sustainability

MDPI

Article

Navigating the Landscape of Autonomous Buses: Insights in Ibaraki, Japan

Kenichiro Chinen [1], Mitsutaka Matsumoto [2,*] and Ai Chinen [3]

[1] College of Business, California State University, Sacramento, CA 95819, USA; chinen@csus.edu
[2] Advanced Manufacturing Research Institute (AMRI), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba 305-8565, Japan
[3] School of Political Science and Economics, Waseda University, Tokyo 169-8050, Japan
* Correspondence: matsumoto-mi@aist.go.jp

Abstract: The integration of autonomous buses (ABs) in Japan offers a solution to the challenges posed by an aging society, promoting safe and convenient transportation for older adults. In Ibaraki, Japan, AB adoption exemplifies forward-thinking infrastructure development, addressing residents' needs through partnerships and innovation. Positive perceptions, especially among females in their 60s and 70s, highlight ABs' role in enhancing safety and trust. This study, based on our interviews in Sakai Town, underscores ABs' significance in meeting practical needs, while fostering social inclusion. Despite challenges like technology and cost, collaborative efforts and policy interventions can maximize ABs' potential, ensuring equal access to services and paving the way for a sustainable and inclusive transportation future, benefiting both aging populations and communities.

Keywords: autonomous buses; aging society; social inclusion; innovation

Citation: Chinen, K.; Matsumoto, M.; Chinen, A. Navigating the Landscape of Autonomous Buses: Insights in Ibaraki, Japan. *Sustainability* **2024**, *16*, 3351. https://doi.org/10.3390/su16083351

Academic Editors: Clara Celauro, Maria La Gennusa, Alberto Di Matteo, Daniele Ronsivalle and Marco Migliore

Received: 16 March 2024
Revised: 12 April 2024
Accepted: 14 April 2024
Published: 17 April 2024

1. Introduction

The past decade has witnessed remarkable strides in artificial intelligence (AI), catalyzing significant advancements in driverless driving technologies. Concurrently, a societal shift towards sustainability, propelled by emerging technologies and innovation, is reshaping the competitive landscape. Notably, emerging mobility services, spanning from Level 0 to Level 5 vehicle autonomy, have captured widespread attention [1]. Media coverage has highlighted industry leaders' vigorous efforts, such as Google, showcasing autonomous vehicles on public streets, driving increased attention and substantial investments. Cautiously optimistic researchers point to reports suggesting autonomous vehicles contribute to smoother traffic flows and potentially significant reductions in fatal accidents [2–4]. From an ecological standpoint, the technical attributes of autonomous vehicles, including enhanced fuel economy, reduced traffic congestion, and diminished parking infrastructure needs, hold promise for lowering energy consumption and related emissions [5].

Adapting to these trends necessitates a fundamental shift in how companies, local governments, and countries conceptualize products, technologies, processes, and designs essential for thriving business operations. The resilience displayed through innovative thinking is poised to play a pivotal role in overcoming recent pandemic challenges. Consequently, there has been intensified industry focus on developing autonomous technologies, exemplified by innovations like Waymo and Chevy Cruise autonomous vehicles, which signal a significant leap forward in fully autonomous operation. Moreover, these technologies stand to introduce new business models, such as car-sharing services, contributing to mitigating traffic congestion [6].

In parallel, Japan's aging population and shrinking society present unique challenges that autonomous buses can help address. With Japan projected to have a population below 100 million by 2050, according to the "National Spatial Strategy 2050" crafted by the Ministry of Land, Infrastructure, Transport, and Tourism, the country faces a shrinking

workforce and escalating demand for elderly care services. Autonomous buses (ABs) offer a reliable transportation option for older adults with limited mobility or requiring assistance [7,8]. Additionally, many rural areas in Japan are grappling with population decline, as younger generations migrate to urban centers for better opportunities, leaving elderly residents with limited access to transportation and essential services. Autonomous vehicles offer a solution by providing cost-effective and efficient transportation [7], connecting rural communities with urban centers and vital services such as healthcare and groceries. Despite Japan's renowned public transportation network, certain rural and suburban areas may have limited access, especially for older adults facing mobility challenges. Autonomous buses (ABs) can complement existing services by offering flexible and on-demand transportation options tailored to the needs of older adults and vulnerable populations [9]. Moreover, like many nations, Japan struggles with recruiting and retaining bus drivers, particularly in rural areas where the population is aging and shrinking. ABs offer a viable solution by eliminating the need for human drivers, reducing operating costs, and ensuring reliable transportation, even in regions where finding qualified drivers is challenging [10]. Social isolation among older adults, particularly in rural areas, is a growing concern. Autonomous buses can help to alleviate this issue by providing transportation options that enable older adults to engage in social activities, attend community events, and maintain connections with friends and family [7]. Addressing these challenges, ABs significantly contribute to Japan's aging and contracting society, ensuring elderly individuals can access safe, dependable, and inclusive transportation options that foster independence, social interaction, and overall well-being. Legislative amendments such as those in Japan's Road Traffic Act reflect a growing recognition of the importance of accommodating the needs of older citizens. Despite some localized initiatives, the ever-increasing optimism surrounding autonomous driving technology offers a promising avenue to address mobility challenges for older individuals in rural areas, often termed the "Mobility Poor."

With increasing awareness of the environmental impact of traditional combustion vehicles, there is a global shift towards electric automobiles. In this context, ABs play a pivotal role [7] in potentially mitigating greenhouse gas emissions, air pollution, and vehicular noise. Transitioning to automated buses and taxis in more confined modes could enhance productivity and reduce subsidies [11]. Particularly, small-capacity ABs without drivers could provide cost-effective alternatives for regional bus operations, addressing the cost challenges of low-volume transit routes [8].

