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Self-Driving and Safety Security Response : Convergence Strategies in the Semiconductor and Electronic Vehicle Industries

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Abstract

The paper investigates how the semiconductor and electric vehicle industries are addressing safety and security concerns in the era of autonomous driving, emphasizing the prioritization of safety over security for market competitiveness. Collaboration between these sectors is deemed essential for maintaining competitiveness and value. The research suggests solutions such as advanced autonomous driving technologies and enhanced battery safety measures, with the integration of AI chips playing a pivotal role. However, challenges persist, including the limitations of big data and potential errors in semiconductor-related issues. Legacy automotive manufacturers are transitioning towards software-driven cars, leveraging artificial intelligence to mitigate risks associated with safety and security. Conflicting safety expectations and security concerns can lead to accidents, underscoring the continuous need for safety improvements. We analyzed the expansion of electric vehicles as a means to enhance safety within a framework of converging security concerns, with AI chips being instrumental in this process. Ultimately, the paper advocates for informed safety and security decisions to drive technological advancements in electric vehicles, ensuring significant strides in safety innovation.

Keywords: *EV, Self-Driving, Safety, Security, AI-Chip, Connectivity*

1. Introduction

This paper discusses the importance of safety and security in electric vehicles (EVs) during the era of autonomous driving. Both safety and security are crucial in this era. EV safety encompasses collision prevention, safe structural design, safe driving, and compliance with traffic rules, as well as safe procedures for battery charging and replacement. From a security perspective, autonomous vehicle sensors and communication systems must be protected from hacking and cyber attacks, and personal information and data security are also significant concerns. Therefore, safety and security are both critical issues in the era of autonomous driving.

The trend of companies designing and producing their own chips, using Tesla as an example, is discussed.

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Developing in-house chips allows companies to optimize chip design specifically for their products, leading to better performance and efficiency. However, the analysis aims to explore evidence or data indicating a discrepancy between nominal innovation and substantial innovation, as evidenced by the sharp decline in prices of key products like DRAM being a major cause of the semiconductor export decline. Furthermore, the transition to in-house chip design may pose risks to traditional chip manufacturers like Samsung and Micron. This valid concern is supported by analysis or evidence. Providing more information on the potential impact of these trends on the semiconductor industry and the strategies chip manufacturers can adopt to address these changes is important. Overall, more evidence and analysis on the trend of in-house chip design are more effective. Samsung secured the production of 5-nanometer foundry processes for autonomous driving semiconductor chips from Ambarella, a US autonomous driving semiconductor specialist, following Tesla in February 2023. Samsung's foundry process produces Ambarella's autonomous driving semiconductor chip, the CV3-AD685, which serves as the brain of autonomous vehicles by independently assessing and controlling driving situations inputted through cameras and radar. The global automotive semiconductor market is projected to reach $740 billion (approximately 92.9 trillion won) by 2026, with an average annual growth rate of 9% from $45 billion in 2021 (IHS). Samsung Electronics continues to invest in the automotive semiconductor market despite the memory semiconductor downturn. Samsung Electronics is developing semiconductors related to autonomous driving. As autonomous driving technology advances, demand for semiconductors and OLED panels installed in vehicles will increase significantly. Autonomous driving Level 4 vehicles require over 2,000 semiconductors, and not only advanced system semiconductors but also memory semiconductors such as DRAM and NAND flash will see a more than 50-fold increase in demand. Samsung Electronics aims to increase its share of the automotive semiconductor market to over 10% by 2025. Integrating semiconductors is essential for the safety and security of autonomous vehicles, as they are key to implementing AI, sensors, and communication. Autonomous vehicles require high-performance, reliable semiconductors to process vast data. Thus, semiconductor technology is vital for the industry, and its convergence with the EV sector will drive advanced technological developments.

2. Prior research

2.1 Tesla Cars and Security Integrated Semiconductors

This paper outlines three scenarios for semiconductor development and examines how changes in safety and security impact the demand for EVs. Integrated semiconductors play a crucial role in ensuring battery safety. Firstly, Battery Management System (BMS) semiconductors monitor factors like charge status and temperature to manage EV batteries safely. Secondly, battery charging control semiconductors optimize charging efficiency and battery lifespan by adjusting voltage and current based on battery conditions. Thirdly, power conversion semiconductors are essential for converting battery DC current to AC current for EV operation. Additionally, Silicon Carbide (SiC) semiconductors minimize electrical losses, while Gallium Nitride (GaN) semiconductors handle high power and facilitate fast charging and long-range driving.

