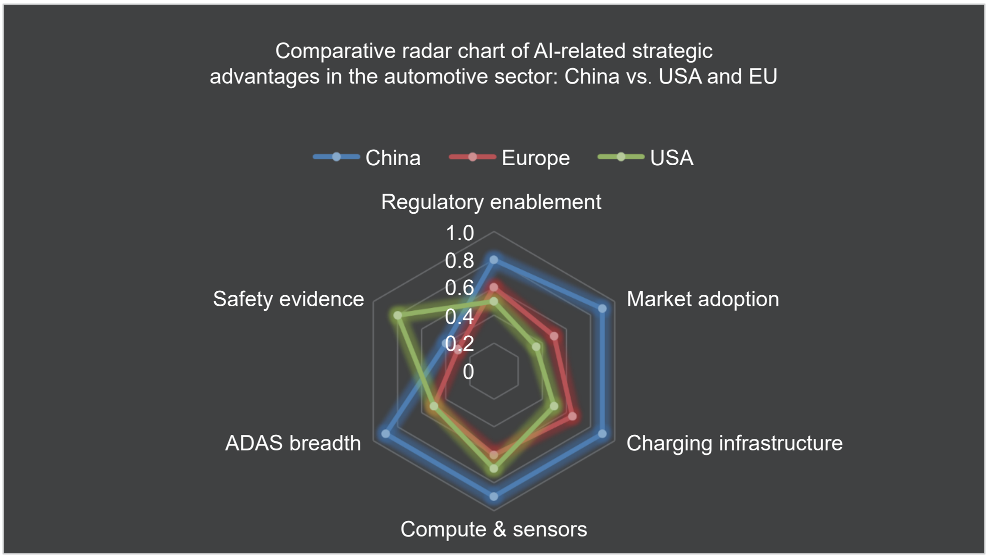

Fig. 1 Comparative radar chart of AI-related strategic advantages in the automotive sector: China vs. West (USA/EU).

China's automotive industry and to compare it with Western approaches. Second, we conduct a structured literature review across peer-reviewed journals, official regulatory documents, and manufacturer/industry technical materials. Third, we apply explicit source-selection criteria (scholarly rigor/impact, relevance to automotive AI, and recency). Fourth, we extract and code evidence into four themes: AI applications, case evidence, regulatory context, and innovation/organization models. Fifth, we run a comparative analysis that cross-references Chinese and Western manufacturers and regulatory regimes; this analysis is operationalized as a multicriteria decision analysis (MCDA) over six indicators: regulatory enablement, market adoption, charging infrastructure, compute & sensors, ADAS breadth, and safety evidence. Indicators are defined in Table 1, normalized to [0,1] by min–max; unless noted, criteria are equally weighted, with ±20% weight perturbation checks. Sixth, we synthesize the results and derive implications. All inputs, figure-ready tables, and robust outputs are provided at https://doi.org/10.5281/zenodo.19218894.

Structure. Section 2 links historical growth to AI via a scale→data→model→function logic. Section 3 develops the analytical lens and reports comparative MCDA results. Section 4 condenses firm-level evidence that supports regional patterns. Section 5 anchors market dynamics with 2015–2024 shares and a 2024 regional snapshot. Section 6 discusses the technical–regulatory challenges, ethics, and forward-looking integration of AI, EVs, and smart cities.

2 Context: the growth of the Chinese automotive industry

2.1 Historical evolution of the automotive industry in China

The world has witnessed China's automotive growth through its early joint ventures and capability development and its current position as a global leader in vehicle production. The historical process of scaling in China has created an internal system that supports AI development. The fast adoption of electric vehicles starting in the mid-2010s produced an enormous amount of vehicle data that drove the development of self-driving vehicle systems and reduced the time needed for over-the-air updates (IEA, 2025a). The Chinese market reached a milestone in 2024 when electric vehicles reached 48% of new car sales, which exceeded European and American markets at 22% and 10%–11%, respectively (IEA, 2025a). The large number of electric vehicles

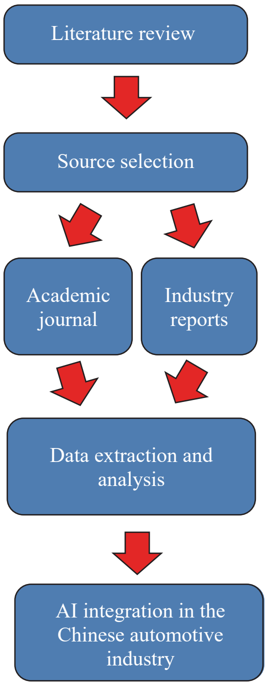

Fig. 2 Research design and data analysis.

sold in China during 2024 created the world's largest operational environment for testing autonomous driving systems and advanced driver assistance systems (IEA, 2025a). Extensive vehicle production enables the development of AI features through a data-driven model development process, which results in cost-effective deployment of new AI features across different vehicle trims. The disclosed compute-and-sensor stacks from leading OEMs such as NIO Aquila/Adam (≈ 1016 TOPS; 33-sensor suite) and XPeng G6 (dual LiDAR; up to ≈ 508 TOPS) demonstrate economic viability through large production numbers and accumulated mileage (IEA, 2025a; NIO, 2022; XPeng Inc., 2023b). The historical growth of China serves as the fundamental factor that enables AI capability development at both the product and fleet levels.

