

Article

Preparing Society for Automated Vehicles: Perceptions of the Importance and Urgency of Emerging Issues of Governance, Regulations, and Wider Impacts

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Abstract: This study explores the overall picture of how people perceive the importance level and urgency level regarding issues associated with automated vehicles, by sorting out ten issues, developing a questionnaire with 66 measurement items, and investigating how Artificial Intelligence (AI) experts and Computer Science (CS)/Electrical Engineering (EE) majors assessed these issues. The findings suggest that AI experts in Taiwan believed that the top five issues for preparing a society for autonomous vehicles (AVs) should include (1) data privacy and cybersecurity, (2) regulation considerations, (3) infrastructure, (4) governance, and (5) public acceptance. On the other hand, for their student counterparts, the results (1) demonstrate a somewhat different order from the third to the fifth place, (2) show an attention-focused profile on the issue of cybersecurity and data privacy, and (3) indicate that gender and a few wider-impact variables (technology innovation, infrastructure) are significant predictors for the assessment on the importance level of AVs, while some wider-impact variables (technology innovation, governance, economic benefits, infrastructure), which are positively associated, as well as concerns variables (cybersecurity and data privacy, regulations), which are negatively associated, could be predictors for the urgency level of AVs. Suggestions for future research and policymakers are provided.

Keywords: automated vehicles; governance; regulation; social impact; perceptions

1. Introduction

As the automobile and technology industries have made significant leaps in autonomous vehicle (AV) development, e.g., a level-4 automated driving system was achieved in early 2020, highly automated vehicles (levels 3–5) have attracted attention from both academia and policymakers. Even though academic research on AVs has long been dominated by the fields of engineering and computer science, research efforts regarding the impacts of automated driving systems on human factor aspects, traffic flow characteristics, and fuel efficiency have been conducted for the last two decades [1,2]. Recently, the interest in wider social, economic, and environmental implications [1–4], especially on a call for policymakers to utilize their roles in governing and regulating AV and its potential risks [5–8], is growing as the technology has accelerated. In this way, emerging responses to the risks of AV, addressed by different governments, were compared [9,10]. Furthermore, a transformation process that emphasizes inclusivity and democracy has been proposed [10–12].

At the same time, the Klynveld Peat Marwick Goerdeler (KPMG), a multinational professional services network, conducted an International Autonomous Vehicles Readiness Index (AVRI) report for the purposes of opening up dialogue and sharing what different countries have been doing in different

sectors as part of their contingency plan. Their report suggested that, from 2018 to 2020, governments around the world have participated in a transformation process, from racing to position themselves as leaders in the field by enabling the technology to be tested [12], working on delivering the AVs' anticipated social benefits while mitigating their potential challenges [13], to dealing with complex tasks in the implementation process that address risks and opportunities for AVs to operate safely and effectively in our society, as AV technology is entering the period of development maturity [14].

Most of the above studies employed the methodologies of literature reviews, policy overviews, and data assessments; at the same time, scenario analyses were also popular in identifying plausible future development and sustainability of AV and formulating policies to cope with the AVs' potential undesirable subsequent influences, in addition to the positive outlook of smart mobility [15–20]. On the other hand, rather than attempting to predict what the future with AV holds, Cohen, Stilgoe, and Cavoli conducted systematic stakeholder workshops to generate insights for AV governance in the UK and formulated questions in four categories: technological and market developments, the use of AVs and reactions to them, the wider impact of AV, and the role of the public sector [6,21].

To better capture how the academic and professional communities have built up our initial understanding regarding emerging issues on AVs' wider impact, governance, and regulations, as well as risk management of the use of AVs, the related literature was reviewed.

2. Literature Review

2.1. AV Impact, Governance, and Regulation

Milakis, van Arem, and van Wee conducted a study with the use of a ripple effect model to describe the potential impacts of automated driving on policy and societal implications. In this model, implications were illustrated and categorized into three stages: (1) first order—traffic, travel costs, and travel choices; (2) second order—vehicle ownership and sharing, land use, and infrastructure; and (3) third order—safety, social equity, economics, public health, energy consumption, and air pollution. While most of the existing literature characterized first-order effects to possibly be beneficial in terms of road capacity, accident risk, fuel efficiency, and emissions, this study reminded us the third-order benefits remained unclear for various reasons, such as the AV possibly causing additional travel demands [1].

Cohen and Cavoli stated that the way this transformative technology should be governed remains under-researched. They explored the possible consequences of government (non) intervention with a focus on capitalist market economics, in particular liberal states (e.g., Australia, Canada, Ireland, New Zealand, the UK, the US) and conservative states (e.g., Finland, France, Germany, Italy, Japan). While a government comprises public authorities at the national, regional, and local level, governance is defined as the policymaking processes at the national and subnational level. They suggested that government intervention included planning/land use, regulation/policy, infrastructure/technology, service provision, and economic instruments, and they recommended anticipatory governance (active engagement) and precautionary governance (avoidance of risk) over laissez-faire governance (abstention from interfering in the workings of the free market) [5]. Specifically, anticipatory governance was used as the keyword to broaden the set of issues considered relevant for AI implications [6].

In addition to the aforementioned social, economic and environmental implications and the urge for government intervention, several studies have articulated AVs' potential risks and expressed concerns over the capacity of governments in the management of wider implications in a timely manner, while acknowledging the opportunities and benefits. First, Fagnant and Kockelman [7] provided an order-of-magnitude estimation about the possible economic impacts of AV in the US context and pinpointed that barriers to implementation included vehicle costs, AV tests and licensing, litigation and liability, data security, and privacy. Similarly, Allen and Overy pointed out the key trends of autonomous and connected vehicles—an industry identified as the third highest spender on Research and Development (R & D) behind healthcare and software and electronics—from the perspective of

legal issues and indicated (1) the need to regulate the testing and deployment of AVs, (2) that AVs gives rise to new liability issues, (3) an emphasis on minimizing risks to data subjects, and (4) the threat to cyber security, among others [8].

Two comparative studies further illuminated how different governments responded to the potential risks of AV. One of the explored strategies was adopted by nine jurisdictions, whereas the other analyzed governance cultures from three societies. Taeihagh and Lim [9] considered that AVs might create unintended consequences and potential environmental, market, social, organizational, political, financial, technological, and turbulent risks. Among them, several types of technological risk are associated with AVs: safety, liability, privacy and cybersecurity, among others. Five types of governing strategies can be taken: first, no response; second, prevention or avoid risks by taking preventive action; third, control or allow the existence of risks but take control by implementing formal policies and regulations; fourth, toleration or take action to ensure the system is robust to cover risks in a wide range of circumstances; and finally, adaptation or embrace uncertainty and improvise its performance. The findings suggested that (1) for risk management, most countries adopted the strategy of light control to provide sufficient room for innovation, while Germany and Singapore adopted a heavy control strategy and Japan adopted the prevention orientation; (2) for liability, most countries adopted the strategies of no response or light control, with the exception of the UK for adopting the tolerance orientation by laying out a comprehensive list detailing the liability of insurers and AV owners in the event of accidents under a wide range of situations; (3) for privacy, all adopted the strategies of control (e.g., China, Japan, Singapore, the US) and light control (e.g., Australia, Germany, South Korea, the UK); and (4) for cybersecurity, diverse strategies were adopted, ranging from no response (e.g., Australia, Germany, Japan, South Korea), control (e.g., China, Singapore, the US), to adaptation (the UK).

Mladenovic et al. [10] identified governance culture as the underlying cultural value associated with acceptable purposes and appropriate mechanism of governance practices. They found (1) for the domains and mechanism of governance, while Finnish culture emphasized extensive public experimentation, the UK stressed liability and cybersecurity, and Germany highlighted liability and ex post transparency, personal data privacy and algorithms, as well as federal cohesion; and (2) for governance actants in AV development, even though all three cultures have an inclination to artifacts decoupled from accountability, Finnish culture emphasized tight network for expert-based assessment and saw citizens as rule-following consumers. In contrast, the UK and Germany stressed the need for new research and government organization outside of the transport sector, whereas the UK saw citizens as resilient users and Germany treated citizens as subjects that needed to be protected. Their concluding remarks have highlighted the need for wider societal inclusion and engagement and to reinforce accountabilities by strengthening democracy in relation to governance. Similar observations from a transition management perspective were proposed to articulate guiding principles for AV transition: (1) inclusivity, involving “outside” viewpoints and interests; (2) democracy, the need to engage with all sectors of society; (3) diversity, multiple ways of organizing and practicing governance; and (4) openness, creating space for different visions of the future and allowing different transition pathways to coexist [11].