EV market growth is driven by technological advancements, but autonomous vehicles also need resilience and security. Some paper proposes a resilience control design for autonomous EVs to enhance steering system security against cyber attacks. By detecting attacks and using a disturbance estimator and robust predictive controller, the system ensures driving safety. Simulations confirm its effectiveness [1]. The following research investigates cyber attacks on steering angle, considered one of the most critical signals for safety in vehicles. According to the simulation results, the maneuverability and stability of the proposed controller are enhanced by optimally allocating tire torque output using AI chips. Consequently, the proposed control framework outperforms the equal allocation controller in terms of yaw rate, lateral position error, vehicle body attitude, and tire force utilization rate [2]. In connected autonomous vehicles (CAVs), safety and security are interconnected and crucial due to the importance of many vehicle components for both safety and security. Achieving functional safety can be attained even if one executor fails. Conversely, employing a simple consensus mechanism to detect abnormal executors due to cyber attacks can ensure security, following the principle that the probability of multiple heterogeneous executors with the same function failing for the same vulnerability is very low. The DHR prototype was designed and installed on an automated bus. Test results demonstrate that the proposed DHR effectively enhances both safety and security in CAVs [3]. The key to the adoption of unmanned autonomous vehicle (UAV) ride sharing and unmanned taxi services lies in the reliability of safety technology. Commercialization hinges on the deployment of various safety technologies aimed at minimizing fatalities and injuries, including inter-vehicle communication technology, autonomous driving technology, automatic brake control technology, artificial intelligence, and others [4]. Also, the adoption of EVs explores various innovative fields within the EV sector, including battery technology, wireless charging, vehicle-to-grid (V2G) communication, lightweight materials, autonomous driving, vehicle-to-everything (V2X) communication, circular economy approaches, advanced charging infrastructure, energy storage, and societal and behavioral innovations. Previous research indicates that advancements in battery technology are driving the adoption of EVs. Through V2G communication, EVs can act as mobile energy storage, while lightweight materials boost efficiency and performance. Autonomous driving can enhance safety, reduce congestion, and optimize energy use. [5]. So, vehicle electrification, automation, and shared mobility represent new trends in future mobility. The combination of the three Rs (reduce, reuse, recycle) can maximize energy savings, carbon mitigation, and health benefits. Policy incentives are necessary to facilitate the transition from individually owned traditional vehicles to shared EVs [6]. Moreover, investments in autonomous vehicle (AV) technology began in the early 2010s, with prototypes developed by companies ranging from Tesla, Ford, and Toyota to Google, Yandex, small startups, and tech giants. Despite significant hype surrounding this technology, several challenges remain in areas such as security, data integrity, privacy, and communication. Blockchain emerges as one of the most attractive technologies as a potential solution. Previous studies have described, classified, and evaluated various solutions in the autonomous vehicle industry that utilize blockchain [7].

According to Jeffrey Moore's "Crossing the Chasm" theory, new technologies must be simple, intuitive, and easy to use, and when costs decrease, making the decision to adopt them straightforward, growth curves begin, and inflection points occur. The EV market now exhibits uncertainties in predicting the adoption process of new technologies in its early stages. Initially, pioneering consumers or product promotion pioneer the market, which does not reach the masses, leading to only a few customers purchasing due to unstable market conditions and high-priced products. However, as technology advances, products become simpler, more intuitive, affordable, and easy to use, reaching a stage easily accepted by the masses, resulting in market expansion. The EV market follows an S-shaped growth curve, evolving from early adopters to the mass market, and finally to the laggards market. This growth curve requires a combination of technological advancement, appropriate pricing, high value, simplicity, ease of use, and effective marketing strategies as shown in Figure 1.