Early adopters of emerging mobility services are poised to significantly contribute to developing a sustainable society, setting high standards for competitors. A global trend toward an aging society underscores the urgency to substantially enhance productivity to sustain GDP. Our study, drawing insights from interviews with residents and operators of autonomous bus operations, carries implications for aging societies beyond Japan. We delve into the history of emerging mobility in Japan, present a case study of autonomous bus operations, and conclude with implications derived from our findings.

2. Literature Review

2.1. Consumer Acceptance of Autonomous Buses

The shift towards electric vehicles and ABs aligns with global efforts to mitigate environmental impacts associated with traditional combustion vehicles. Electric automobiles are anticipated to contribute significantly to reducing worldwide CO_2 emissions, leading to reduced reliance on carbon-constrained energy sources [12]. ABs, in addition to potentially lowering greenhouse gas emissions, air pollution, and vehicular noise, offer compelling advantages in this regard. However, public acceptance remains a critical factor in the successful integration of autonomous technologies into mainstream transportation systems. Studies indicate widespread apprehension among consumers about riding in automated cars, with attitudinal and emotional barriers often outweighing technological concerns [13]. Closing the perception–reality gap is identified as pivotal in fostering passenger acceptance towards autonomous vehicles.

2.2. Exploring Autonomous Mobility from the Consumer Perspective

Various theoretical frameworks have been proposed to explain public acceptance of emerging mobility services, yet psychological determinants remain poorly understood [14,15]. Earlier studies predominantly relied on hypothetical scenarios rather than real-world experiences, limiting insights into actual passenger acceptance of driverless concepts [16,17]. Recent studies, however, have focused on passengers who have experienced autonomous vehicles firsthand, providing more realistic perspectives on consumer acceptance [14,15,18].

The importance of providing passengers with direct experiences of emerging technology is evident, as it can mitigate anxiety and increase consumer acceptance. However, the impact of such experiences, whether positive or negative, on overall acceptability requires further exploration [19]. This study's strength lies in evaluating respondents' direct experiences with ABs, allowing for a nuanced understanding of factors influencing future acceptance. A pre-test–post-test design will facilitate a comprehensive assessment of these factors, contributing to a deeper understanding of consumer attitudes towards ABs.

2.3. Evolution of Technology in Japan

Autonomous vehicles are classified into the following two categories based on their reliance on infrastructure: infrastructure-based autonomous vehicles and infrastructure-less autonomous vehicles [20]. In Japan, the development of autonomous cars has progressed alongside infrastructure-based models, which depend on physical infrastructure such as roads, traffic signals, and mapping systems for operation. According to Kamata [21], Japan's exploration of autonomous driving dates back to the 1970s, with research and experiments conducted at institutions like the Institute of Industrial Science and Technology under the Ministry of International Trade and Industry. Notably, in 1977, a vehicle equipped with a camera capable of recognizing white lines marked a milestone in intelligent vehicle technology. Subsequent advancements included experiments with magnetic guidance systems in the 1990s and a demonstration of automated convoy driving on the Jōshinetsu Expressway in 1996. In the late 1990s, Toyota introduced the Intelligent Multi-mode Transit System (IMTS), a convoy system designed to alleviate traffic congestion and provide accessible transportation for senior citizens [22]. Despite its aim to enhance mobility for seniors, IMTS operations were discontinued due to the high costs and logistical challenges associated with the nationwide deployment of infrastructure-based systems.

In contrast, since 2010, autonomous technology has gained prominence in Japan. This shift was catalyzed by events like the U.S. Defense Advanced Research Projects Agency (DARPA) organizing contests in the early 2000s, such as the Grand Challenge and Urban Challenge, which focused on crewless autonomous vehicles for military purposes. Additionally, Google's development and testing of the self-driving Google Car in 2012 further propelled interest in autonomous technology. However, during this period, the integration of expensive LiDAR sensors into vehicles, costing over twice the vehicle's price, hindered its widespread adoption [23], with emphasis placed more on demonstrations than practical implementation. The ongoing discourse in Japan centers on determining the superiority between infrastructure-based and infrastructure-less autonomy in achieving autonomous driving. Recently, cost-effective automation has been considered by synergizing both approaches, particularly in scenarios where vehicles follow predetermined routes, such as regular bus or truck services, suggesting that targeted infrastructure coordination could offer a viable solution.

2.4. Key Technologies for Autonomous Buses

Advancements in perception, motion planning, chassis execution, and integrating Internet of Vehicles (IoV) are pivotal for shaping the future of ABs and autonomous transportation. Perception systems, utilizing LiDAR, radar, cameras, and GPS sensors, allow ABs to accurately interpret their surroundings [24]. Motion planning algorithms analyze real-time data to generate optimal routes, respond dynamically to changing conditions,

and enhance safety [25,26]. Chassis execution, integrating actuators and control systems, ensures precise maneuvers, contributing to passenger comfort and confidence [27]. The integration of IoV facilitates real-time data exchange and communication between vehicles and infrastructure, optimizing traffic and enhancing safety features [28]. These technologies collectively revolutionize public transportation, offering efficient, safe, and sustainable mobility solutions for urban environments and shaping the future of autonomous transportation ecosystems.

3. Case Study

ABs offer a transformative solution to the multifaceted challenges posed by aging societies [7], particularly exemplified in shrinking, aging populations. As Japan grapples with its aging population's significant economic, social, and healthcare burdens, innovative transportation solutions like ABs emerge as crucial tools in promoting healthy aging and sustainable reforms. However, determining ABs' potential hinges on overcoming several hurdles, including technological barriers, financial constraints, regulatory uncertainties, and social acceptance issues. Addressing these challenges is paramount to ensuring equitable access to transportation services for individuals of all ages and abilities, fostering inclusive and age-friendly communities worldwide. Through a comprehensive examination of the benefits and challenges associated with AB integration, this study seeks to shed light on the transformative potential of autonomous transportation solutions in addressing the complex needs of aging populations and promoting sustainable mobility solutions globally.