2.2. *Preparing for the Future*

The KPMG suggested that private sector research and testing is essential; however, on its own it would not be sufficient for public sector engagement with legislation, and infrastructure is also important. To support an AV future by spreading best practice, they proposed a four-pillar model to assess countries’ openness and preparedness for AV [12]. In the third edition of AVRI, 30 countries and jurisdictions were assessed on 28 measures under four pillars: (1) policy and legislation (AV regulations, government-funded AV pilots, AV-focused agency, government readiness for change, future orientation of government, efficiency of the legal system in challenging regulations, data-sharing environment); (2) technology and innovation (industry partnerships, AV firm headquarters, AV-related patents,

industry investments in AV, availability of the latest technologies, innovation capability, cybersecurity, assessment of cloud computing, market share of electric cars); (3) infrastructure (electric vehicle charging stations, 4G coverage, quality of roads, technology infrastructure change readiness, mobile connection speed, broadband); and (4) consumer acceptance (population living near test areas, civil society technology use, consumer ICT adoption, digital skills, individual readiness, online ride-hailing market penetration) [14].

A review on AV policy formulation suggested that there are three methods to deal with a future with uncertainties and potential disruptive consequences. These are (1) policy transfer and migration of using knowledge about policymaking from one setting and implementation to another, (2) dynamically adaptive methods, to take immediate action and create a framework for future actions that allow for adjustment over time, and (3) scenario analysis and backcasting, which can be useful when the business-as-usual case is no longer appropriate and significant transformation is required [15]. Among them, scenario analysis was widely adopted. For example, a scenario analysis was conducted for AV and energy impacts with three scenarios discussed: partial automation and personal vehicles dominate, full automation and personal vehicles dominate, and full automation and shared vehicles dominate [16]. Similarly, scenario analysis was exercised to provide a country-level evaluation on AV and greenhouse gas emissions. The findings suggested that, with a higher AV penetration rate, an optimistic scenario in association with a net reduction in emissions is expected to be realized in China [17]. For transport implications, scenario analysis was performed for the Netherlands for the period of 2030–2050 through workshops by a group of diverse experts. Four scenarios (AV in stand-by, in bloom, in demand, in doubt) were constructed, assuming combinations of high or low technological development and restrictive or supportive policies [3]. Another study was designed to identify critical decisions concerning AV by using a scenario-based approach (optimistic vs. pessimistic), and they found key decisions included sharing, social exclusion, environmental sustainability, automatic cooperation, public transport, inter-modal regulations, network information system, sensitive data management, parking, land use, and transport network design [18]. A third study presented three transition pathways toward urban mobility by the year 2040: the “individual” scenario that sees mobility as an individual right, the “shared” scenario that integrates urban mobility, and the “smart” scenario that combines smart grids and AV [19]. Finally, a study differentiated backcasting from forecasting by suggesting forecasting is suitable for the first two levels of uncertainty, a clear enough future and alternative future. Backcasting is particularly appropriate for the third and the fourth levels of uncertainty, a multiplicity of plausible futures, and the unknown future. The study described three visions for an Italian city based on more than ten AV-related items: the business-as-usual vision, the strong deregulation vision, and the strong regulation vision [20].

To contrast, Cohen, Stilgoe, and Cavoli conducted systematic stakeholder workshops to broaden the debate and stretch the ambitions of debates around responsible innovation. The participants of mapping the territory, scene discussion, and plenary feedback sessions included government officials, people from the industry, people from the third sector, and researchers from higher institutions. More than 350 questions were sorted out into four categories: (1) technological and market developments, the set of actions that will determine the AV offer; (2) the use of reaction to AVs, how AV will be accessed; (3) the wider impact, the range of first- and higher-order impacts of AV; and (4) the public sector’s role, the scope for government at all levels to affect the directions of technology, and the consequences of uptake and the policy issues that are likely to arise [6,21].

2.3. The Present Study

To summarize, the recent literature regarding the wider impact, governance, and regulation of AI, as well as the plausible future development of AI, have provided a comprehensive coverage upon emerging issues associated with preparing the society for AV. To be specific, ten issues were identified and explored, and some were discussed in depth and illustrated with examples by academic and professional communities: (1) governance [5–15,17–21]; (2) regulation considerations [5–15,18–21];

(3) data privacy and cybersecurity [6–14,18,21]; (4) traffic, environmental and public health benefits [1–4,6,9,12–21]; (5) economic and industry [1,3,5–7,12–14,21]; (6) public acceptance [6,10–14,21]; (7) social equity [1,6,10,11,21]; (8) technology innovation [6,12–14,18,21]; (9) transportation planning [1,3,5,6,12–14,18,21]; and (10) infrastructure [1,5,6,12–14,21]. Generally speaking, these issues characterize three major themes. First, governance, public sector's roles upon the overall AV governing; second, regulation, regulation considerations (e.g., safety and testing, liability, and insurance) and data privacy and cybersecurity; and finally, the wider social, economic, and environmental impact, including traffic, environmental and health benefits, economic and industry, public acceptance, social equity, technology innovation, transportation planning, and infrastructure. Furthermore, the study by Cohen, Stilgoe, and Cavoli [6,21] generated specific questions, with some corresponding to the above issues from AVs' various stakeholders' viewpoints and, thus, can be served as a database for policy-relevant communication. Therefore, the purposes of this study were (1) to sort out issues related to bridging to an AV future for sustainable development based on recent studies and reports; (2) to extend Cohen et al.'s study [6,21] by selecting some of the questions associated to the ten issues and constructing a questionnaire instrument; (3) to involve participants who are currently outsiders in the dialogue of the aforementioned studies but will be core members in the near future, the Computer Science (CS)/Electrical Engineering (EE) major undergraduate and graduate students, in addition to AI experts in the higher institution, for a more inclusive perspective; and (4) to initiate a conversation with policymakers as a social science researcher in Taiwan, since it was the first time Taiwan was assessed as a new member in the 2020 KGMP AVRI report and was ranked 13th [14].

3. Research Methodology

3.1. Research Questions

This study is part of a larger project entitled, "Competition or Collaboration between Human Beings and AI?" sponsored by the Ministry of Science and Technology in Taiwan, with a focus on "AI applications and their social impact". The project was funded for Taiwanese social science researchers to work side by side with their technological counterparts to explore the opportunities and the challenges AI generates. Following a project on examining the approach toward the impact of AI on human professions, AV and smart homes from the previous year [22], as the second year of a four-year project, we focused on AV, and set out to investigate the perceptions of Taiwanese AI experts and CS/EE majors on the importance and urgency of emerging issues of governance, regulation, and the wider impact toward preparing society for the future of sustainable AV. The specific research questions of the present study are as follows:

1. What are the perceptions of AI experts on the levels of importance and urgency toward the ten issues: governance, regulation considerations, data privacy and cybersecurity, traffic/environmental/public health benefits, economic and industry, public acceptance, social equity, technology innovation, transportation planning, and infrastructure?
2. What are the perceptions of CS/EE majors on the levels of importance and urgency toward the ten issues: governance, regulation considerations, data privacy and cybersecurity, traffic/environmental/public health benefits, economic and industry, public acceptance, social equity, technology innovation, transportation planning, and infrastructure?
3. Among the ten issues and background variables, what are the significant predictors for overall perceptions of the levels of importance and urgency upon AV development in Taiwan, according to CS/EE majors?

3.2. Participants

Existing AV studies were mostly based on experts' standpoints, but this study attempted to broaden the participation. On the other hand, the survey used for this research consisted of high-level technical terminology; therefore, we involved CS/EE majors only, rather than students with a wider

profile or even the general public, as a comparative group to AI experts to obtain a more diversified voice at this stage. A pilot study was conducted in March 2020 with $N = 206$. Formal survey data were collected in April 2020, with 31 AI experts from various higher institutions in Taiwan, and 335 CS and EE majors. Information on the sample distribution is shown in Table 1.