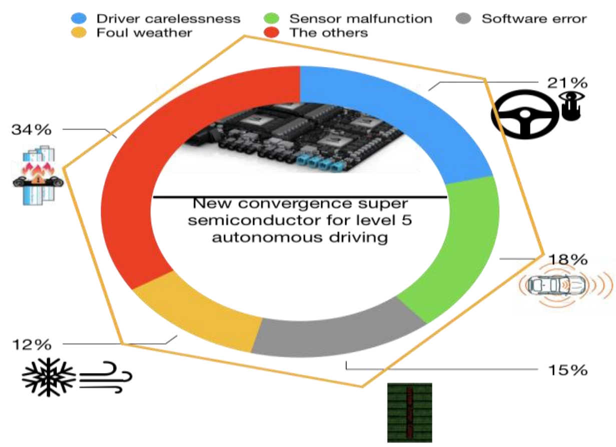

Figure 1. Model of security against accidents in autonomous driving

Tesla's success lies in its ability to learn from and improve upon previous products at each stage. For instance, before successfully launching the Model 3 and Model Y, Tesla had to master battery technology, power management, safety, stability, and service center infrastructure with its initial models. Tesla has already positioned itself in the next big market, namely the Full Self-Driving (FSD) market. The FSD market is fifty times larger than the entire transportation market and Tesla's approach primarily revolves around providing software and AI-based solutions in this market. While the FSD market is highly complex and may result in a winner-takes-most scenario, Tesla currently leads the market. However, Fully autonomous driving faces significant regulatory and safety challenges, delaying mainstream adoption. Despite this, Tesla leads the market with its FSD technology, software, AI, and data-centric approach.

2.2 Chinese Autonomous Vehicles and Security

The development of autonomous driving technology has progressed to nearly Level 4, but the remaining 1% of challenges remain unresolved due to legal, societal, and safety issues. Moreover, even in the United States, companies like Uber have shuttered their autonomous driving divisions due to technical challenges, and incidents of accidents involving autonomous vehicles have been attributed to issues with interaction with human drivers. Legislation on autonomous driving outlines responsibilities for tech companies in case of accidents, along with driver insurance. Germany has already implemented such laws, and the United States and South Korea are expected to follow suit. However, due to uncertainties and concerns among companies, there's a possibility of encountering unforeseen situations. China is advancing in autonomous driving technology with significant investments but proceeds cautiously due to societal and legal responsibilities. Despite commercial use and evolving acceptance domestically, cooperation with Chinese companies faces skepticism in the US and South Korea due to concerns over intellectual property theft. Incidents like the minimal fine for a fatal autonomous taxi accident in 2021 highlight lenient penalties, potentially reducing accountability and undermining trust in the technology. Semiconductor convergence, integrating CPUs with memory and non-memory, is crucial for enhancing safety, efficiency, and cybersecurity in autonomous vehicles, thereby addressing some of these challenges.

2.2 Economic downturn and safety

Furthermore, this paper explores how the sustainability and growth trends of the semiconductor industry affect safety and security. Following Europe's lead, the United States is accelerating the expansion of EVs, aiming for a 67% increase by 2032. This trend is driven by the significant growth in battery production, as well as the increasing revenue from various types of electronic devices and charging stations. While environmental regulations are accelerating the expansion of EVs, the strategy in the United States is to seize early leadership in the EV era, expand employment in new sectors, and establish manufacturing hubs domestically. This paper could provide additional insights into how these macroeconomic factors impact safety and security in the EV battery sector of the semiconductor industry. It offers insights into how the acceleration of EVs, driven by new mechanisms and technologies required for K-semiconductors, influences safety and security factors in sustainability and growth trends.

The reason for this is that when the demand for EVs disappears, it often leads to a decline in investment and resources dedicated to the industry. This can result in a lack of attention and resources being devoted to safety and security measures, which can ultimately lead to a neglect of safety. So, in this case, the statement is a fact, and it highlights the importance of ensuring that safety and security are prioritized even when demand for EVs is low.