2.2 China as a world leader in automotive production

The leadership position of China in output and export activities enables AI development because large-scale manufacturing operations distribute the costs of advanced technologies and shorten the time needed to develop multiple models at different price points. The 2024 record-breaking production numbers and export growth, which EVs led as the primary driver, occurred simultaneously with the market-wide availability of ADAS systems and fast NOA deployments across entry and mainstream segments (IEA, 2025a). The path of Chinese OEMs follows a disruptive architectural transformation according to innovation theory because they use cost-effective manufacturing and domestic digital systems to create software-based vehicle platforms (Christensen, 1997; Henderson and Clark, 1990). The integration of Orin-class silicon and perception stacks into modular platforms by OEMs demonstrates their dynamic capabilities through platform deployment across different nameplates (Teece et al., 1997). The market adoption of EVs has shifted from early adopters to early majority consumers, while charging and connectivity network effects strengthen usage patterns and data density (Bass, 1969; Rogers, 2003). The MCDA model shows that China leads in market adoption and charging infrastructure and computing and sensor capabilities and ADAS breadth, but Western regions excel in different areas, such as safety evidence from rider-only deployments (Fig. 1). The AI system functions as a self-sustaining loop through infrastructure development. The expansion of public charging networks decreases driving apprehension while enabling users to perform more diverse activities through trip planning and dynamic routing and energy management, which generate behavioral data for AI systems. The combination of fast Chinese charging network expansion with Shenzhen Special Economic Zone Regulations for ICV testing allows extensive real-world data collection. The Baidu and Pony.ai companies can now operate their driverless vehicles in the Beijing and Shanghai Pudong areas because of the issued permits. The EU AI Act (Regulation 2024/1689) interacts with the vehicle type-approval regime (Regulation 2018/858) to determine the deployment sequence of advanced features in European markets (EUR-Lex, 2018, 2024; IEA, 2025a; Reuters, 2023; Pony.ai, 2025).

2.3 Impact of technology on the evolution of industry

The continuous adoption of electric vehicles (Fig. 4) leads to extended software usage periods that generate more detailed telematics and HMI data that enhance energy management and perception and planning through ML pipelines (IEA, 2025a). The expansion of NOA technology reaches 200 cities through XPeng's XNGP system and BYD plans to implement NOA across its entire product range in 2025, while Europe sees L3 autonomous driving become available under specific operational design domains (BMW Group, 2023, 2024; Reuters, 2025a; XPeng Inc., 2023a). The Western rider-only services have produced peer-reviewed safety evidence showing reduced accidents compared to human drivers, which we use as the safety evidence indicator in our MCDA. The evidence shows that AI functions as the fundamental organizing principle that guides product development and validation and governance processes in intelligent mobility systems. Detailed indicator definitions, units, and normalization procedures are provided in the MCDA table presented in Section 3, whereas historical sales and market-share developments are discussed later in the market-dynamics analysis.

3 Comparison with AI use in the western automotive industry

3.1 Analytical lens

The analysis of China, Europe, and USA uses an innovation–adoption framework that combines disruptive/architectural change models from Christensen (1997) and Henderson and Clark (1990) with dynamic capabilities from Teece et al. (1997) and diffusion/adoption models from Bass (1969) and Rogers (2003). The architectural shift of AI-enabled EVs toward software-defined vehicles depends on firms' data management and computational abilities and regulatory control, which determines deployment speed and extent, and consumer adoption patterns influence the final safety and functionality results.

The selection and weighting of the six MCDA criteria are explicitly informed by established innovation frameworks, disruptive and architectural change, dynamic capabilities, and diffusion/adoption, operationalized as measurable indicators for cross-regional comparison (Bass, 1969; Christensen, 1997; Henderson and Clark, 1990; Rogers, 2003; Teece et al., 1997).

Comparative propositions

√ P1 (Scale→AI): higher EV penetration and usage density accelerate AI learning loops and OTA expansion.

√ P2 (Architecture & capabilities): greater on-board compute/sensors and SDV platforms correlate with broader, faster ADAS/NOA roll-outs.

√ P3 (Governance & evidence): permissive but accountable governance yields faster feature deployment; stricter ex-ante regimes slow roll-out but strengthen audited safety evidence.

3.1.1 Empirical augmentation: regulatory index, case vignettes, and robustness

We operate six criteria (see Table 1, MCDA indicators—definitions, data sources, and normalization):

(1) Regulatory enablement (index): presence of L3 allowances, L4/rider-only pilots, driverless permits, and AI compliance interactions with type-approval.

(2) Market adoption: EV share of new light-duty sales (%).

(3) Charging infrastructure: public charge points per 100k inhabitants (or per EV), complemented by fast-charging share.

(4) Compute & sensors: representative flagship TOPS and sensor-suite composition (LiDAR/camera/radar) aggregated to a 0–1 index.

(5) ADAS breadth: functional coverage index (ACC/LCC/AEB; highway/city NOA; OTA cadence).

(6) Safety evidence: peer-reviewed crash-rate comparisons from rider-only services and publicly auditable safety dashboards.

The data sources used for this analysis include IEA and Global EV Outlook 2025 for market and charging information as well as AFDC/ICCT for infrastructure details and technical data from manufacturers about NIO Aquila/Adam (1016 TOPS) and XPeng G6 (up to 508 TOPS) and Tesla Vision and BMW Personal Pilot L3 and Shenzhen ICV rules and Beijing/Shanghai driverless permits and EU AI Act with Reg. 2018/858 and peer-reviewed safety studies such as Waymo rider-only vs. human crash rates in Traffic Injury Prevention.

3.1.2 Autonomous driving and algorithms

For each criterion c and region r, we compute a normalized score with reverse-coding for cost-type indicators where applicable. Unless otherwise stated, we apply equal w_c = 1/6 weights and compute the composite index $I_r = \sum_c w_c S_{r,c}$. Sensitivity varies each w_c by ±20% (Dirichlet perturbations). Missing values are rare; if present, we impute via last observation carried forward or regional median.

$$S_{r,c} = \frac{x_{r,c} - \min(x,c)}{\max(x,c) - \min(x,c)}; I_r = \sum_c w_c S_{r,c}; w_c = 1/6 \quad (1)$$

3.1.3 Manufacturing and production optimization

√ Market adoption. In 2024, approximately 48% of new car sales in China, 22% in Europe, and 10%–11% in USA were electric, positioning China at the forefront of usage-driven data generation. (IEA, 2025a).

√ Charging infrastructure. China and Europe show denser public networks and faster year-on-year growth; U.S. expansion is ongoing but more fragmented across states (IEA, 2025a).