3.1. Sakai Town, Ibaraki Prefecture

3.1.1. Demographic Challenges in an Aging Society

Japan's aging population presents significant economic, social, and healthcare challenges, including strains on public finances, labor shortages, and healthcare infrastructure [29]. By 2040, a projected worker deficit of 11 million underscores the urgency for measures like the 2018 Guidelines for the Aging Society to enhance participation among older workers. Japan's declining birth rate, reaching a record low in 2022, compounds demographic pressures, impacting social security systems reliant on a shrinking workforce to support a growing retired cohort. The resulting demographic crisis manifests in economic strains, labor scarcities, and healthcare system pressures, necessitating comprehensive strategies to promote healthy aging and sustainable reforms.

Autonomous buses present a transformative solution to the challenges of an aging society in Sakai Town. By providing safe, accessible, and convenient transportation options, these vehicles empower older adults to maintain independence and engage in essential activities like healthcare appointments and social interactions. With advanced safety features and reduced reliance on traditional driving, autonomous buses mitigate the risks associated with aging-related mobility limitations, ensuring enhanced safety for older passengers. Moreover, their increased accessibility and potential to accommodate individuals with mobility challenges promote inclusivity and equal access to transportation services. Ultimately, autonomous transportation addresses practical needs, fosters social inclusion, and enhances the overall quality of life for older adults.

3.1.2. The Advent of Autonomous Buses in Sakai Town

Situated near the borders of Chiba, Saitama, and Gunma prefectures, Sakai Town lacks a railway station and faces challenges in transportation infrastructure development. In response, the town initiated autonomous driving in 2019 to address various challenges [30], as follows:

- Population Decline and Aging—shrinking and aging demographics led to corporate withdrawals and increased vacant properties.
- Vulnerability of Public Transportation—inadequate public transportation hindered elderly individuals from surrendering their driving licenses and limited travel options for young residents.

The town mayor learned about autonomous driving buses through media coverage in November 2019 and subsequently met with SoftBank Drive's president to explore autonomous driving services [31]. Following budget approval by the town council in January 2020, the town introduced three autonomous buses manufactured by NAVYA, Villeurbanne, France. These buses utilized cutting-edge autonomous vehicle operation management platforms developed by SoftBank subsidiaries, Tokyo, Japan. Positive feedback from residents during test rides prompted the town to request approval from the Minister of Economy, Trade, and Industry to operate autonomous buses on public roads. Operations commenced in November 2020, initially servicing a 5 km route connecting key locations in the town center.

The success of the initial operation led to the expansion of autonomous bus services to include routes connecting medical facilities, post offices, schools, banks, and other destinations within the town. Additional bus stops were added in December 2021 to improve accessibility, and demonstrations of autonomous bus use for elementary school students' commuting began in February 2021 [32]. With the relaxation of regulations in April 2021, level 4 autonomous driving became possible, further enhancing operational capabilities. The town now operates a fleet of autonomous buses, providing safe and efficient transportation to residents, while contributing to the overall development and sustainability of Sakai Town.

3.1.3. The Leadership

In the town of Sakai, leadership took center stage when Mr. Hashimoto assumed the role of mayor in 2014. At that time, Sakai Town faced the daunting challenge of significant debt, a common struggle among rural municipalities in Japan. Despite its location in the southern part of Ibaraki Prefecture, boasting a population of approximately 24,000, Sakai Town found itself burdened with a local debt of about JPY 17.2 billion in 2013, ranking it as the 29th most indebted municipality in the country [33]. Mayor Hashimoto's leadership epitomized a shift towards self-sufficiency and strategic thinking in municipal governance. For example, by spearheading initiatives like Furusato Nōzei and leveraging innovative projects for economic growth, Sakai Town aimed to thrive independently and contribute to the collective advancement of Japan's municipalities [34]. Sakai Town has embraced a distinctive operational approach that Hashimoto calls the Sakai Town Model, where the goal is to avoid creating a business reliant on taxes for maintenance. Over three years, the town secured JPY 150 million from the Cabinet Office's "Regional Revitalization Promotion Subsidy" and the Ministry of Land, Infrastructure, Transport and Tourism's "Demonstration Project Using Big Data".

According to the Cabinet Secretariat in Japan [35], the allocated budget for implementing three autonomous driving buses over five years totals JPY 520 million. Nonetheless, within a year and a half of commencement, the collective economic impact surges to JPY 850 million, equivalent to USD 5.67 million (calculated at JPY 150 per US dollar). The breakdown delineates direct effects, such as government subsidies and donations, constituting 61% of the overall impact, with indirect effects—encompassing advertising benefits and heightened consumption—comprising the remaining 39%. Many local governments in Japan may manage and operate facilities directly, using taxpayer money to cover the associated costs [33]. Sakai Town's model is a commendable example for small towns due to its innovative facility management approach. Unlike many local governments in Japan that rely solely on taxpayer funds to operate facilities, Sakai Town adopts a more sustainable strategy. By leveraging government subsidies and hometown tax contributions, Sakai Town constructs facilities and delegates their operation to service providers. Moreover, the town collects facility usage fees, aligning its approach with the principles commonly observed in private enterprises. This model ensures the efficient use of resources and promotes self-sufficiency and fiscal responsibility, making it an exemplary model for small towns striving for sustainability and economic viability.

The concern of budget limitations in the future arises when considering the potential replication of Sakai Town's strategy by many other towns. While Sakai Town has demonstrated remarkable success in revitalizing its economy and managing facilities through innovative approaches like Furusato Nōzei [34] and leveraging government subsidies, scalability and sustainability are looming questions [33]. With the success of Sakai Town's initiatives, other municipalities might be tempted to adopt similar strategies to address their financial challenges. However, the allocated budget for implementing such initiatives, like autonomous driving buses, might strain the resources of smaller towns, especially if they face similar financial burdens, as Sakai initially did. Moreover, while Sakai Town has managed to generate significant economic impact from its initiatives, there is a risk that other towns may not achieve the same level of success, due to differences in local conditions, population size, or economic dynamics. This could result in financial strain if towns invest heavily in projects without seeing comparable returns. Furthermore, the reliance on government subsidies and donations, as seen in Sakai's model, may not be long-term, especially if there is uncertainty about future funding or if other towns also compete for the same resources. In essence, while Sakai Town's approach serves as a commendable example for small towns striving for sustainability and economic viability, there is a need for careful consideration of budget limitations and potential challenges in replicating such strategies on a larger scale. Local governments should assess their financial capacities and the feasibility of implementing similar initiatives before embarking on such endeavors.