3. Research Design : Integrated AI Self-Driving Semiconductors

3.1 AI Semiconductor Battery Integration

From the perspective of AI semiconductors (HBM+NPU), there are several potential things. First, Integration of AI semiconductors, it could explore the potential of AI semiconductors in the memory semiconductor industry, highlighting their advantages and challenges in terms of performance, power consumption, and cost. Second, Analysis of AI semiconductor market trends, it could analyze the current market trends and forecast the future demand for AI semiconductors, identifying potential growth areas and challenges.Third, Discussion of AI semiconductor applications, it could discuss the various applications of AI semiconductors, such as edge AI, autonomous vehicles, and smart homes, and how they impact the memory semiconductor industry. Fourth, Examination of AI semiconductor supply chain, it could examine the supply chain of AI semiconductors, including the production process, manufacturing costs, and logistics, to identify potential bottlenecks and opportunities for improvement. Fifth, Investigation of AI semiconductor competition, it could investigate the competitive landscape of AI semiconductors, including the market share of different companies, and the strategies they employ to stay competitive. Sixth, Analysis of AI semiconductor pricing, it could analyze the pricing strategies of AI semiconductors, including the impact of economies of scale, and the potential for price wars in the market. Seventh, Discussion of AI semiconductor security, it could discuss the security concerns surrounding AI semiconductors, including the potential for data breaches and the need for secure manufacturing processes. Eighth, Examination of AI semiconductor environmental impact, it could examine the environmental impact of AI semiconductors, including the energy consumption and e-waste generated by their production and disposal. So it can provide a more comprehensive understanding of the AI semiconductor industry and its potential impact on the memory semiconductor market.

3.2 Battery share and consumption on safety

Panasonic is the leading cell supplier in the Americas, largely due to its batteries being used in Tesla's Model 3 and Model Y. However, in Europe, Tesla does not equip its best-selling Model 3 and Model Y vehicles with cells supplied by Panasonic as shown in table 1.

Table 1. Local market share change of main battery-related companies

Market share	Global	North-American			EU			China		
	2023	2022	2023	Change	2022	2023	Change	2022	2023	Change
Panasonic	7.1%	48%	48%	-	2%	8%	Increase	7%	6.4%	Decrease
LG ES	14.2%	18%	7.5%	Decrease	-	16%	Decrease	7%	3.5%	Decrease
CATL	36.9%	14%	20%	Increase	11%	21%	Increase	33%	37.4%	Increase
SK On	5.1%	10%	6.5%	Decrease	-	6%	Increase	-	0.14%	-
Samsung SDI	4.1%	8%	12%	Increase	-	5%	Increase	-	-	Decrease
BYD	15.9%	-	2.1%	-	-	17%	Increase	13.9%	15.8%	Increase
Svolt	-	-	-	New player	-	-	-	1.3%	2.7%	New player
Farasis Energ	-	-	-	New player	-	3%	New Entry	4%	5%	New player

Source: Author own (NikkeiAsia; Amadeus Intelligence; Cnevpost, 2024)

This marks the ongoing of price-value survival battle among EV battery companies, driven by market differentiation. There are several methods to minimize battery consumption in autonomous vehicles, commonly including due to the changes in the battery industry as table 1. First, Route Optimization: Autonomous vehicles use GPS and other sensors to perceive roads and driving environments. This information can be utilized to optimize the vehicle's driving route, thereby extending battery life. Second, Engine Control: Autonomous vehicles utilize engine control technology to regulate the vehicle's speed, acceleration, etc. This can help reduce battery consumption. Third, Efficient Regenerative Braking: Autonomous vehicles use regenerative braking systems to extend battery life. Fourth, Energy Management: Autonomous vehicles employ energy management systems to optimize the vehicle's electrical usage. Fifth, Reduction of Resistance: Autonomous vehicles work to reduce resistance in the vehicle, such as aerodynamic and frictional resistance, to extend battery life.

4. Results: Semiconductor Platformization for Safety & Security

The role of semiconductors in EVs is crucial and growing, with a focus on safety and security. As the EV market continues to grow, the development of advanced semiconductor technology will be essential in enhancing the performance, efficiency, and user experience of these vehicles. Safety and security are critical in autonomous vehicles. Safety is directly related to human lives, and the safety of autonomous vehicles must be ensured [8-9]. Security involves protecting the computer systems integrated into autonomous vehicles from hacking, making it essential to guarantee this protection.