Table 1. Sample distributions of the AI experts ($N = 31$) and the Computer Science (CS)/Electrical Engineering (EE) majors ($N = 335$).

Variables		AI Experts Percentage (%)	CS/EE Majors Percentage (%)
Gender	Male	93.5	67.5
	Female	6.5	32.5
Level	Undergraduate	0	49.3
	Master	0	44.5
	Ph. D	100	6.3

3.3. Measurements

3.3.1. Importance and Urgency on Ten AV Issues

Ten issues associated with preparing the society for AV were identified as mentioned in the earlier section, with a total of 66 questionnaire items constructed for the present study. These items were developed based on three major sources: a study by Cohen, Stilgoe, and Cavoli's study [6,21], on the context of Taiwan [22–24], and four Taiwanese AI experts, who have research expertise on regulation and governance, technology innovation and industry, engineering and computing, and AI application. The backtranslation method was used for all measures in the questionnaire to ensure consistency of meaning across languages. Specifically, participants were asked to respond to “If AV is a future trend, how would you assess the importance and urgency of the following issues?” In other words, for each item, participants were asked to respond to two individual questions: “How would you assess its importance?” and “How would you assess its urgency?” with a 9-point Likert scale, ranging from 1 (extremely unimportant/unurgent) to 9 (extremely important/urgent).

The ten issues, followed with the number of items, one questionnaire item as an example, and the Cronbach alpha coefficients from the CS/EE majors, are as follows.

- (1) Governance, 11 items, “How can we set clear road safety threshold and road safety specifications for AVs?”, and Alpha reliability for student sample: Importance (0.842) and Urgency (0.898).
- (2) Regulation consideration, 12 items, “In case of accidents involving autonomous vehicles, what is the legal responsibility of the owner of the autonomous vehicle?”, and Alpha reliability for student sample: Importance (0.89) and Urgency (0.926).
- (3) Data privacy and cybersecurity, 5 items, “How do we prevent the impact of information security (virus, hacker attack) of autonomous vehicles system networking on driving safety?”, and Alpha reliability for student sample: Importance (0.893) and Urgency (0.93).
- (4) Traffic, environmental, and public health benefits, 6 items, “What is the ideal operation of autonomous vehicles to reduce traffic accidents?”, and Alpha reliability for student sample: Importance (0.841) and Urgency (0.874).
- (5) Economy and industry, 7 items, “What may be the new economic benefits brought by the development of autonomous vehicles in the development of software and related industries?”, and Alpha reliability for student sample: Importance (0.859) and Urgency (0.902).
- (6) Public acceptance, 4 items, “Who should own and control the data of autonomous vehicles and the purpose of using the data?”, and Alpha reliability for student sample: Importance (0.826) and Urgency (0.832).

- (7) Social equity, 5 items, “What may be the possible relationship between autonomous vehicles and resource equality (e.g., will it benefit specific groups or improve the accessibility of transportation shared by the general public)?” Alpha reliability for student sample: Importance (0.843) and Urgency (0.861).
- (8) Technology and innovation, 5 items, “What is the new value of big data obtained and generated by planning autonomous vehicles in business and transportation?”, and Alpha reliability: Importance (0.859) and Urgency (0.887).
- (9) Transportation planning, 6 items, “How may autonomous vehicles resource control software be applied in traffic sign, traffic rules, and construction regulations?”, and Alpha reliability: Importance (0.874) and Urgency (0.881).
- (10) Infrastructure, 5 items, “What will be the possible damage and cost of the communication infrastructure needed for autonomous vehicle operation in the process of promotion?”, and Alpha reliability: Importance (0.903) and Urgency (0.91).

3.3.2. Overall Importance and Urgency of AV Development in Taiwan

Participants were also asked to respond to the overall importance and urgency of AV development in Taiwan: “What do you think is the importance of the development of autonomous vehicles in Taiwan?” and “What do you think is the urgency of the development of autonomous vehicles in Taiwan?”, both with a 9-point Likert scale.

4. Results

4.1. Importance and Urgency of the Ten Issues

4.1.1. Governance

For each of the measurement of emerging-issue items of governance, with a range of scores of one (extremely unimportant/unurgent) to nine (extremely important/urgent), the means (M) are shown in Figure 1, with the scores from the AI experts ($N = 31$) shown in blue bars and the scores from the CS/EE majors ($N = 335$) shown in green. We used the M scores assessed by the AI experts to arrange the order of the question items in the figure, from highest to lowest. In addition, we utilized the median scores of the 66 items across the ten issues to differentiate them into two categories: the above median and the below median. The median scores were 7.370 and 6.648 for importance level and urgency level, respectively, for the AI experts’ assessment, whereas the median scores were 7.305 and 6.160 for the importance level and urgency level, respectively, for the CS/EE majors’ assessment. Then, we categorized the measurement items into four groups: (1) above median importance and above median urgency, which were highlighted in red; (2) above median importance but below median urgency, which were highlighted in orange; (3) below median importance but above median urgency, which were highlighted in purple; and (4) below median importance and below median urgency, which were highlighted in gray.

The results suggested that, among the 11 items, five were assessed as both important and urgent by the AI experts, two as important but not urgent, one as not important but urgent, and three as not important and not urgent; while four as both important and urgent, two as important but not urgent, and five for not important and not urgent, by the students. Both AI experts and CS/EE majors indicated the most important and urgent task related to governance is to “set clear road safety threshold for AV”, and the second and third priorities, for AI experts, were “AI related policies” and “AI integrated into public transportation system”, meanwhile, the CS/EE majors stressed them to be “governance and public trust” and “government and citizens interact to determine the AI development and deployment”.

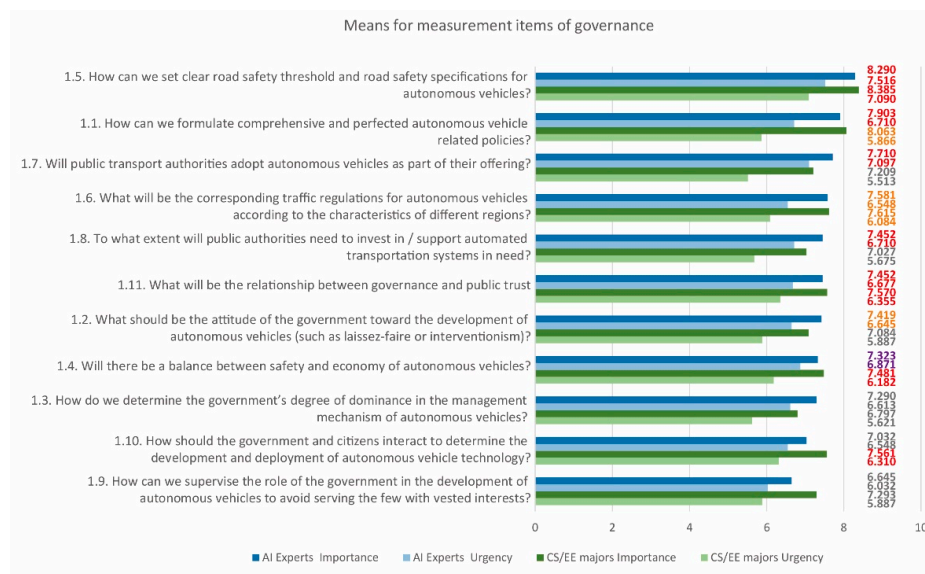


Figure 1. Means for measurement items of governance.

4.1.2. Regulation Considerations

Figure 2 shows that, among the 12 items for regulation considerations, eight were categorized as both important and urgent by the AI experts, while CS/EE majors considered 11 items to be important and urgent, with only one item being urgent but relatively not so important. Recent studies proposed the significance of AV testing, liability, and insurance [7–10,12–14]. This study provided empirical evidence to support their advocacy and found that liability-related questions received the highest attention, especially “the legal responsibility of the owner of the AV” followed by “the legal responsibility of the original manufacturer of the AV” and “the legal responsibility of R & D personnel of the AV”. At the same time, AI experts were concerned about the insurance consideration, while CS/EE majors stressed the importance and urgency regarding AI testing. Both AI experts and CS/EE majors were relatively uncertain about the “government’s power to enforce the supervision of autopilot algorithm”.