3.1.4. Social Acceptance

Social acceptance of autonomous driving is a significant theme for regions in Japan [36]. Without a driver, the responsibility for accidents may fall on operators or system developers. While safety concerns might have been voiced, holding test ride events for residents gradually dispelled negative opinions [37]. Even in limited areas, thorough explanations and understanding by residents are indispensable and it takes time for a region to accept such a technology. In support of social acceptance, Chinen et al. [38] conducted a pre-test/post-test-designed study on autonomous buses operated in a closed environment. Their findings indicate that passenger attitudes, perceived benefits, and anxiety significantly influence the willingness to use emerging mobility services before and after ride experiences. The study highlights that passengers who find emerging mobility services less intimidating tend to perceive their benefits more readily, increasing their willingness to use such services. Additionally, initial skepticism tends to diminish after passengers experience the services firsthand, leading to greater support for them. The study also underscores the importance of early adopters in the diffusion of autonomous technologies, as they are pivotal in embracing and promoting innovative ideas. Those who consider themselves early adopters of new technology tend to view semi-autonomous buses positively and are more willing to use emerging mobility services.

NHK [39] summarizes that the key to the safe operation of public transportation running on public roads lies in the understanding of the residents. To gain social acceptance, the autonomous driving bus is operated at a low speed of 20 km per hour and stops when it detects obstacles, addressing concerns about congestion. In the town, efforts have been made to secure passing spaces at bus stops and designated areas along the route and awareness campaigns have been conducted to discourage roadside parking and seek understanding. In the report [39], an elderly user made the following comment: "at first, there were concerns, but now I'm not worried anymore. People who have surrendered their licenses use the bus to go to places like hospitals and cafes, and I, too, will use it for our senior citizens' group. It's a bit slow, but safety is crucial". There have been no accidents during autonomous driving and over 17,000 people have utilized the service since the service began. Masahiro Hashimoto, Mayor of Sakai Town, Ibaraki Prefecture made the following statement: "Our town has no train station, and it was a town where even if you wanted to surrender your license due to aging, you couldn't. The concern about whether we could continue living here was greater than the fear of accidents caused by

autonomous vehicles. By operating at Level 4 in this town, I have high expectations that it will expand nationwide".

3.1.5. Voices of Residents in Sakai Town

In Sakai Town, where regulations on autonomous driving have eased, including the nationwide standardization of autonomous driving license acquisition and reductions in required assistant personnel, the expectation is for fully crewless operations by 2023. Despite these regulatory relaxations, ABs in Sakai Town have maintained an impressive record of nearly accident-free operations. To gain deeper insights into the perceptions of safety and trustworthiness regarding autonomous buses among Sakai Town residents, we conducted interviews with a sample of 24 participants in January and February 2024. During these interviews, participants rated autonomous buses on a scale of 0 to 100, where 100 indicates a high level of safety and complete trust. Additionally, participants were asked about their beliefs regarding the potential for autonomous buses to reduce traffic accidents, rating their agreement on a scale of 0 to 100, with 100 indicating complete agreement with the notion that autonomous buses, operating without human intervention, could lead to a decrease in traffic accidents. Initially, we considered gathering quantitative data from the community. However, we were concerned that many elderly individuals might be hesitant to respond to survey questionnaires, potentially impacting the data's accuracy and completeness. Overcoming these challenges and devising innovative methods to collect reliable data from diverse demographic groups was essential for conducting comprehensive and representative productivity studies. Consequently, we chose to conduct interviews as an alternative approach. We utilized a semi-structured interview guide to conduct interviews at both exhibitions. These interviews were conducted with individuals, pairs, and small groups, depending on the number of attendees at any given time and whether they arrived at the bus stop. The data collected from these interviews provide valuable insights into the perceptions and attitudes of Sakai Town residents towards autonomous buses. It sheds light on their level of confidence in the safety of autonomous technologies and their expectations regarding the impact of autonomous buses on traffic safety. These findings contribute to a broader understanding of public sentiment towards autonomous transportation technologies in the context of evolving regulatory frameworks and technological advancements.

Table 1 provides a summary of our survey results. We did not observe a statistical difference between males and females regarding safety concerns and trust in autonomous buses. Although the sample size in our study was small, females perceived that autonomous buses would contribute to a decrease in traffic accidents (mean difference = 13.00, t = 2.061, df = 22, $p < 0.05$). Overall, participants perceive autonomous buses as safe, with most ratings falling between 70 and 100 on the safety scale. The highest safety ratings were given by females in their 60s and 70s, with scores of 100. However, there is some variability in perceptions, as indicated by the range of safety ratings across different individuals. Similarly, there is a generally high level of trust in autonomous buses among participants, with ratings mostly falling between 50 and 100 on the trust scale. Again, females in their 60s and 70s tend to express the highest levels of trust, with several individuals giving perfect scores of 100 (See Table 1). Participants also believe, in general, that autonomous buses will contribute to a decrease in traffic accidents, although there is more variability in this perception compared to safety and trust. The ratings for the reduction in accidents range widely, with some individuals expressing strong belief in accident reduction (scores of 80–100) and others being more skeptical (scores below 50).