Battery safety and EV security are closely related. The battery is a critical component of EVs, and safety issues such as heat, fire, and explosions during charging and discharging can lead to security concerns. For example, a hacker could attack the battery system of an EVto overcharge or overheat the battery, resulting in explosions or fires. Chinese company BYD is growing and pursuing a semiconductor foundry business for EVs based on its own hardware platform. This could be a signal for a change in the traditional automotive value chain. BYD is also expanding its business through open partnerships with companies like Foxconn in Taiwan.

However, there are issues related to the integration of semiconductors and batteries in EVs, particularly concerning commercialized replaceable batteries in China since 2018. When using integrated batteries, separate design and development are required for communication and control functions between semiconductors and batteries. This necessitates appropriate protocols and interfaces, as well as sufficient verification and testing to ensure the stability and reliability of each component. BYD is also integrating semiconductors into batteries. LG Chem launched "intelligent batteries" applying internal semiconductor technology, and SK Innovation developed technology directly embedding semiconductors inside batteries. This involves applying semiconductor components directly inside the cell using ceramic coating technology to increase battery stability, improving both performance and safety.

In anticipation of changes in the value chain and platformization in the EV industry, traditional component-focused EV companies may find it challenging to generate profits. Therefore, companies like BYD and Huawei are establishing strategic partnerships and exploring new competitive strategies in advance.

4.1 Empirical analysis

The proposed analysis is suitable for investigating the correlation between semiconductor security and EV safety, but it lacks some important factors. Other factors such as government policies, driver characteristics, and technological advancements that may influence EV safety and security need to be considered.

H1, H2 hypotheses seem reasonable. For H1: it's plausible that the accident rate in autonomous driving includes security considerations. Autonomous driving technology relies on various sensors, software, and communication systems, so issues related to the safety and security of these systems could affect accident rates.

Regarding H2: it's also valid to suggest that the growth of EVs depends on the development of integrated semiconductors (AI:HBM+NPU+SNS). EVs and autonomous driving are closely related, relying on AI and semiconductor technologies. So, the growth of EVs may drive the development of more integrated semiconductors (AI), which could impact the security and safety of vehicles. Using predictive data to evaluate both hypotheses could be valid. Analyzing the relationship between the two hypotheses using predictive data could help anticipate future trends in the safety and security of the autonomous driving and EV industries.

- **Dependent variable**: Percentage of accidents.
- **Independent variable:** Convergence Semiconductor(AI-rated) Production Growth Rate (predictive data).

Additionally, this paper assumes a linear relationship between semiconductor security and EV safety, which may not be realistic. In reality, this relationship could be nonlinear or exhibit threshold effects, requiring more sophisticated modeling techniques. According to the NHTSA's autonomous vehicle accident (AVA) data, the total proportion of accidents that occurred from 2021 to 2022 is as follows: driver negligence (errors) : 21%, sensor malfunction: 18%, software errors: 15%, adverse weather conditions: 12%, other: 34%. Each company's projected production scale is related to these figures. For sensor-related semiconductors, Intel (Jacinto6) accounts for 20%, Nvidia (Orin) accounts for 20%. For software-related semiconductors, Nvidia (Drive AGX Orin) accounts for 15%. For adverse weather-related semiconductors, Intel (Mobileye) accounts for 15%, Continental V2X accounts for 10%, and Bosch accounts for 10%. These products' application is analyzed through regression analysis to predict a decrease in accidents as table 2.

Table 1. Percentage of accidents vs. Convergence Semiconductor Production Growth Rate (predictive data)

Regression Statistics					
R	0.6401	R-Squared	0.4098	Adjusted R-Squared	0.2130
MSE	0.0057	S	0.0755	MAPE	28.6151

Durbin-Watson (DW)	2.3985	Log likelihood	7.0981		
Akaike inf. criterion (AIC)	-2.0392	AICc	-1.7726		
Schwarz criterion (BIC)	-2.1955	Hannan-Quinn criterion (HQC)	-2.4585		
PRESS	0.0524	PRESS RMSE	0.1024	Predicted R-Squared	-0.8063
Percentage of accidents = 0.2548 - 0.6094 * Convergence Semiconductor Production Growth Rate (Fore outlook)					