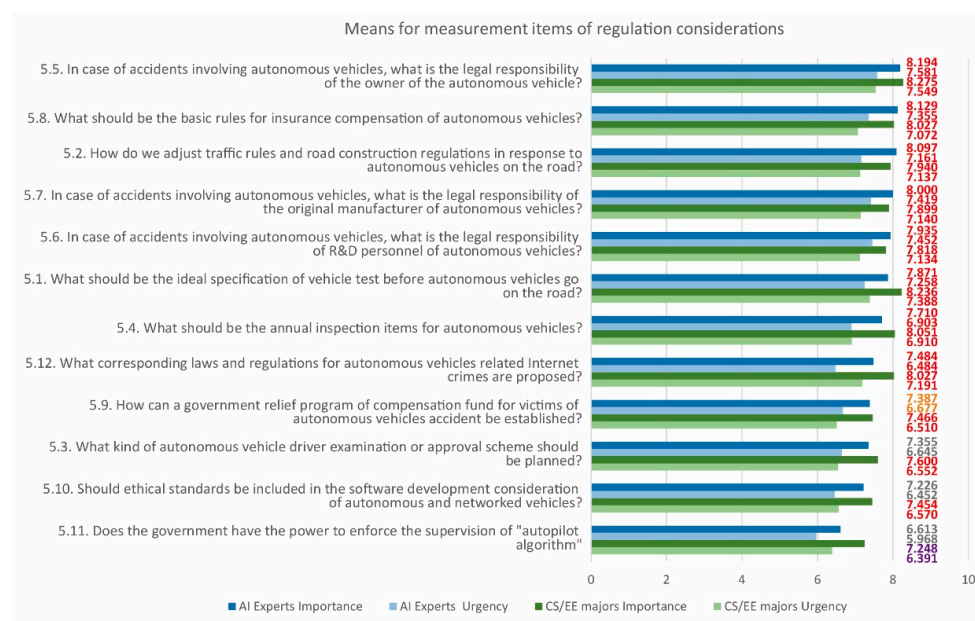


Figure 2. Means for measurement items of regulation considerations.

4.1.3. Data Privacy and Cybersecurity

Moreover, both AI experts and CS/EE majors assessed all five items related to data privacy and cybersecurity to be important and urgent at the same time, according to Figure 3. These findings also provided evidence to corroborate most recent studies' indicating an emergent need for policy and strategies to minimize risks to data, (e.g., [6–14,18,21]). In addition, our findings suggested that the younger generation was especially concerned about this issue; actually, their mean scores for these five items were found to be higher or much higher than those reported by their counterparts.

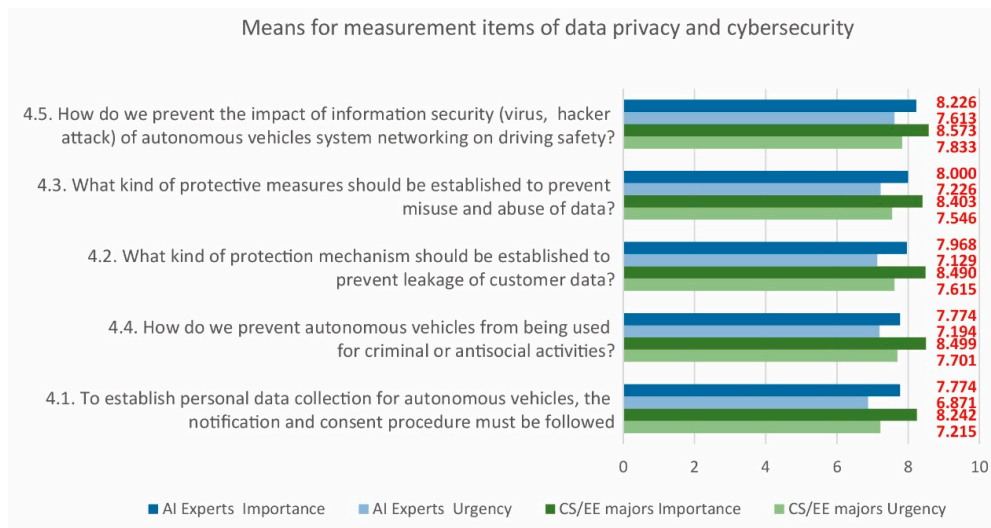


Figure 3. Means for measurement items of data privacy and cybersecurity.

4.1.4. Traffic, Environmental and Public Health Benefits

Figure 4 shows that, among the six items related to the traffic, environment, and public health benefits of AV impact, one item was assessed as important and urgent by both AI experts and CS/EE students: the traffic benefit regarding “reducing traffic accidents”. Another item assessed by AI experts as important and urgent was AVs’ positive impact upon the wellbeing of the disadvantaged by “improving their mobility”. It is interesting to note that, many extant studies suggested it might bring about potential traffic, environment and public health benefits into our future society, but when the corresponding items were put together with items associated to issues like AI governance, regulation, and data security, their importance and urgency levels appeared not to be recognized: Most items were assessed as not important and not urgent by both groups.

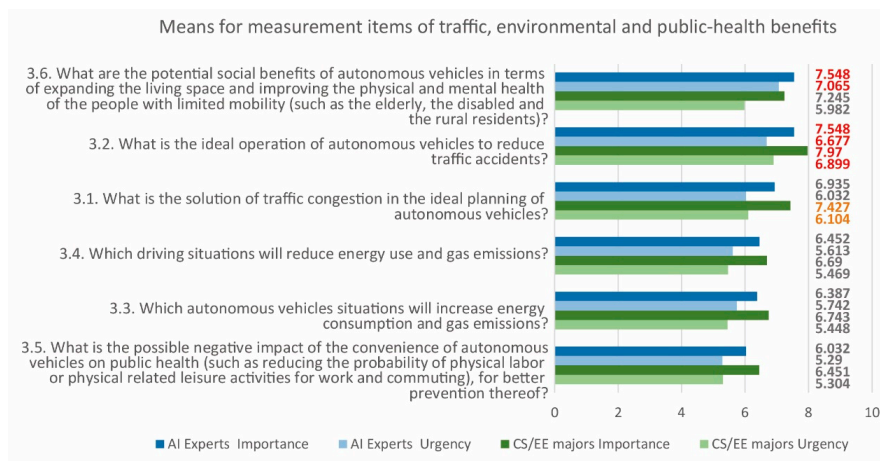


Figure 4. Means for measurement items of traffic, environmental and public-health benefits.

4.1.5. Economy and Industry

Under the wider impact, both AI experts and CS/EE majors assessed two items to be important and urgent at the same time among the seven items for economy and industry: “the economic benefit regarding software and related industries” and “overall impact on society and national economy”, as shown in Figure 5. In other words, these two economy-related benefits were perceived to be as important and urgent as the traffic-related benefits regarding reducing accident rate. Another item reported to be important and urgent by AI experts was “the impact of cross regional alliance”, while CS/EE majors were concerned about the urgency related to “the job loss caused by AV” and the importance of positive impact on “transportation and logistics industries”.

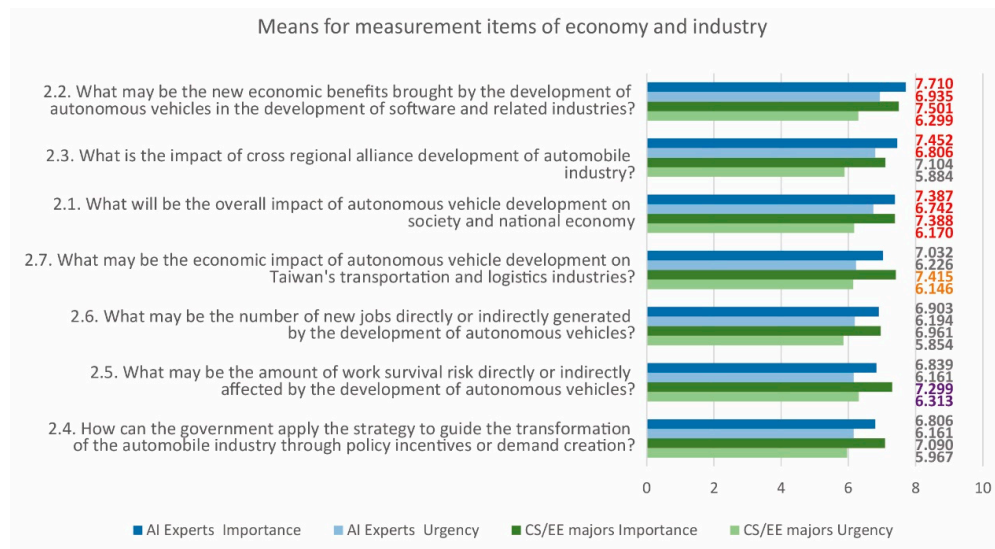


Figure 5. Means for measurement items of economy and industry.