While our survey reveals no significant difference in safety and trust perceptions between genders, there are noteworthy age-related trends, particularly among females in their 60s and 70s who consistently expressed higher ratings for safety and trust. However, what is concerning is the variation in beliefs regarding accident reduction across all age groups. Specifically, there seems to be a notable apprehension among elderly individuals, particularly those in their 70s, suggesting underlying safety concerns. It is essential to

recognize that safety perceptions are not solely tied to age; individual experiences, perceptions, and attitudes also shape them. Despite the overall positive perception of autonomous buses as being safe and trustworthy, this lingering concern highlights the importance of further research with a larger sample size to explore these differences and their implications for fostering trust and ensuring safety in autonomous transportation systems.

Table 1. Perception of autonomous buses—safety, trust, and reducing accidents.

Gender	Age	Safety *	Trust **	Reduction in Accidents ***
Female	60s	100	100	85
Female	70s	100	100	80
Male	60s	70	70	80
Male	60s	70	70	80
Female	60s	80	80	80
Female	40s	80	80	90
Male	40s	80	70	70
Male	30s	90	50	50
Female	60s	80	75	80
Female	40s	80	80	80
Female	30s	90	90	70
Male	70s	85	90	90
Male	70s	100	100	100
Female	70s	80	80	60
Female	70s	50	50	50
Female	50s	70	70	70
Male	70s	90	90	90
Female	60s	80	80	80
Male	60s	90	90	90
Female	50s	80	80	80
Female	70s	90	90	50
Female	70s	70	70	50
Female	50s	50	50	50
Male	70s	80	80	100

* Safety: On a scale of 0 to 100, where 100 represents very safe, how safe do you consider autonomous buses to be? ** Trust: On a scale of 0 to 100, where 100 represents complete trust, how much do you trust autonomous buses? *** Reduction in accidents: Do you believe that autonomous buses, which operate without human intervention, will contribute to a decrease in traffic accidents? Answer on a scale of 0 to 100, where 100 indicates a significant reduction in accidents.

For these individuals, ABs have been seamlessly integrated into their daily routines, becoming indispensable. They rely on the convenience and accessibility offered by ABs, especially for essential tasks such as visiting hospitals or grocery shopping. ABs provide a reliable and efficient means of transportation, enabling users to navigate their daily activities with ease and peace of mind. Beyond mere transportation, ABs represent independence, accessibility, and freedom for these individuals. The seamless integration of ABs into their lives has transformed them from mere vehicles to essential companions, enhancing their quality of life and providing a sense of empowerment and autonomy.

Surprisingly, only one respondent reported having experienced rides in ABs. This observation (based on our two-day observations in January and February 2024) was unexpected, given the predominantly positive portrayal of ABs and their operations in the media. Residents, especially those from older generations accustomed to driving cars, harbor reservations about Abs, stemming from their established reliance on personal vehicles. For this demographic, the concept of ABs appears unnecessary, as they already have means of transportation and perceive little need for an alternative mode of travel. Additionally, their experiences with ABs reinforce their skepticism, as these vehicles are often observed to operate at notably slow speeds, leading to frustration and annoyance. Conversely, among younger generations who also drive cars, attitudes towards ABs lean towards ambivalence rather than outright rejection or endorsement. These individuals seem to lack strong opinions or feelings towards ABs, viewing them as just another mode

of transportation without eliciting particular enthusiasm or apprehension. Their neutral stance may stem from a combination of factors, including a lack of exposure to ABs or a limited understanding of their potential benefits and drawbacks.

3.1.6. Voices of AB Operators

During our visits to Sakai Town to interview residents, AB operators shared insights into their daily routines. They explained that manual control is necessary in certain situations, such as for on-street parking or encountering obstacles like bicycles. The demographic profile of AB users was also discussed, revealing that on weekdays, the buses are predominantly utilized by elderly town residents for trips to hospitals or supermarkets. Additionally, operators shed light on their motivations for becoming involved in AB operation, citing an interest in autonomous driving technology as a key factor.

Moreover, they revealed that the service extends beyond Sakai Town, with operations also available in Hokkaido, Aichi Prefecture, as well as Haneda Airport. Discussions regarding maintenance revealed the challenges faced by ABs in Sakai Town's demanding driving conditions, with operators emphasizing the need for regular maintenance intervals to ensure optimal performance. Introducing the MiCa autonomous bus, capable of avoiding obstacles, introduced new considerations for operators and passengers alike. ARMA seems more popular among passengers due to its better visibility, although MiCa offers advanced features such as obstacle avoidance. Regarding the temperature in ARMA, passengers find it comfortable in winter but unbearable in summer due to the high temperatures inside, leading to some operators quitting due to this issue. While challenges persist, notably regarding temperature control within the ARMA buses during summer months, scenes of Sakai Town's ABs were featured in popular media, including the Sazae-san animation, leading to a surge in passenger demand and highlighting growing acceptance of autonomous transportation solutions within the community.

3.1.7. Enhancing Accessibility in Sakai Town

Sakai Town's visionary plan revolutionizes public transportation and prioritizes inclusivity and accessibility, especially for the aging population who may face difficulties reaching bus stops. With the introduction of on-demand operation through a Mobility as a Service (MaaS) application in 2021, the town takes a monumental step forward in addressing these challenges. By strategically positioning 26 bus stops and integrating the communication app "LINE" for summoning autonomous buses from multiple locations, the town ensures that residents, including those living far from traditional bus stops, have convenient access to transportation services [40]. Furthermore, recognizing the technological barriers faced by some elderly residents, Sakai Town is pioneering the use of facial recognition systems for reservation confirmation, catering specifically to those without smartphones. This holistic approach enhances mobility options and fosters a sense of inclusivity, empowering aged individuals to maintain independence and access essential services with ease. In embracing cutting-edge technology, while prioritizing the needs of its aging population, Sakai Town sets a commendable example for communities striving to create more accessible and age-friendly transportation systems.

We also present the brief case of Eiheiji, Fukui, a town making ongoing efforts to operate autonomous buses, offering a comparative perspective with similar initiatives in other smaller regions of Japan.