√ Compute & sensors. Chinese OEMs deploy high-TOPS, LiDAR-inclusive stacks at scale (e.g., NIO Aquila/Adam ≈ 1016 TOPS; XPeng up to ≈ 508 TOPS), consistent with an SDV strategy; Western exemplars diverge (Tesla camera-centric; BMW LiDAR-supported L3).

√ ADAS breadth. XNGP (XPeng Inc., 2023a) expanded toward ~200 cities by early 2024; BYD announced a line-upwide NOA for 2025; in Europe, BMW Personal Pilot L3 diffuses under well-defined ODDs.

√ Regulatory enablement. China's municipal pilots (Shenzhen/Beijing/Shanghai) create expansive ODDs for data collection; the EU AI Act's high-risk classification, interacting with type-approval, moderates deployment pace; U.S. governance is heterogeneous at the state level.

√ Safety evidence. The most robust peer-reviewed evidence comes from USA rider-only deployments (e.g., Waymo vs. human benchmarks in Traffic Injury Prevention), informing the risk–benefit profile of higher automation.

The radar in Fig. 1 visualizes these normalized positions.

3.1.4 Robustness and limitations

Weight perturbations (±20%) leave the qualitative ordering of strengths unchanged. The results are sensitive to (1) how "compute & sensors" index LiDAR/camera/radar trade-offs and (2) regulatory granularity within regions (e.g., USA, EU members). We therefore provide a jurisdiction-level regulatory subindex and invite replication with alternative weights (e.g., innovation-theory-informed priors).

3.1.5 Implications

Consistent with P1–P3, China's scale and SDV architecture produce faster AI feature diffusion; Europe balances advancement with ex ante compliance and L3 standardization; and the USA contributes disproportionate safety evidence via rider-only services despite lower EV penetration. These trajectories explain the cross-regional differences captured by the MCDA and inform policy and strategy debates on AI deployment in mobility.

3.1.6 Tesla, Google (Waymo) vs. Chinese companies

Tesla and Waymo lead in autonomous driving with distinct strategies. Tesla uses vision-only systems and neural networks trained on fleet data for Level 2 autonomy. In contrast, Waymo follows a more conservative, infrastructure-heavy model, combining LiDAR, radar, cameras, and HD maps to achieve Level 4 autonomy in geo-fenced areas. The system integrates deep reinforcement learning and 3D semantic mapping, allowing for precise localization and obstacle avoidance (Zhou et al., 2022).

Chinese automakers are converging toward hybrid models that combine the strengths of both vision-based and LiDAR-centric approaches. Baidu's Apollo system, for instance, employs sensor fusion techniques combining LiDAR, camera, and radar data processed through graph neural networks (GNNs) and Bayesian inference models for high-resolution environmental perception and trajectory prediction (Zhou et al., 2022). Similarly, NIO combines a vision-first approach with millimeter-wave radar and ultrasonic sensors, integrating a transformer-based AI architecture to anticipate traffic flows and pedestrian behavior (Peng, 2024). This combination reflects a more pragmatic strategy optimized for China's dense and often unpredictable urban mobility contexts. While Western OEMs focus on proprietary AI, Chinese firms such as Baidu adopt open innovation. Apollo collaborates with automakers and universities, enabling faster, decentralized development, unlike Tesla and Waymo's integrated AI models.

Table 1 enables analytical evaluation through its presentation of MCDA indicators with their definitions and units and reference years and primary sources and normalization approach. The indicators consist of EV share of light-duty sales for market adoption and public chargers per 100,000 inhabitants or per EV for charging infrastructure and on-board TOPS and sensor-suite composition for computing & sensors and functional coverage index for ADAS breadth and ICV pilots and driverless permits and EU AI Act high-risk classification for regulatory enablement and peer-reviewed crash-rate comparisons from rider-only services for safety evidence. The data originate from the Global EV Outlook 2025 (IEA, 2025a) and charging statistics and reports and official technical materials from manufacturers (NIO, XPeng, Tesla, and BMW) and peer-reviewed studies and dashboards on autonomous-driving safety (Waymo, 2024, 2025) and relevant regulations (EUR-Lex, 2018, 2024). The normalization process applies min–max scaling to create values between 0 and 1, while indicator construction and weighting methods receive detailed explanation in Sections 3.1.1 and 3.1.2.

The analysis uses Fig. 1 to show the relative positions of China and Europe and the USA through normalized scores across the six criteria. The analysis uses equal weights for all indicators unless otherwise specified, and the robustness checks and sensitivity analyses appear in supplementary dataset S1. The radar chart functions as an integrative tool for comparison, but readers should not treat it as a definitive ranking system. The figure legend contains additional information, and readers should consult Sections 3.1.1 and 3.1.2 for methodological explanations.

China demonstrates the highest market penetration and charging infrastructure development while achieving better on-board computer and sensor performance and wider ADAS and NOA system deployment according to the software-defined transition model in Section 2.3 (IEA, 2025a; NIO, 2022; XPeng Inc., 2023a). The European market shows steady development but faces limitations because of its high-risk status under the AI Act, which affects vehicle type-approval processes. USA has low electric vehicle adoption, but it leads the world in safety research through its rider-only service operations (Kusano et al., 2025), which guides discussions about advanced automation systems.

4 Manufacturers' AI innovation: Chinese leaders and Western benchmarks

To anchor the comparative lens developed in Section 3.1, we compare selected Chinese OEMs with two Western benchmarks (Tesla and BMW), which serve as reference points for compute capacity, sensing configurations, and ADAS/NOA functional coverage across major markets.

The benchmarks serve as reference points for the MCDA in Section 3.3, but they do not represent complete Western coverage. The availability of features depends on the market/ODD and trim level and software version according to the information found in the last column. The comparative lens requires evidence-based data, which Table 2 presents to show sensing suite capabilities and onboard computer systems and functional coverage of selected models. The evidence-based method uses official technical documentation and investor statements from NIO and XPeng and reliable reports about BYD's 2025 NOA deployment plans to replace general terms with specific technical details and version information (NIO, 2022; Reuters, 2025a; XPeng Inc., 2023a, 2023b).