4.1.6. Public Acceptance

Figure 6 shows that, among the four items, both AI experts and CS/EE students assessed two data privacy items under public acceptance to be important and urgent: “Who should own and control the data of AV and the purpose of using the data?” and “what surveillance system will be necessary/justifiable for autonomous vehicles?” In addition, CS/EE majors also considered “Can society accept the handing of life/death decisions of computers?” as important and urgent.

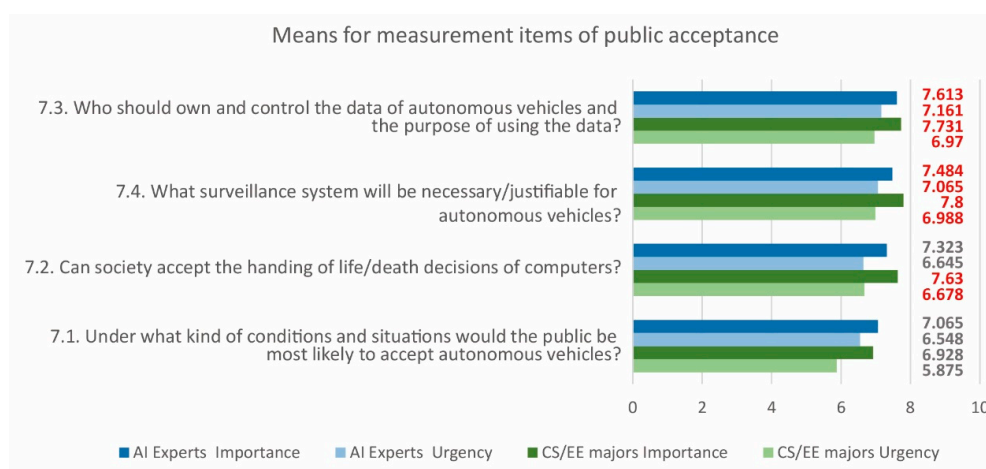


Figure 6. Means for measurement items of public acceptance.

4.1.7. Social Equity

Figure 7 shows that both AI experts and CS/EE majors perceived items linked to social equity to be (relatively) not particularly important or urgent, compared to items associated with other issues, toward preparing a society for the AV future.

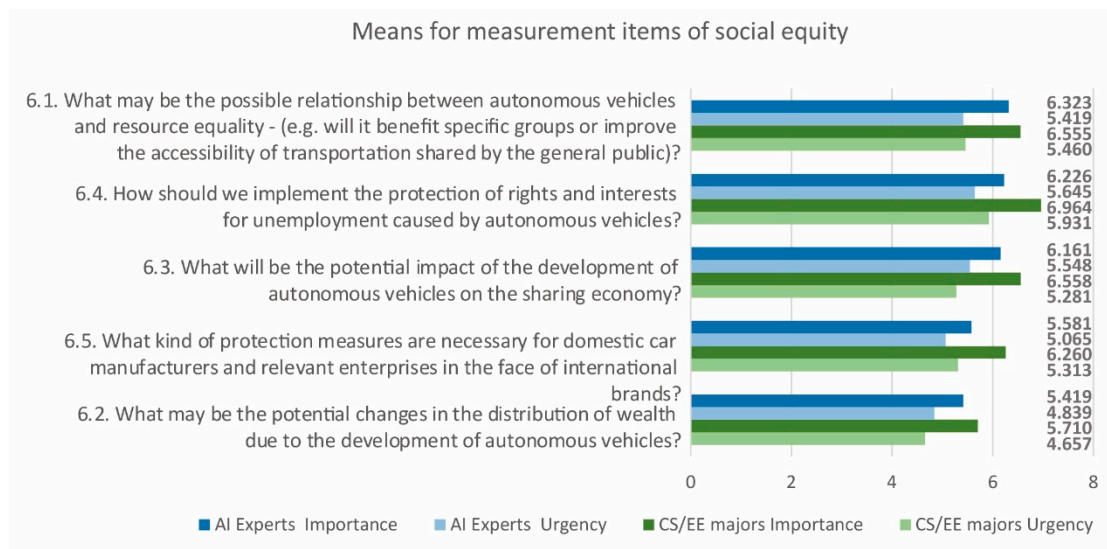


Figure 7. Means for measurement items of social equity.

4.1.8. Technology and Innovation

Similarly, Figure 8 shows that both AI experts and CS/EE majors perceived items associated to technology and innovation to be relatively not so important or urgent compared to items related with other issues toward preparing a society for the AV future.

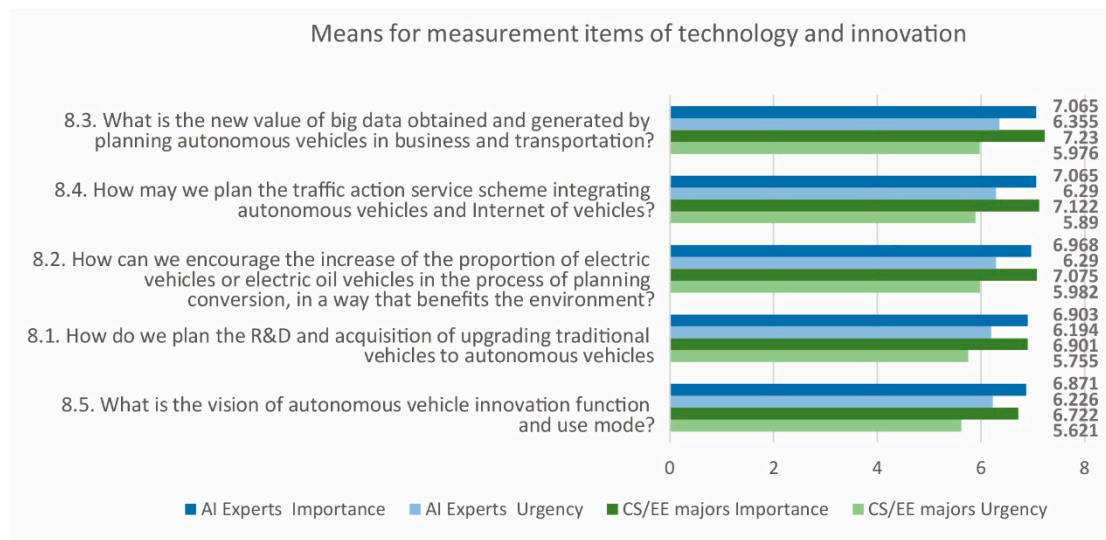


Figure 8. Means for measurement items of technology and innovation.

4.1.9. Transportation Planning

Furthermore, among the six items related to transportation planning, as shown in Figure 9, only one item was assessed as important and urgent by both AI experts and CS/EE majors: "How may autonomous vehicles resource control software be applied in traffic sign, traffic rules, and construction regulations?"