3.2. Eiheiji, Fukui Prefecture

3.2.1. Pioneering Autonomous Transit at Eiheiji Station

Located along the abandoned railway track near the final stop, Eiheiji Station, of the former Keifuku Electric Railroad Eiheiji Line, spanning approximately 2 km, the autonomous driving site marks the nation's inaugural fully autonomous operation with passenger transport [41]. This groundbreaking autonomous bus route connects Eiheiji Station on the Echizen Railway with the precincts of Eiheiji. The concept aimed at estab-

lishing second-tier transportation connecting the station and tourist destinations using autonomous vehicles, specifically tailored for the Eiheiji area [42]. According to the mayor of Eiheiji Town, the decision to employ autonomous vehicles over traditional taxis or buses was grounded in a well-founded rationale, as follows: In a town experiencing population decline and an aging society, challenges in public transit arise due to a shortage of manpower. In anticipation of such future scenarios, there was a realization of the importance of harnessing new technologies [41].

3.2.2. Efforts towards Ensuring Safe Autonomous Operation

Eiheiji Town initiated a Level 3 demonstration experiment from 2021. In the long-term test, AIST (National Institute of Advanced Industrial Science and Technology) provided the autonomous driving system and oversaw the project; Hitachi provided the operation management system; Yamaha Motor provided the vehicles and electromagnetic induction line infrastructure; Toyota Tsusho managed administrative tasks and coordinated stakeholders; Keio University provided the user interface for the remote monitoring system; Keifuku Bus provided drivers and operational management support; and ZEN Connect, the third-sector organization in Eiheiji Town, was responsible for overall operation management coordination [42]. Enhancements included increasing the number of cameras around the vehicle, ensuring the system can detect situations where humans or animals may be under the vehicle. Communication functions were designed to remain uninterrupted by bundling the networks of three mobile phone companies, allowing continued operation even if one network faces issues. Through these enhancements, AIST applied for Level 4 certification [41]. The Level 4 autonomous road travel was unprecedented nationally. Following document reviews by the Ministry of Land, Infrastructure, Transport and Tourism, as well as third-party examinations for vehicle certification, Eiheiji became the first town in Japan to receive Level 4 vehicle certification in late March 2023 [43].

3.2.3. Public Approval

Public approval of autonomous driving is a significant theme for regions in Japan [44]. Despite being conditional upon "fully autonomous driving", there is still a risk of accidents. Without a driver, the responsibility for accidents may fall on operators or system developers. Eiheiji Town began community explanation sessions seven years ago to prepare for practical implementation, raising awareness among local residents, from seniors to elementary and middle school students, about the benefits and risks of autonomous driving. While concerns about safety were initially voiced, holding test ride events for residents from Level 2 and 3 demonstration experiments gradually dispelled negative opinions [41]. Even in limited areas, thorough explanations and understanding by residents are indispensable and it takes time for a region to accept such a technology. The technology level of autonomous driving is on the brink of "full autonomy," becoming an attractive option for regions grappling with maintaining traditional public transportation networks and a shortage of drivers [42].

Incorporating ABs offers a promising solution to address the multifaceted benefits and challenges associated with aging populations (refer to Table 2 for a concise overview of interview findings). This impact resonates worldwide, presenting avenues to enrich mobility solutions for elderly individuals globally. Yet, unlocking the complete potential of ABs necessitates overcoming a spectrum of hurdles encompassing technological, financial, regulatory, and social dimensions. Conquering these obstacles is crucial to guaranteeing fair access to transportation for people of diverse ages and abilities.

Table 2. Benefits and challenges of autonomous buses, as identified through interviews.

Benefits	Challenges
Enhanced Mobility: ABs provide safe and convenient transportation options for elderly individuals, enabling them to maintain independence and access essential services such as healthcare appointments, grocery shopping, and social activities.	**Technical Barriers:** The adoption of ABs may face technical barriers, including the need for advanced infrastructure such as dedicated lanes, sensor networks, and communication systems to support autonomous operations.
Improved Accessibility: Utilizing technology such as communication apps like 'LINE,' ABs will enhance accessibility by providing door-to-door services and catering to individuals with mobility challenges, including those who use wheelchairs or mobility aids.	**Budgetary Concerns:** The high initial costs associated with the development, deployment, and maintenance of ABs may pose financial challenges for municipalities and transportation authorities, particularly in smaller towns with limited budgets.
Reduced Isolation: For elderly individuals living in rural or isolated areas, ABs can mitigate social isolation by connecting to community centers, recreational facilities, and social events.	**Regulatory and Legal Frameworks:** The absence of clear regulatory frameworks and liability laws for autonomous vehicles may hinder their widespread adoption, leading to uncertainty among policymakers, transportation agencies, and the public.
Enhanced Safety: With advanced safety features and reduced reliance on traditional driving, ABs offer enhanced safety for older passengers, reducing the risk of accidents associated with aging-related mobility limitations.	**Public Perception and Acceptance:** Concerns about safety, reliability, and privacy may impact public perception and acceptance of ABs, particularly among elderly individuals (especially in their 70s) who may be more hesitant to embrace new technologies. ABs appear unnecessary as they already have transportation options and perceive little need for an alternative mode of travel. Their experiences with ABs reinforce their skepticism, as these vehicles often operate at slow speeds, causing frustration.
Environmental Benefits: As autonomous vehicles typically use electric or hybrid propulsion systems, adopting ABs can contribute to reducing carbon emissions and improving air quality, benefiting elderly individuals and the broader community.	**Equity and Accessibility:** Ensuring equitable access to ABs for all segments of the population, including low-income individuals, marginalized communities, and individuals with disabilities, remains a challenge. Addressing issues of affordability, accessibility, and inclusivity is crucial to maximizing the benefits of ABs for aging populations worldwide.

4. Conclusions, Recommendations, and Implications

Integrating ABs in Sakai Town, Ibaraki Prefecture, presents a transformative solution to the demographic challenges an aging society poses. As Japan grapples with an aging population and its associated economic and social implications, innovative transportation solutions like ABs offer hope. By providing safe, accessible, and convenient transportation options, ABs empower older adults to maintain independence and engage in essential activities such as healthcare appointments and social interactions.