4.1 Major manufacturers and their AI approach

4.1.1 BYD: AI applications in batteries and energy efficiency

BYD has positioned itself as a major actor in the AI-enabled EV market by integrating intelligent driving and energy-management functions across a broad product portfolio. Rather than limiting advanced functions to premium models, the company has sought to diffuse AI-enabled driving technologies across multiple market segments. Recent reporting on the rollout of the "God's Eye" system suggests that BYD is pursuing a strategy of large-scale functional diffusion, thereby extending AI-enabled driving features beyond the premium end of the market (Reuters, 2025a). Furthermore, BYD has announced the integration of DeepSeek AI software into 21 of its models, including low-cost vehicles. This technology, dubbed "God's Eye", will enable advanced autonomous driving functions and a more sophisticated voice command system, thus democratizing access to these technologies in the mass market.

4.1.2 NIO: Autonomous driving systems and intelligent assistants

Table 2 Comparative overview of AI applications in selected manufacturers—Chinese OEMs (BYD, NIO, and XPeng) and Western benchmarks (Tesla and BMW)

Manufacturer	Representative models/SW	Sensor	On-board computer (TOPS)	ADAS/NOA highlight	Note (market/version caveats)	Primary source
NIO	ET7/ES8–NAD (Aquila + Adam)	Aquila: 33 sensors (11×8MP cameras, 1×Hi-Res LiDAR, radars, ultrasonics)	Adam: 4× NVIDIA Orin ≈ 1016 TOPS	Highway & City NOA (market-dependent), OTA cadence for perception/plan	Feature availability varies by region and SW version; verify local homologation	NIO official tech pages (Aquila/Adam)
XPeng	G6/P7i/X9–XNGP	Up to 31 sensors incl. dual LiDAR (model-dependent)	Up to ≈ 508 TOPS (NVIDIA Orin configuration)	XNGP nationwide coverage; city & highway NOA; OTA expansion	Coverage tied to HD map/nav availability; functions vary by trim/SW	XPeng Inc. (2023a, 2023b)
BYD	Across lineup–DiPilot/"God's Eye" (reports)	Camera/radar baseline; LiDAR on higher trims (varies by model)	Reported mixed stacks (e.g., Horizon + Orin on select platforms)	Announced plan to roll out NOA (highway/urban) broadly in 2025 (reports)	Sources include Reuters; features may vary by price band & region	Reuters (2025a, 2025b, 2025c)
Tesla	Model 3/Y/S/X–Autopilot & Full Self-Driving (Supervised)	Camera-centric (Tesla Vision); no LiDAR; Ultrasonic Sensors removed in 2022+ builds; radar generally not used post-2021 (region/build dependent)	FSD Computer HW3 (dual SoCs; widely reported ≈144 TOPS); HW4 newer/higher compute (official TOPS not disclosed)	Navigate on Autopilot (highway), Auto Lane Change, Autosteer; FSD (Supervised) city streets in select regions; frequent OTA	Functions vary by market/regulation and hardware generation (HW3 vs HW4); Tesla Vision transition impacted low-speed features during rollout	Tesla support: Transitioning to Tesla Vision (2025); Autonomy Day recaps for HW3 (~144 TOPS)
BMW	7 Series (G70/i7) Personal Pilot L3; 5 Series. Highway Assistant (L2)	Cameras + radar + ultrasonic + 3D LiDAR; HD map (HERE) for L3 positioning; 360° perception	New software stack + powerful computing platform; BMW–Qualcomm Snapdragon Ride collaboration; Valeo ADAS domain controller	Personal Pilot L3 up to 60 km/h on motorways with separated carriageways; works in the dark; L2 Highway Assistant with eye-confirmation lane change up to 130 km/h	L3 initially Germany-only with defined ODD; requires ConnectedDrive services; mapping coverage and regulatory approvals apply	BMW Group (2023, 2024); Qualcomm Technologies, Inc. (2021, 2022)

NIO has distinguished itself through its focus on high-level autonomous driving systems and AI-based intelligent assistants. The company has developed the NIO Aquila Super Sensing system, which incorporates 33 high-performance sensing units, including cameras, LiDAR, and radars. This system generates an impressive 8 gigabytes of data per second, forming the foundation of NIO's autonomous driving capabilities (NIO, 2022).

A key component of NIO's AI strategy is the NIO Adam system, powered by four NVIDIA DRIVE Orin SoCs, boasting a total computing power of 1016 TOPS. This remarkable processing capability enables advanced autonomous driving features and real-time decision-making based on complex environmental data.

NIO has also introduced NOMI GPT, an AI-powered voice assistant that incorporates large language models to provide a more intuitive and comprehensive in-vehicle dialog experience.

4.1.3 *Geely: AI investments in electric vehicles and smart cars*

Geely's AI strategy has evolved from the 2021 Smart Geely 2025 roadmap, where the group committed to full-stack capabilities in chips (SE1000), electronic/electrical architectures (GEEA 2.0→3.0), and software, into 2024–2025 product programs that place AI at the center of powertrain management, digital cockpits, and intelligent driving (Geely Auto, 2021, 2024).

A core execution pillar is ECARX, a Geely-backed Tier-1/tech platform that supplies both computing and software for "smart vehicles". ECARX (2025) announced in 2025 that its Skyland® Pro ADAS stack will power G-Pilot, Geely Galaxy's unified intelligent-driving system (features include highway pilot and automated parking; deployment across Galaxy models and prior rollouts on Lynk & Co 08/07). In parallel, Geely's 2025 Galaxy A7 launch documentation shows the Antora 1000 digital-cockpit computing platform (ASIL-B, with customized Flyme Auto OS) moving into series production, signaling Geely's vertical integration of AI-ready cockpit computers and software (ECARX, 2025).