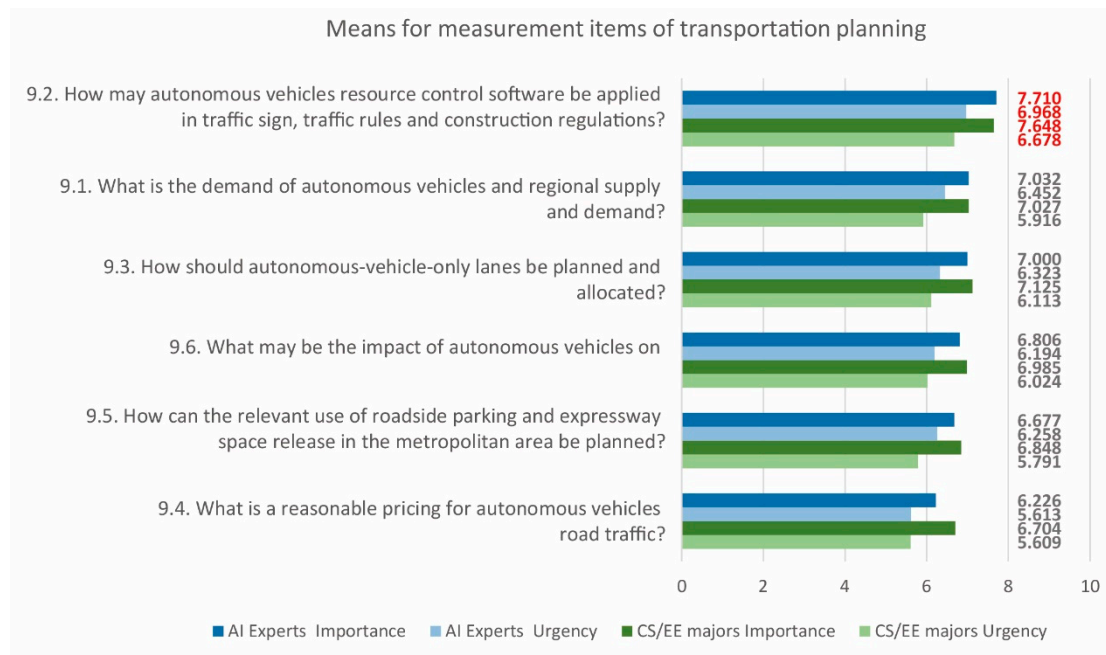


Figure 9. Means for measurement items of transportation planning.

4.1.10. Infrastructure

To contrast, for the final issue under the wider impact, among the five items related to infrastructure, AI experts assessed four items to be both important and urgent, while CS/EE majors assessed only two items to be both important and urgent, as shown in Figure 10. The two items recognized by both groups were “the possible damage and cost” and “the environment best suited for early development”. On the other hand, AI experts also considered the questions “how compatible is current infrastructure with the future demand of autonomous vehicles?” and “how can the infrastructure construction and autonomous vehicle technology develop synchronously?” to be important and urgent, while CS/EE majors perceived them to be important but not urgent.

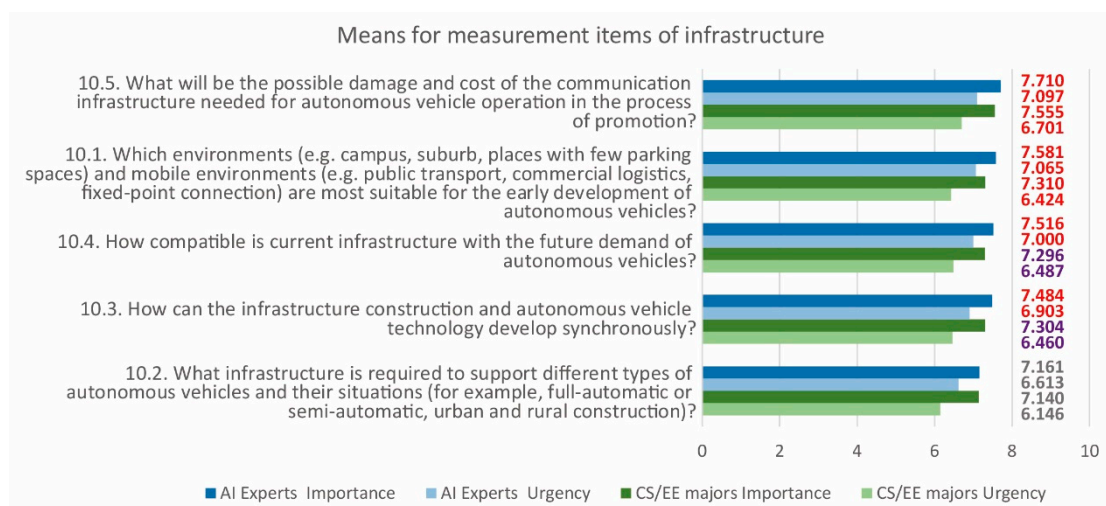


Figure 10. Means for measurement items of infrastructure.

4.2. Overall Importance and Urgency of the Ten Issues

Figure 11 presents the M and SD for each issue, by calculating the average score from items under the same issue. Again, we used the M scores assessed by the AI experts to arrange the order of

measurement items in the figure, from highest to lowest. Generally consistent patterns were found from the previous section; the findings indicated the top five issues in terms of importance and urgency: (1) data privacy and cybersecurity, (2) regulation considerations, (3) infrastructure, (4) governance, and (5) public acceptance, according to AI experts, while CS/EE majors assessed the top five to be (1) data privacy and cybersecurity, (2) regulation considerations, (3) public acceptance, (4) governance, and (5) infrastructure, demonstrating a somewhat different order for the third to the fifth place. Nevertheless, both groups of respondents indicated similar opinions regarding the remaining issues: the sixth to the least important and urgent were: economy and industry, technology and innovation, transportation planning, traffic/environmental/public health benefits, and social equity.

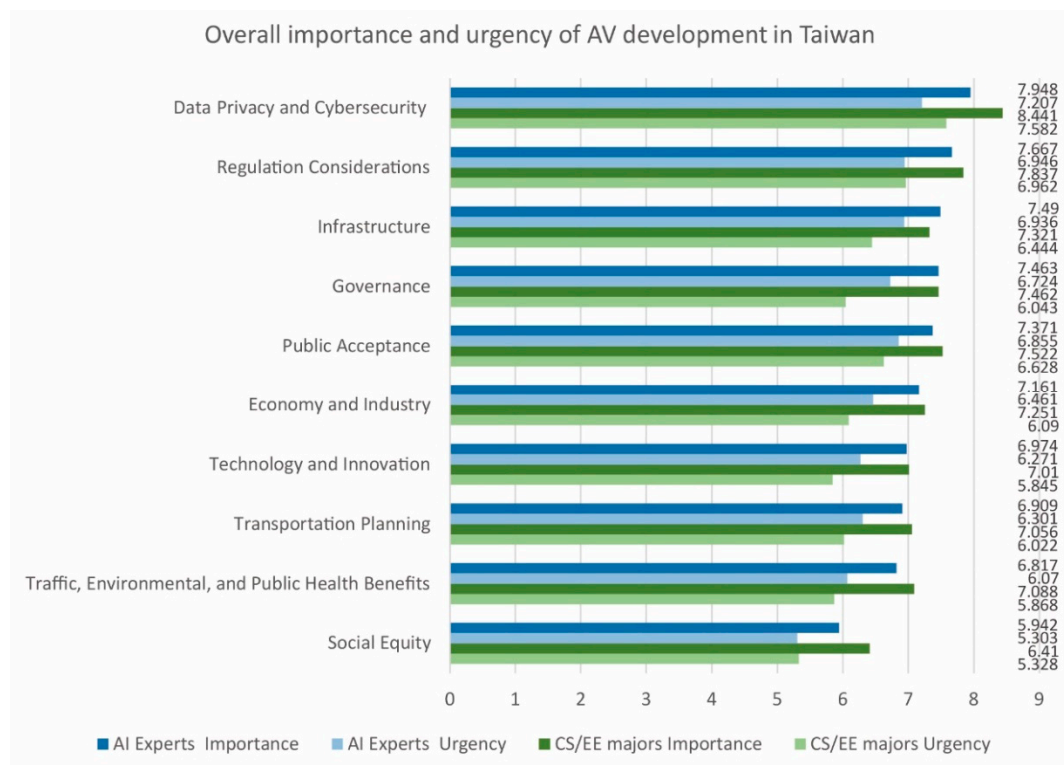


Figure 11. Overall importance and urgency of AV development in Taiwan.