ANOVA

	d.f.	SS	MS	F	p-value
Regression	1	0.0119	0.0119	2.0826	0.2447
Residual	3	0.0171	0.0057		
Total	4	0.0290			

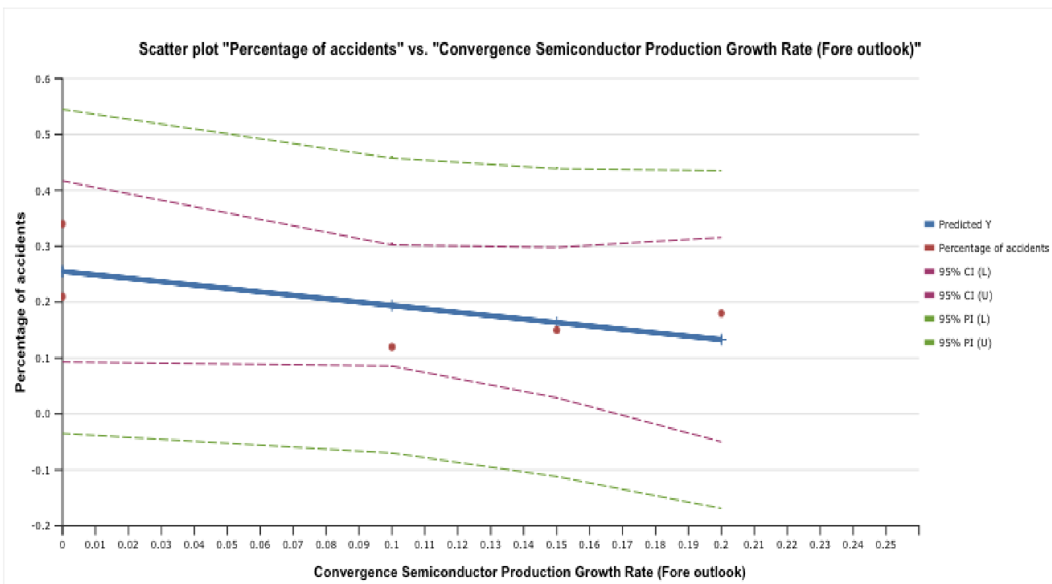

Figure 1. Scatter plot: Accidents vs. Convergence chip

Advanced AI technology is being used to develop automated systems that analyze driving situations in autonomous vehicles and identify semiconductor errors. These systems can utilize existing data to generate new data or predictions, helping to address issues arising from the absence of big data. High-performance AI semiconductor chips can be used to analyze the correlation between battery fire incidents and the usage of high-performance semiconductors. By establishing regression analysis models, the impact of High Bandwidth Memory (HBM) usage on battery fire incidents can be estimated, facilitating the development of safer and more reliable battery products. According to NHTSA's autonomous vehicle accident data, factors such as driver negligence, sensor malfunctions, software errors, and adverse weather conditions are significant contributors to accidents. Analyzing expected accident reductions based on each company's announced production scale and the application of their respective products can help in developing safer autonomous vehicles. Considering these additional factors and analysis methods can broaden and refine the understanding of semiconductor security and EV safety.

4.2 Discussions: Korean perspective

The integration of High Bandwidth Memory (HBM) in EVs is expected to increase the reliability of EV safety and security. With the growth of autonomous vehicles and IoT devices, the demand for HBM technology is expected to rise. Companies such as Google, Microsoft, Baidu, and advanced technology firms in the EV sector are increasingly associated with enhancing EV safety and security [10]. The integration of AI chip(HBM+NPU+SNS) technology in EVs may contribute to a decrease in EV accidents and improve overall safety and security as Figure 2. The increased demand for semiconductor products incorporating HBM technology is relevant to the reliability of EV safety and security. Companies such as Samsung and SK Hynix offer memory devices directly attached to semiconductor chips, providing higher bandwidth. This technology is expected to play a crucial role in the development of autonomous vehicles and IoT devices. So the integration of AI chip in EVs is expected to increase the reliability of EV safety and security. The growth of autonomous vehicles and IoT devices is driving the demand for HBM technology, which is expected to contribute to a decrease in EV accidents and improve overall safety and security.