Within the Geely group, ZEEKR provides a second pathway for AI-assisted driving through collaboration with Mobileye. By September 2023, Mobileye SuperVision functions had been delivered via OTA to approximately 110,000 ZEEKR vehicles, including the ZEEKR 001 (Mobileye, 2023). In 2024, Mobileye and ZEEKR announced an expanded collaboration to accelerate technology localization for the Chinese market and integrate Mobileye technologies into next-generation models (Mobileye, 2024). Together, these developments suggest sustained investment in perception, planning, and in-vehicle computing capabilities within the group.

Geely also publicized an AI-native vehicle stack in 2024–2025—GEA (a "four-in-one" AI intelligent architecture combining hardware, system, ecology, and AI) and a full-domain AI system unveiled at CES 2025—framing AI not only as ADAS but also as an end-to-end capability spanning "digital chassis", energy management, and cloud-connected services (Geely Auto, 2024, 2025). While these are manufacturer claims, they are consistent with Geely's organizational moves in 2025 to consolidate smart-cockpit R&D teams and deepen external AI partnerships, steps reported by independent outlets (Reuters, 2025b, 2025c).

4.2 Software and hardware development in China

4.2.1 *Tech companies involved: Baidu, Huawei, and Tencent*

Major Chinese tech companies have played a crucial role in advancing AI technologies for the automotive industry. Baidu, with its Apollo autonomous driving platform, has partnered with multiple automakers to accelerate the development of self-driving technologies. A study in the Journal of Intelligent and Connected Vehicles reports that Baidu's Apollo platform has reduced the development time for Level 4 autonomous driving systems by up to 50% for partnering automakers (Xu et al., 2020).

Huawei has made significant inroads into the automotive sector with its Huawei Inside (HI) solution, which provides comprehensive AI capabilities for smart vehicles. According to a report in the International Journal of Automotive Technology, Huawei's HI solution has demonstrated a 35% improvement in processing efficiency for autonomous driving algorithms compared to traditional automotive-grade processors (Chen et al., 2025).

Tencent has focused on developing AI-powered infotainment systems and cloud services for connected vehicles. Their TAI (Tencent Auto Intelligence) system, as reported in *Journal of Cloud Computing*, has shown a 60% reduction in latency for cloud-based vehicle services, significantly enhancing the user experience in connected cars (Chen et al., 2024).

4.2.2 *Collaborations with startups and universities*

A prominent example of this constructive collaboration is the collaboration between NIO and Tsinghua University, resulting in the establishment of the NIO Institute of Advanced Technologies. This joint venture focuses on innovative research in AI and autonomous driving. More broadly, Chinese universities have become strategic agents in facilitating applied research and the development of industrial-scale AI technologies. In recent years, a dynamic and state-supported ecosystem has matured in which academia and industry codevelop core innovations. Policies such as the "Made in China 2025" initiative and the AI Development Plan have actively encouraged the formation of joint laboratories, data-sharing infrastructures, and cooperative research arrangements between academic institutions and the automotive sector (Woodburn Accountants & Advisors, 2024). These frameworks have allowed top-tier universities to embed applied research directly into the technological roadmaps of both emerging firms and established manufacturers.

NIO has also entered into agreements with the University of Science and Technology of China and Hefei University of Technology to cocreate research institutes specializing in intelligent vehicle systems (Chen et al., 2025). These institutes serve not only as centers for high-impact research but also as training grounds for talent, offering postdoctoral placements and direct immersion in real-world industrial challenges. Such arrangements enable a seamless flow of knowledge from theory to application while providing access to large-scale datasets and testing environments that would be difficult to replicate within academia alone. Other firms are replicating this model. Li Auto, for example, collaborated with Tsinghua University to develop DriveVLM, a multimodal foundational model that underpins its latest intelligent driving system, integrating innovative advances in computer vision and natural language processing (Research and Markets, 2025). Meanwhile, SAIC Motor—China's largest carmaker—has partnered with Tongji University to establish a state-of-the-art innovation lab dedicated to autonomous decision-making and control systems, bridging theoretical algorithm design with real-time vehicular applications (Gabriella, 2024).

These collaborations are not limited to technological outcomes. They also contribute to building a highly qualified workforce aligned with the needs of intelligent mobility. Chinese universities are increasingly acting as innovation hubs that connect basic science with industrial deployment. Their contributions to the development of deep learning models, sensor fusion techniques, and autonomous control architectures are critical to reducing the innovation cycle time and increasing the market readiness of new solutions. As Hsu et al. (2024) demonstrate, companies engaging in sustained collaboration with academia report higher levels of product-based patenting and improved commercial viability of innovations. The Chinese academic sector plays a decisive role in shaping the future of AI-powered automotive systems. These alliances are accelerating not only technological breakthroughs but also human capital formation, placing China at the forefront of the global race toward fully autonomous vehicles.

4.3 Success stories and flagship models

4.3.1 XPeng P7, NIO ES8, and BYD Han EV

These flagship models represent the pinnacle of Chinese AI innovation in the automotive sector. XPeng P7, equipped with the XNGP system, has demonstrated Level 3 autonomous driving capabilities in urban environments, as verified in a study published in *Transportation Research Part C: Emerging Technologies* (Chen et al., 2025).

The NIO ES8, featuring the NIO Aquila Super Sensing and Adam systems, has shown remarkable performance in autonomous driving tests. According to a report in the Journal of Field Robotics, ES8 achieved a 95% success rate in complex urban driving scenarios, outperforming several Western competitors (Chen et al., 2025).

The BYD Han EV, with its AI-optimized battery management system, has set new standards for energy efficiency in electric vehicles. A study in the Journal of Power Sources reports that the Han EV demonstrated a 20% improvement in range under real-world driving conditions compared to similarly sized electric vehicles, attributing this enhancement to its advanced AI-driven energy management (Chen et al., 2025).

4.3.2 Most advanced technologies implemented

Some of the most advanced technologies implemented by Chinese manufacturers include (BMW Group, 2023, 2024; Kusano et al., 2025; XPeng Inc., 2023a, 2023b):

(1) NIO's NOMI GPT improves in-vehicle interaction through AI-powered voice recognition.