4.3. Predictions on the Importance and Urgency of AV in Taiwan by CS/EE Majors

Finally, when respondents were asked “what do you think is the importance of the development of autonomous vehicles in Taiwan” and “what do you think is the urgency of the development of autonomous vehicles in Taiwan”, a mean score of 7.387 (SD = 1.687) was found for the importance level, and 6.548 (SD = 1.690) for the urgency level, for AI experts, while 7.307 (SD = 1.362) for importance level, and 5.785 (SD = 1.814) for urgency level, for CS/EE majors. Then, two regressions were performed, both on the importance and on the urgency levels of AV in Taiwan, with two background variables, gender and academic level (graduate vs. undergraduate), and ten issues (mean scores of the ten issues) as independent variables, 12 in total, with data collected from CS/EE students. A correlation of 0.634 is found between the importance level and the urgency level reported by the CS/EE students. Since the sample size of the AI experts was quite small, regression analyses were not performed for this group.

For the importance level of AV development in Taiwan, three variables were found to be significant predictors, accounting for 26.1% of the variance, as shown in Table 2: gender, technology and innovation, and infrastructure. Those who are more likely to report a higher importance level of AV development in Taiwan are male, are students with a higher tendency of perceiving technology and innovation as an important issue, and are those who have a higher tendency of perceiving infrastructure as an important issue. On the other hand, with regard to the urgency level of AV development in

Taiwan, six variables were found to be significant predictors. Four variables were positively associated: governance, technology and innovation, infrastructure, and economy and industry; two variables were found to be negatively related, data privacy and cybersecurity and regulation considerations, which have 42.2% of variance, shown in Table 2. In other words, students who have a higher tendency to perceive governance, technology and innovation, infrastructure, and economy and innovation to be urgent issues and those who have a lower tendency to perceive data privacy and cybersecurity and regulation considerations to be urgent issues are more likely to perceive a higher urgency level in relation to AV development in Taiwan.

Table 2. Regressions of importance/urgency of the development of autonomous vehicles in Taiwan and importance/urgency of ten AV issues as predictors ($N = 335$).

Variable	What Do You Think Is the Importance of the Development of Autonomous Vehicles in Taiwan?		What Do You Think Is the Urgency of the Development of Autonomous Vehicles in Taiwan?	
	β	t -Value	β	t -Value
Gender	0.126	2.562 *	0.047	1.079
Level	−0.019	−0.393	−0.014	−0.320
Data Privacy and Cybersecurity	0.108	1.763	−0.135	−2.262 *
Regulation Considerations	0.007	0.099	−0.136	−2.057 *
Infrastructure	0.155	2.301 *	0.131	2.146 *
Governance	0.115	1.647	0.309	4.219 ***
Public Acceptance	−0.098	−1.429	0.007	0.113
Economy and Industry	0.067	0.947	0.185	2.411 *
Technology and Innovation	0.271	3.897 ***	0.248	3.775 ***
Transportation Planning	0.046	0.648	0.043	0.658
Traffic, Environmental, and Public Health Benefits	−0.084	−1.183	−0.003	−0.046
Social Equity	0.054	0.801	0.051	0.819
DF	(12, 322)		(12, 322)	
Adj. R^2	0.261		0.422	
F-value	10.832 ***		21.333 ***	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Discussions

As AV technology has advanced rapidly in recent years, academic and professional communities have begun to pay attention on how it can be effectively implemented into our future from various perspectives: (1) by articulating the need for the public sector's role on the governance and regulation in response to AVs' potential risks in addition to discussions on AVs' wider social, economic, and environmental impact in the earlier wave [1–8,11]; (2) by employing scenario analyses on how different indicators might be deployed in order to achieve a future with a better society [15–20]; (3) by comparing and contrasting what different governments are doing in terms of policies and legislation, as well as how different jurisdictions were preparing for the future with a joint effort among different sectors [9,10,12–14]; and (4) by identifying specific questions related to issues associated with AVs [6,21–24]. This study is among the first attempts to explore the overall picture on how people perceive the importance level and urgency level regarding issues associated with AV, and whether AV is a future trend, from the perspective of a social science researcher, by sorting out issues, developing a questionnaire, and investigating how AI experts and CS/EE majors assessed the importance and urgency levels of these issues in preparation for a future with AVs. Specifically, perceptions toward ten issues (governance, regulation considerations, data privacy and cybersecurity, traffic/environmental/public health benefits, economic and industry, public acceptance, social equity, technology innovation,

transportation planning and infrastructure) were collected using 66 questionnaire items. Data were collected from respondents of 31 AI experts and 335 CS/EE graduate and undergraduate students in Taiwan in April 2020. The findings regarding each research question were discussed as follows.

5.1. RQ1. What are the AI Experts' Perceptions of the Levels of Importance and Urgency of the Ten Issues?

AI experts in Taiwan assessed the top five issues that must be faced in preparing a society for AV to include (1) data privacy and cybersecurity, (2) regulation considerations, (3) infrastructure, (4) governance, and (5) public acceptance. This was the result of their assessment on the overall importance and urgency levels of ten issues, shown in Figure 11. The first and second issues considered were under Regulation, the fourth was regarding the public sector's role for general engagement, Governance, while the third and fifth were under the Wider Impact.

The above results are consistent with observations made on individual items within each issue, shown in Figures 1–10, based on both the proportion of numbers of item categorized into the group of being important and urgent, and on the distribution of means for items within an issue. To be specific, the top three issues have all or over two-thirds of items categorized as important and urgent, issues ranked fourth to sixth have some items, whereas issues ranked seventh to tenth have none or a few items categorized as important and urgent. Furthermore, the top five individual items across ten issues are (1) governance for AV in terms of road safety, (2) cybersecurity for driving safety, (3) regulations on liability regarding the owners of AVs, (4) regulations on insurance compensation, and (5) regulations on traffic rules and road construction. On the other hand, if we examine the top three individual items in the seven issues under Wider Impact, the results reveal: (1) the damage and cost regarding communication infrastructure, (2) transportation planning for AV resource control software applied to traffic-related matters, and (3) the economic benefits from software and related industries.

5.2. RQ2. What are the CS/EE Majors' Perceptions of the Levels of Importance and Urgency of the Ten Issues?

CS/EE majors in Taiwan assessed the top five issues in preparing a society for AV to include (1) data privacy and cybersecurity, (2) regulation considerations, (3) public acceptance, (4) governance, and (5) infrastructure. They also assessed the overall importance and urgency levels of the ten issues. Furthermore, the top five individual items across ten issues were four cybersecurity items, plus a governance item: (1) information security on driving safety, (2) preventing AV-related antisocial activities, (3) protection mechanism for data leaking, (4) preventing the misuse and abuse of data, and (5) governance for AV in terms of road safety. On the other hand, if we examine the top individual items within seven issues under Wider Impact, the results reveal: (1) the traffic benefits of reducing accidents, (2) public acceptance of surveillance systems justifiable for AVs, and (3) public acceptance for who should own and control the data related to AVs.

In other words, across ten issues and 66 questionnaire items, CS/EE majors demonstrated a distinctive characteristic: they are most concerned with the issue of cybersecurity and data privacy, and considered both as the most important and most urgent tasks in preparing for a society for AVs. This observation was supported by (1) data privacy and cybersecurity as the top among ten issues, and four items regarding cybersecurity as the top four individual items among 66; and (2) public acceptance in third place among the ten issues, while two items under the issue of public acceptance with regard to data privacy and security were assessed as top individual items under Wider Impact. While they presented an attention-focused profile regarding the emergent issues and questions, the AI experts showed broader concerns, including issues on regulation, governance, infrastructure, transportation planning, and economy and industry, in addition to data privacy and cybersecurity.

5.3. RQ3. Among the Ten Issues and Background Variables, What are the Significant Predictors of Importance and Urgency of AV Development in Taiwan According to CS/EE Majors?

The results of two regression models, shown in Table 2 suggest that technology and innovation, gender, and infrastructure were found to be significant predictors of the overall importance level of

AV development in Taiwan, all of which were positively associated. On the other hand, six variables were found to be significant predictors of the overall urgency level of AV development in Taiwan, four variables were positively associated—governance, economy and industry, technology and innovation, and infrastructure—while two variables were negatively related: data privacy and cybersecurity and regulation considerations. Gender was not found to be a significant predictor for urgency level.