5. Conclusion

The regression analysis was conducted to examine the relationship between the proportion of accidents caused by sensor errors, software errors, and adverse weather conditions, and the expected adoption rate of AI-integrated semiconductor chips(HBM+NPU+SNS). The results show a positive correlation between the two variables. Specifically, the analysis found that as the adoption rate of fusion neuron semiconductors increases, the proportion of accidents in those areas decreases. We suggest that the paper explores how the fusion of semiconductors can enhance the safety and security of autonomous vehicles and help prevent accidents. However, it's important to note that this correlation does not prove direct causation, and other factors such as security and driver-related factors may also influence the accident rates. Overall, the results of the regression analysis provide evidence that fusion semiconductors are a key factor in enhancing autonomous vehicle security and accident prevention. While other factors may also play a role, the correlation between the adoption rate of fusion semiconductors and the reduction in accidents suggests that these semiconductors can play a critical role in improving the safety and security of autonomous vehicles.

References

[1] L. Guo, B. Yang, J. Ye, J. M. Velni and W. Song, "Attack-Resilient Lateral Stability Control for Four-Wheel-Driven EVs Considering Changed Driver Behavior Under Cyber Threats," in IEEE Transactions on Transportation Electrification, Vol. 8, No. 1, pp. 1362-1375, March 2022. DOI: https://doi.org/10.1109/TTE.2021.3102134

[2] S. Tan, Y. Wang, W. Cheng, T.nLuo, N. Zhang, S. Li, B. Pan, and X. Cui, Cascade Direct Yaw Moment Control for an Independent Eight In-Wheel Motor-Driven Autonomous Vehicle. Electronics. Vol. 11, No. 18 : 2930, 2022. DOI: https://doi.org/10.3390/electronics11182930

[3] Y. Li, Q. Liu, W. Zhuang, Y. Zhou, C. Cao and J. Wu, "Dynamic Heterogeneous Redundancy-Based Joint Safety and Security for Connected Automated Vehicles: Preliminary Simulation and Field Test Results," in IEEE Vehicular Technology Magazine, 2023. DOI: https://doi.org/10.1109/MVT.2023.3263334.

[4] D.S. Seo, A Study on the Application of AI and Linkage System for Safety in the Autonomous Driving, Journal of Korea Convergence Society, Vol.10, No.11, pp.95-100, 2019. DOI: https://doi.org/10.15207/JKCS.2019.10.11.095

[5] Patil, P., Innovations in Electric Vehicle Technology: A Review of Emerging Trends and Their Potential Impacts on Transportation and Society. Reviews of Contemporary Business Analytics, Vol.4, No.1, pp.1–13, 2021. Retrieved from https://researchberg.com/index.php/rcba/article/view/123

[6] Shuai Pan, Lewis M. Fulton, Anirban Roy, Jia Jung, Yunsoo Choi, and H. Oliver Gao, Shared use of electric autonomous vehicles: Air quality and health impacts of future mobility in the United States,Renewable and Sustainable Energy Reviews, Vol.149, 2021.
[7] Megha, Swati, et al. "A survey of blockchain solutions for autonomous vehicles ecosystems." Journal of Physics: Conference Series. Vol. 1694. No. 1. IOP Publishing, 2020.
[8] Chen Y, Shiwakoti N, Stasinopoulos P, and Khan SK. State-of-the-Art of Factors Affecting the Adoption of Automated Vehicles. Sustainability, Vol. 14, No. 11:6697, 2022. DOI: https://doi.org/https://doi.org/10.3390/su14116697
[9] N. E. Bezai, B. Medjdoub, A. Al-Habaibeh, M. L. Chalal, and F. Fadli, Future cities and autonomous vehicles: analysis of the barriers to full adoption, Energy and Built Environment, Vol. 2, No. 1, pp 65-81, 2021. DOI: https://doi.org/10.1016/j.enbenv.2020.05.002.
[10] D.S. Seo, Study on the Failure of Autonomous Mobility in World Network Cities, The International Journal of Internet, Broadcasting and Communication, Vol. 15, No. 3, pp 73-81, 2023. DOI:https://doi.org/10.7236/IJIBC.2023.15.3.73.