(2) Advanced sensing systems such as NIO Aquila Super Sensing provide the foundation for high-level autonomous driving capabilities.

(3) BYD's upcoming Blade battery uses AI to improve energy density and reduce charging time.

(4) AI-driven predictive maintenance systems, which use machine learning algorithms to anticipate vehicle issues before they occur, potentially reduce maintenance costs and improve vehicle reliability.

On the other hand, the integration of self-driving technologies into the automotive sector has necessitated the development of robust regulations and compliance mechanisms to ensure safety, reliability, and ethical standards. In China, regulatory frameworks for autonomous vehicles are rapidly evolving to accommodate technological advancements. The Ministry of Industry and Information Technology (MIIT) has established testing zones for Level 3 and Level 4 autonomous vehicles, allowing manufacturers such as Baidu and NIO to conduct trials under controlled conditions (Xu et al., 2020). These zones provide a safe environment for testing edge cases such as adverse weather conditions and complex urban scenarios, ensuring that self-driving systems meet stringent performance criteria before mass deployment.

Chinese manufacturers are innovating in automotive AI, especially in EVs. Companies such as BYD, NIO, XPeng, and Geely are leveraging AI to enhance battery efficiency, autonomous driving capabilities, and overall vehicle intelligence. As these technologies continue to evolve, they are likely to reshape the global automotive landscape, with Chinese manufacturers playing a pivotal role in this transformation. Fig. 3 illustrates the AI integration flow in autonomous driving as implemented by NIO, summarizing the key phases from sensor data acquisition to real-time decision-making.

5 Economic impact and global competitiveness

5.1 Chinese automotive market in numbers

The Chinese automotive industry has experienced remarkable growth in recent years, solidifying its position as a global leader in both production and exports. According to the China Association of Automobile Manufacturers (CAAM), China's cumulative vehicle production and sales in 2024 reached 31.282 million and 31.436 million units, respectively, representing year-on-year growth of 3.7% and 4.5% (Gasgoo, 2025).

The growth in production has been accompanied by a significant increase in exports. In 2024, China's total automobile exports stood at 5.86 million units, marking a year-on-year increase of 19.3%.

The new energy vehicle (NEV) sector has been a particular bright spot in China's automotive landscape. In 2024, NEV production and sales reached 12.89 million and 12.87 million units, respectively, up to 34.4% and 35.5% year-on-year (IEA, 2025a). These record highs underscore China's dominance in the global NEV market, marking the 10th consecutive year that the country has topped global rankings in NEV production and sales (IEA, 2025a).

Anchoring the historical trajectory, Fig. 4 compares the evolution of EV market shares across China, Europe and USA since 2018. Europe held steady at "about one in five" new car sales being electric in 2024, while USA edged up to roughly one in ten. China approached the 50% threshold in 2024, after surpassing 35% in 2023, underscoring its scale advantage. The 2024 inset highlights volumes: global EV sales exceeded 17 million (> 20% share), with China at ~11.2 million, Europe at ~3.1 million (EU + Other Europe), and North America at ~1.9 million.

To summarize the 2024 snapshot used in the regional comparison, Table 3 reports electric-car sales by region and each region's share of the global total. These figures provide the numeric basis for the subsequent bar chart and for the discussion on scale effects in AI deployment.

Investments in AI and their economic impact have been substantial. According to McKinsey, AI could deliver more than $380 billion in economic value to China's automotive, transportation, and logistics sectors (Shen et al., 2022).

The market potential for AI in China is staggering. The AI sector is projected to grow from US$34.2 billion in 2024 to US$154.8 billion by 2030, with machine learning showing an even higher growth trajectory. These developments are underpinned by

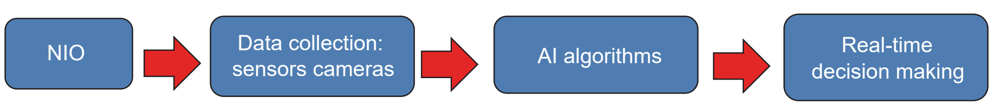

Fig. 3 Flowchart of the integration of AI in NIO's autonomous driving system.

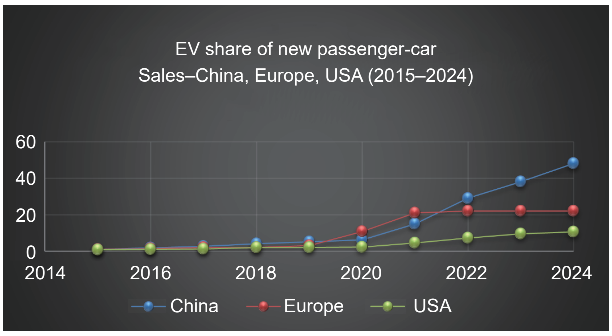

Fig. 4 Evolution of electric vehicle market share by region (China, Europe, and USA), 2015–2024.

Table 3 Electric-car sales by region in 2024 and share of global total

Region	EV sales 2024 (million)	Share of global (%)
China	11.20	64.74
EU	2.20	12.72
Other Europe	0.90	5.20
USA	1.60	9.25
Other North America	0.30	1.73
Other Asia Pacific	0.80	4.62
Others	0.30	1.73

significant demand in subsectors such as robotics, generative AI, and healthcare applications (IEA, 2025a).

Fig. 5 shows how 2024 electric-car sales are overwhelmingly concentrated in China: 11.2 million units, ~65% of the global total. Europe reaches ~3.1 million (EU 2.2 + Other Europe 0.9; ~18%), North America ~1.9 million (USA 1.6 + Other North America 0.3; ~11%), while Other Asia Pacific (0.8) and "Others" (0.3) together contribute ~6%. Summed across regions, global EV sales exceed 17 million in 2024. This distribution quantifies the scale advantage underpinning China's faster AI learning loops (more vehicle miles → richer data → quicker OTA/feature rollout), while Europe's sizeable but more regulated uptake and North America's smaller base (despite advanced L4 pilots) imply different trajectories for AI deployment.