The results suggest that, among CS/EE students, those who have higher regard for the potential benefits of AVs in relation to technology and innovation, such as new value, action service schemes, an increase in the proportion of electric vehicles, upgrading the traditional vehicle industry, and an overall new vision, who are male, and who have higher regard for the importance of strategies related to AV infrastructure, such as assessing the damage and cost, suitable environment for early development, and compatibility, are more likely to perceive a higher importance level of AV development in Taiwan. These three variables account for around one fourth of the variance.

In contrast, six issues were found to be significant predictors for the urgency level of AV development in Taiwan, and, altogether, accounted for a total of more than two-fifth of the variance. To be more specific, in addition to technology and innovation, as well as infrastructure, those who have higher regard for the urgency of strategies being taken related to AV governance upon various decisions, and those who have higher regard for the urgency of potential benefits of AV to the national economy and various industries, as well as those who have less concerns over the urgency of data privacy and cybersecurity, and those who have less concerns over the urgency of various dimensions regarding regulations, are more likely report a higher urgency level of AV development in Taiwan. It is interesting to note that, even though, as a group, the students were very concerned about cybersecurity and data privacy, as well as regulation considerations, on average, those who had a lower degree of concern over cybersecurity and data privacy were more likely to perceive AV development as urgent in Taiwan.

Furthermore, in both regression models for importance and urgency, technology and innovation was found to be a strong positive predictor, indicating that CS/EE majors have a higher regard for AV technology innovation and were ardent supporters of AV development in Taiwan. However, for the regression model of urgency, the other strong positive predictor was governance, revealing that CS/EE majors valued this factor as much as AV technology innovation when assessing the urgency level of AV development in Taiwan.

6. Conclusions

Overall, the findings of this study appear to provide empirical evidence to support the belief that people, in this case, even the AI experts and CS/EE majors, do not prefer “laissez-faire governance” [5], even though the respondents did not pay much attention to the measurement item of 1.2 related to “laissez-faire or intervention” under the issue of governance, especially the students. In actuality, they have high regard for the importance and urgency of issues related to cybersecurity and data privacy, regulations, and governance, and they expect the public sector to play an active role in a joint effort with other sectors in the process of preparing a society for AVs. Furthermore, these results appear to corroborate the Ethically Aligned Design (EAD) of The Institute of Electrical and Electronics Engineers (IEEE) in stressing the principles of data agency, awareness of misuse, accountability, effectiveness, competence, and wellbeing [25], and the Trustworthy AI Ethics Guidelines (2019) of the EU on the requirements for trustworthy AI, regarding privacy and data governance, technical safety, accountability, and societal and environmental wellbeing [26].

To summarize, this study has contributed to advancing our knowledge regarding issues related to preparing a society for AV in the following dimensions.

First, extant studies have discussed AV, both its potential benefits to society and its risks, as well as challenges, and many of them provided expert opinions on policy-related recommendations. This study employed a survey instrument to investigate the perception of AI experts as well as CS/EE majors on

ten issues associated with the implementation of AI in the future. We found both groups assessed the importance and urgency levels of wider social, economic, and environmental impact far behind their top concerns over cybersecurity and data privacy, regulation consideration, and governance strategies, such as information security on driving safety, governance of road safety thresholds, regulations related to the legal responsibility of owners, manufacturers, and R & D personnel in case of accidents, regulations related to insurance compensation, cybersecurity for the misuse of data, and so on, with results providing empirical evidence to support most recent studies calling for a role for the public sector in the regulation and governance of AVs' potential risks [5–14,18,21]. Furthermore, the student respondents of this study were found to be especially concerned about the issue of cybersecurity and data privacy, but, unfortunately, comparative policy overview studies revealed that diverse responses were adopted by different governments toward this issue, and, in reality, many of them are still in the process of coping with this potential risk [9,10].

Second, regarding the importance and urgency levels of the wider impact of AVs, the findings suggested that both groups looked at these issues both from the perspective of the beneficial change they might bring about, such as economic benefits for the software industry and other related industries, and traffic benefits in terms of reducing the accident rate, and from the perspective of their potential risks, such as the possible damage and cost of the communication infrastructure. A third dimension was also addressed: actual coping strategies, questions related to how and who, such as how software would be applied in transportation planning and who should own and control the data on AVs and what the purpose would be of using these data. Most previous studies only discussed AVs on the level of issues related to them, but the results of the present study offer an initial understanding of how AI experts and CS/EE majors perceive the relative importance and urgency levels regarding specific aspects or questions that stem from these issues, so that future studies can conduct investigations based on this foundation.

Finally, the associations between background variables as well as diverse issues in relation to the perceptions of the importance level and the urgency level of AV development have rarely been explored. The findings of this study illuminate how a few wider-impact variables (technology innovation, infrastructure) can help predict the importance level of AV development, while some wider-impact variables (technology innovation, governance, economic benefits, infrastructure) as well as concern variables (cybersecurity and data privacy, regulations) can help predict the urgency level of AV development. Furthermore, regarding gender, previous studies (e.g., [22]) have found that male students tend to have a higher positive attitude toward the overall impact of AV on mankind. The results of this study corroborate those of previous studies, as we also found that male CS/EE majors were more likely to report a higher importance level of AV development, but gender was not a significant predictor for the urgency level of AV development.

To conclude, the results of this study have the following research and policy-related implications. Following engineering and computer scientists, and researchers from transportation and other interdisciplinary fields, the academic landscape and international involvement mean that social scientists are now able to join the dialogue regarding preparing a society for AVs and can investigate the related issues from the general public's perspective. As this is one of the first attempts to initiate a study for this purpose, this research has a research design that still needs to be improved. First, the survey instrument consists of ten issues and 66 measurement items. In future research, issues could be identified and re-categorized and measurement items deleted and added. Second, in terms of participants, this study has the research limitation of only including AI experts and CS/EE students; therefore, further study is recommended to improve the results by expanding the expert pool to involve urban and transportation engineers to understand their perspectives related to how AVs should change the way we live, including land use, mode choice, and relevant regulations. Then, the next step should be a more democratic approach, which involves civilians or the general public. Third, this study employed descriptive statistics and regression models to analyze data and conduct discussions. Other approaches are suggested to generate more in-depth observations and conclusions.

Finally, the results of this study pinpointed the significance of issues related to cybersecurity and data privacy, regulations, and the governance of AVs, in addition to their wider economy and social and environmental impact, indicating a need for a more comprehensive examination of the first three issues. More importantly, since this study was mostly based in Taiwan and the context is socially and culturally bound, studies based on other jurisdictions are recommended.

For policymakers, the findings of this study seem to suggest we are still a long way from an AV-ready society. Among the issues related to preparing a society for AVs, in this case, AI experts and CS/EE majors are concerned about cybersecurity and data privacy, regulations on road safety, liability in terms of accidents, as well as insurance compensation, and governance-related decisions. It appears that, only when the most urgent issues are taken into consideration and dealt with, can socially beneficial decisions regarding the implementation of AV be the next steps. Take the issue of cybersecurity, for example: since “most governments have developed non-mandatory guidelines on cybersecurity best practices and researched to explore the implications of AVs on cybersecurity”, according to Taihagh and Lim [9], efforts to generate coping strategies and legal considerations are encouraged to be sped up. This would involve both data technology innovation, which major automobile brands are working on side by side with leading cloud platforms [27], and the efforts of the public sector’ to create AV-specific legislation.

Finally, Taiwan has set up the goals of AV development by the year of 2025 to include (1) technology innovation on software and hardware for highly automated vehicles, (2) industry development for driverless electric minibuses and an The Society of Automotive Engineers (SAE) Lv5 system integration service, (3) well-established government-funded pilot testing, (4) regulations, and (5) educational investment in related fields [14,28]. Since, currently, there is only one AV-related regulation in Taiwan, the Unmanned Vehicles Technology Innovative Experimentation Act, the findings from this study suggest that policymakers need to put more effort into regulation considerations and, at the same time, extend their commitment to cybersecurity and data privacy and governance strategies by identifying best practice, as observed from other countries and jurisdictions, as well as developing context-appropriate policies based on inclusive, democratic, diverse, and open discussions.

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