Our interviews with residents in Sakai Town provide valuable insights into the perceptions of autonomous buses (ABs) among participants. While no significant difference was observed between males and females regarding safety concerns and trust in ABs, there were notable trends among different age groups, particularly among females in their 60s and 70s, who consistently expressed higher levels of safety and trust. Despite individual variability, participants generally perceive ABs as safe and trustworthy, with most ratings falling between 70 and 100 on the safety scale and between 50 and 100 on the trust scale. Many participants believe that ABs will contribute to a decrease in traffic accidents, although opinions on this matter vary across age groups. In the future, elderly individuals who currently drive cars out of necessity will find themselves benefiting from autonomous transportation, as autonomous vehicles become more prevalent. Older adults may transition to using them as their primary mode of transportation, despite any reservations they may now have. This shift could occur due to various factors, including physical limitations that make driving increasingly challenging with age. By addressing the social, economic, and demographic challenges associated with aging populations, autonomous transportation contributes to creating more inclusive and age-friendly communities in Japan, the U.S., and around the world. Sakai Town's emphasis on innovative features

such as on-demand operation and facial recognition systems sets a precedent for other smaller towns seeking to improve accessibility. By adopting these technologies, towns can overcome barriers to transportation access faced by older adults and individuals with mobility challenges, ensuring equal access to essential services and opportunities for all residents. The implications of Sakai Town's successful integration of ABs extend beyond its borders, serving as a model for other smaller towns struggling with demographic shifts and accessibility issues. By drawing inspiration from Sakai Town's innovative approach and lessons learned, smaller towns can develop tailored solutions to address their unique transportation needs, ultimately improving the well-being and quality of life for aging populations and fostering vibrant, inclusive communities.

We offer specific recommendations for transportation planners, urban developers, and policymakers regarding autonomous transportation technologies, particularly focusing on aging societies. First, regarding infrastructure development, prioritize creating accessible infrastructure for elderly passengers, including features like low-floor boarding, ample seating, and clear signage. Additionally, implementing smart infrastructure solutions such as dedicated lanes or priority signals for autonomous buses to enhance their efficiency and reliability, as well as ensuring that infrastructure designs take into account the accessibility requirements of elderly passengers, including wheelchair access and user-friendly interfaces for ticketing and information systems. Secondly, setting clear guidelines and standards in collaboration with regulatory bodies for the deployment and operation of autonomous buses in aging populations, as well as developing comprehensive safety protocols and certification processes for autonomous vehicle technologies to address concerns about reliability and passenger safety. Consider offering incentives and subsidies to transportation providers adopting autonomous technologies, especially those serving elderly communities, to encourage innovation and accessibility. Thirdly, developing strategies for enhancing public acceptance and trust towards autonomous transportation technologies. This can include conducting targeted public awareness campaigns and education initiatives to familiarize elderly passengers with autonomous transportation technologies and address any misconceptions or concerns, as well as engaging stakeholders, including elderly advocacy groups, in community consultations to ensure inclusivity and acceptance of autonomous bus services. Implementing pilot programs and trials in collaboration with local communities to demonstrate the benefits and safety of autonomous buses, gathering feedback, and addressing concerns in real-world scenarios. These recommendations can help transportation planners, urban developers, and policymakers to create an environment that supports the successful adoption of autonomous transportation technologies in aging societies, while addressing key infrastructure, regulatory, and public acceptance challenges.

Sakai Town's adoption of ABs reflects a forward-thinking approach to transportation infrastructure development. Situated in an area lacking a railway station and facing challenges in transportation infrastructure, the town recognized the need for innovative solutions to enhance mobility. Through strategic partnerships and budget allocation, the town successfully introduced ABs, revolutionizing public transportation and addressing the needs of its residents. The voices of residents and AB operators further highlight the significance of ABs in enhancing accessibility and convenience. While avid users of ABs express overwhelmingly positive attitudes towards this mode of transportation, older generations accustomed to driving cars exhibit reservations stemming from their established reliance on personal vehicles. However, ABs have the potential to bridge the gap between traditional and autonomous transportation, offering viable alternatives to address urban mobility challenges such as safety, pollution, and congestion.

Furthermore, Sakai Town's visionary plan to enhance accessibility through on-demand operation and the integration of facial recognition systems demonstrates a commitment to inclusivity and innovation. By prioritizing the needs of its aging population and leveraging cutting-edge technology, Sakai Town sets a commendable example for communities striving to create more accessible and age-friendly transportation systems. Second, the successful integration of ABs in Sakai Town offers valuable implications for other smaller towns

grappling with similar challenges related to an aging population and accessibility. As demographic shifts continue to impact communities across Japan and beyond, innovative transportation solutions like ABs present an opportunity for smaller towns to address mobility needs and promote social inclusion among older residents. The case of Sakai Town demonstrates that with strategic planning and investment, smaller towns can overcome transportation infrastructure limitations and enhance accessibility for aging populations. By leveraging partnerships and securing funding, towns facing similar demographic challenges can introduce ABs to provide safe, convenient, and accessible transportation options for older adults. This approach empowers older residents to maintain independence and engage in essential activities, fosters social inclusion, and enhances their overall quality of life.