Fig. 6 reports each region's share of global EV sales in 2024. China accounts for ≈ 64.7% of the total, the European Union ≈ 12.7% and Other Europe ≈ 5.2% (Europe combined ≈17.9%). USA ≈ 9.2% and Other North America ≈ 1.7% (North America combined ≈ 11.0%). Other Asia Pacific ≈ 4.6% and Others ≈ 1.7% complete the distribution. The concentration of demand in China underscores where data for AI-enabled functions (usage traces, perception edge cases, OTA feedback) are most abundantly generated, while Europe's share, sizable but fragmented, and North America's smaller base imply different trajectories and speeds for AI deployment across regions.

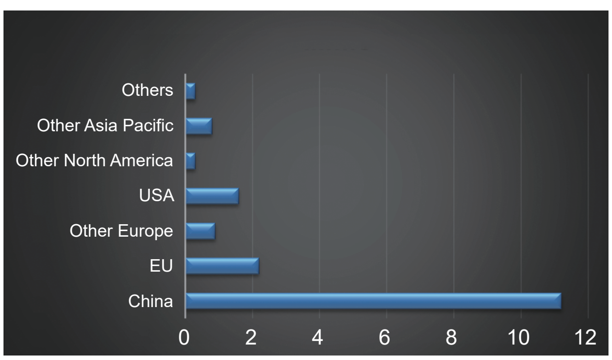

Fig. 5 EV sales 2024 (million).

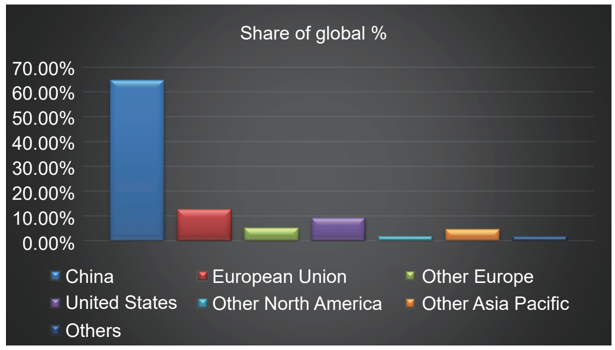

Fig. 6 Share of global (%).

5.2 Competition with USA and European manufacturers

The rapid growth of Chinese automakers has intensified competition with established manufacturers from USA and Europe. Chinese brands have significantly increased their market share, especially in the NEV segment. In 2024, Chinese brands' share has risen markedly since 2020, especially in NEVs, while foreign brands' share has declined; exports roughly doubled between 2022 and 2024, underscoring rising global competitiveness (IEA, 2025a). This growth has come at the expense of foreign brands, which have lost share of the Chinese passenger vehicle market since 2020. The shift is particularly pronounced in the NEV market, where Chinese local brands have captured 65% of the market share (IEA, 2025a).

Chinese automakers are actively pursuing international expansion strategies. The surge in exports, from approximately 3 million units in 2022 to nearly 6 million in 2024, demonstrates the growing global competitiveness of Chinese vehicles (IEA, 2025a). However, this expansion is not without challenges. The complex international landscape and emerging challenges facing China's auto exports have been noted by industry experts (IEA, 2025a).

5.3 Government policy and regulations in automotive AI

The Chinese government has played a crucial role in supporting AI research and development in the automotive sector. The government has launched a series of initiatives, including Made in China 2025, the Action Outline for Promoting the Development of Big Data in 2015, and the Next Generation Artificial Intelligence Development Plan in 2017 (Woodburn Accountants & Advisors, 2024).

The government's commitment to fortifying and elevating China's vanguard status in the sector of intelligently connected and new energy vehicles was reaffirmed in the 2024 government work report (Huaxia, 2024). In September 2024, Shanghai passed China's first provincial-level law covering AI development, effective October 1, 2024 (Woodburn Accountants & Advisors, 2024). China's automotive industry, driven by significant investments in AI and supported by favorable government policies, has achieved remarkable growth in both production and exports. The country's focus on EVs and autonomous driving technologies has positioned it as a formidable competitor to established Western manufacturers.

6 Challenges and opportunities of AI in the Chinese automotive industry

The integration of AI in the Chinese automotive industry presents both significant challenges and promising opportunities. This section explores the technical and regulatory hurdles, ethical dilemmas, and future perspectives of AI implementation in China's rapidly evolving automotive sector (Table 4).

6.1 Technical and regulatory challenges

6.1.1 *Safety and reliability of autonomous systems*

One of the primary challenges is the complexity of data acquisition and processing. According to a study by Controlar (2025), data fragmentation, heterogeneity, and data silos pose significant difficulties in implementing AI systems in automotive manufacturing. Moreover, the rapid development of AI technology has put enormous pressure on regulators to keep pace. The existing regulatory frameworks are struggling to fully adapt to the characteristics and needs of emerging technologies, creating a risk of regulatory lag. For instance, while self-driving cars represent a typical application of AI with great market prospects, they have also triggered a series of legal challenges involving AI legal subject status, product liability, cybersecurity, and privacy protection (Huang et al., 2024).

6.1.2 *Restrictions and AI standards in the EU and USA*

In the USA, for example, regulatory caution has increased following accidents involving autonomous vehicles. General Motors' "Cruise" robotaxi service suspended its operations after a collision in San Francisco, leading to a suspension of their license by California regulatory authorities (Bork, 2024). Similarly, the EU is developing comprehensive AI regulations that will likely impact the automotive sector. Chinese manufacturers will need to ensure compliance with these evolving standards to successfully enter and compete in these markets.

6.2 Ethical dilemmas and data privacy

6.2.1 *Use of driver data and privacy protection*

In China, the Cyberspace Administration has published draft rules clarifying data and cyber compliance obligations for the automobile industry. These rules push for most personal information and important data to be kept within China. The draft "Several Provisions on the Safety Management of Automobile Data" applies across the industry, including vehicle designers, manufacturers, parts and software providers, dealers, maintenance agencies, and insurance companies (Bigg, 2021).

6.2.2 *AI and decision-making in accident scenarios*

Despite strong governmental support for AI in China's automotive sector, ethical and data risks remain insufficiently addressed. A critical concern is algorithmic bias, where AI decision systems may produce unintended discrimination, especially in complex or diverse real-world scenarios. For example, if AI perception systems are trained predominantly in urban environments or specific demographic groups, they may underperform in rural areas or when interacting with unfamiliar pedestrian behaviors (Zhou et al., 2022). Another major concern is data misuse and privacy violations. In 2022, a widely reported case involved the Chinese EV manufacturer XPeng Motors, where researchers discovered that certain in-vehicle cameras could transmit data back to servers without adequate encryption, raising concerns over unauthorized surveillance and data leakage (Chen, 2022). XPeng denied wrongdoing and addressed the issue, highlighting AI system vulnerabilities.

Although this scenario has been mostly theoretical, recent simulations and moral machine experiments suggest cultural differences in expectations. For instance, studies show that Chinese users tend to prioritize group safety over individual protection, which may influence algorithm design (Awad et al., 2018). This contrasts with Western frameworks such as the EU AI Act, which include provisions for risk classification, human oversight, and algorithmic transparency (European Commission, 2021). A balanced regulatory framework must not only promote innovation but also anticipate and mitigate risks related to bias, data misuse, and ethical decision-making. Without such safeguards, the rapid integration of AI in mobility could undermine public trust, both in China and globally.

6.3 Future perspectives and emerging trends

6.3.1 *Advancements in AI and autonomous driving in the next decade*

The next decade promises significant advancements in AI and autonomous driving technologies in China. The Chinese Society of Automotive Engineers predicts that by 2030, 20 percent of all vehicles sold in China will be completely autonomous (level 5), with an additional 70 percent equipped with relatively advanced assistance systems (Bork, 2024).

6.3.2 *Integration of AI with electric vehicles and smart cities*

The integration of AI with electric vehicles and smart cities represents a significant opportunity for the Chinese automotive industry. This convergence is already underway, with AI being used to optimize battery performance, enhance energy efficiency, and improve overall vehicle performance.

While the integration of AI in the Chinese automotive industry faces significant challenges, particularly in terms of safety, regulation, and ethical considerations, it also presents immense opportunities for innovation and growth. As China continues to invest heavily in AI and autonomous driving technologies, it is poised to play a leading role in shaping the future of global automotive technology.

Table 4 Comparative regulatory frameworks for AI in the automotive sector: China vs. West (USA/EU) (Basis: EUR-Lex 2018/858; 2024/1689; Shenzhen ICV Regs; Beijing/Shanghai permits)

Regulatory area	China	West (USA/EU)
Data governance	Strict data localization laws; real-time vehicle data to be stored domestically	GDPR (EU) and CCPA (California); strong data privacy focus
Autonomous vehicle testing	Government-led pilots in cities (Beijing and Shanghai); fast-track permits	State-based (USA); EU allows testing under specific safety frameworks
AI safety & standards	MIIT; initiative-taking standardization of AI in vehicles	Voluntary industry standards; focus on risk classification (AI Act in EU)
Cybersecurity	Mandatory integration with government cybersecurity protocols	Company-led; based on ISO/SAE cybersecurity practices
Cross-border data transfer	Restricted without state approval	Permitted under privacy compliance
Government support	Strong public investment industrial policy	Tax incentives, grants; more fragmented policy approach

7 Conclusions

7.1 Summary of key findings

AI integration has transformed China's automotive sector, boosting innovation in design, manufacturing, and autonomous driving. China's automotive industry has experienced remarkable growth, solidifying its position as a global leader in both production and exports. The country has maintained its status as the world's largest automobile market for 16 consecutive years, with cumulative vehicle production and sales reaching over 31 million units in 2024. This growth has been particularly pronounced in the NEV sector, where China has dominated global rankings in production and sales for a decade.

Chinese manufacturers have made significant strides in AI applications, demonstrating innovation across various domains. Companies such as BYD, NIO, XPeng, and Geely have leveraged AI to enhance battery efficiency, develop advanced autonomous driving systems, and create intelligent in-vehicle assistants. These advancements have not only improved vehicle performance but also redefined the user's experience in modern automobiles. The gap between China and Western countries in advanced automotive technologies is rapidly closing. Chinese companies are now competing directly with established Western manufacturers in areas such as electric vehicles and autonomous driving. This progress is evident in the increasing market share of Chinese brands, both domestically and internationally, particularly in the NEV segment.

Moreover, this technological rise is supported by a robust innovative ecosystem characterized by state-backed research programs, cross-sector collaborations, and fast deployment cycles. Such dynamics enable Chinese firms to experiment, iterate, and scale faster than many Western counterparts, reinforcing their competitive edge.

7.2 Implications for global industry

The rise of AI-driven innovation in China's automotive sector is poised to reconfigure the global automotive market. Chinese manufacturers are expanding their presence in international markets, challenging the dominance of traditional Western automakers. This shift is particularly noticeable in the EV market, where Chinese brands have captured a significant market share.

The global automotive industry is likely to see a shift toward more AI-centric vehicle designs and functionalities. As Chinese manufacturers continue to innovate and set new standards in AI integration, Western companies are under increasing pressure to accelerate their own AI adoption efforts to maintain competitiveness.

This transformation presents new opportunities for both established manufacturers and startups specializing in AI technologies. The demand for AI expertise in the automotive sector is creating fertile ground for innovation and collaboration. Startups developing cutting-edge AI solutions for autonomous driving, battery management, or in-vehicle user experiences have the potential to play a crucial role in shaping the future of the industry. The integration of AI with electric vehicles and smart city infrastructure represents another significant opportunity.

Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

Replication and data sharing

All the relevant replication materials are available at https://doi.org/10.5281/zenodo.19218894.

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