The challenges facing the widespread adoption of ABs present significant hurdles that must be addressed through coordinated efforts and strategic initiatives. First, the technological barriers associated with AB deployment, including the need for advanced infrastructure such as dedicated lanes and sensor networks, necessitate concerted investment and innovation in transportation infrastructure. Collaborative partnerships between technology firms, governmental bodies, and transportation authorities are essential to overcome these hurdles and create an environment conducive to AB operation. Second, the high initial costs involved in AB development, deployment, and maintenance pose financial challenges, particularly for municipalities and transportation authorities with limited budgets. To address this, comprehensive financial planning and investment strategies must be formulated, leveraging alternative funding sources and exploring public–private partnerships to alleviate the financial burden and ensure the sustainability of AB initiatives. Third, the absence of clear regulatory frameworks and liability laws for autonomous vehicles contributes to uncertainty among policymakers, transportation agencies, and the public. Therefore, there is an urgent need for policymakers to prioritize the development of robust regulatory frameworks that address safety, liability, and operational standards, thereby fostering confidence in AB technology and facilitating its widespread adoption. Furthermore, public perception and acceptance concerns, particularly among elderly individuals, underscore the importance of proactive public engagement and education initiatives. Transparent communication about the safety features and benefits of ABs, coupled with efforts to address privacy concerns and misconceptions, is crucial for building trust and garnering public support for autonomous technology.

Addressing these challenges requires a multifaceted approach involving collaboration, innovation, and proactive policy interventions. By tackling these hurdles head-on, stakeholders can unlock the full potential of autonomous buses and pave the way for a more sustainable, inclusive, and accessible transportation future. Policymakers and stakeholders must prioritize initiatives that reduce transportation disparities and promote accessibility features tailored to diverse needs, maximizing the benefits of ABs for aging populations and fostering inclusive transportation systems.

Considering the small sample size in this study, it is essential to note that the interviewed respondents may not fully represent the entire town's diverse perspectives and experiences with autonomous transportation technologies. While the insights gathered from the interviews provide valuable qualitative data, they may not comprehensively reflect the perceptions of all residents in the town. To address this limitation and ensure a more robust understanding of the town's residents' attitudes and views towards autonomous transportation technologies, future studies should consider implementing broader data collection methods.

Author Contributions: Conceptualization, K.C.; Data curation, A.C.; Formal analysis, K.C.; Funding acquisition, M.M.; Investigation, K.C. and A.C.; Methodology, K.C. and M.M.; Project administration, K.C.; Supervision, K.C. and M.M.; Validation, K.C. and M.M.; Writing—original draft, K.C. and A.C.; Writing—review and editing, M.M. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by JSPS KAKENHI Grant Number 22K12494.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was waived because the research posed minimal risk and ensured participant anonymity.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions of data openness.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Litman, T. Autonomous Vehicle Implementation Predictions. In *Implications for Transport Planing*; Victorial Transport Policy Institute: Victoria, BC, Canada, 2017.
2. Cars, D.; Fuller, B. Cautious Optimism About. *Cityscape J. Policy Dev. Res.* **2016**, *18*, 181.
3. Van Arem, B.; Van Driel, C.J.; Visser, R. The Impact of Cooperative Adaptive Cruise Control on Traffic-Flow Characteristics. *IEEE Trans. Intell. Transp. Syst.* **2006**, *7*, 429–436. [CrossRef]
4. ANSYS, Global Autonomous Vehicle Report 2019. Available online: https://www.ansys.com/ja-jp/news-center/press-releases/10-01-19-most-consumers-believe-self-driving-cars-will-outperform-humans (accessed on 31 August 2020).
5. Morrow, W.R.; Greenblatt, J.B.; Sturges, A.; Saxena, S.; Gopal, A.; Millstein, D.; Shah, N.; Gilmore, E.A. Key Factors Influencing Autonomous Vehicles' Energy and Environmental Outcome. In *Road Vehicle Automation*; Meyer, G., Beiker, S., Eds.; Lecture Notes in Mobility; Springer International Publishing: Cham, Switzerland, 2014; pp. 127–135, ISBN 978-3-319-05989-1.
6. Chun, Y.-Y.; Matsumoto, M.; Tahara, K.; Chinen, K.; Endo, H. Exploring Factors Affecting Car Sharing Use Intention in the Southeast-Asia Region: A Case Study in Java, Indonesia. *Sustainability* **2019**, *11*, 5103. [CrossRef]
7. McKinsey Report. Autonomous Driving's Future: Convenient and Connected. 2023. Available online: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/autonomous-drivings-future-convenient-and-connected (accessed on 8 March 2024).
8. Cregger, J.; Dawes, M.; Fischer, S.; Lowenthal, C.; Machek, E.; Perlman, D. *Low-Speed Automated Shuttles: State of the Practice Final Report*; Joint Program Office for Intelligent Transportation Systems: Gaithersburg, MD, USA, 2018.
9. Booth, L.; Tan, T.; Norman, R.; Anund, A.; Pettigrew, S. Experiences of Older Adults Interacting with a Shared Autonomous Vehicle and Recommendations for Future Implementation. *Transp. Res. Part F Traffic Psychol. Behav.* **2022**, *90*, 100–108. [CrossRef]
10. McPeak, M. How Self-Driving Trucks Curtail the Driver Shortage. Food Logistics 2023. Available online: https://www.foodlogistics.com/transportation/trucking/article/22865529/hale-trailer-how-selfdriving-trucks-curtail-the-driver-shortage (accessed on 8 March 2024).
11. Abe, R. Introducing Autonomous Buses and Taxis: Quantifying the Potential Benefits in Japanese Transportation Systems. *Transp. Res. Part A Policy Pract.* **2019**, *126*, 94–113. [CrossRef]
12. Barbarossa, C.; Beckmann, S.C.; De Pelsmacker, P.; Moons, I.; Gwozdz, W. A Self-Identity Based Model of Electric Car Adoption Intention: A Cross-Cultural Comparative Study. *J. Environ. Psychol.* **2015**, *42*, 149–160. [CrossRef]
13. Shariff, A.; Bonnefon, J.-F.; Rahwan, I. Psychological Roadblocks to the Adoption of Self-Driving Vehicles. *Nat. Hum. Behav.* **2017**, *1*, 694–696. [CrossRef] [PubMed]
14. Xu, Z.; Zhang, K.; Min, H.; Wang, Z.; Zhao, X.; Liu, P. What Drives People to Accept Automated Vehicles? Findings from a Field Experiment. *Transp. Res. Part C Emerg. Technol.* **2018**, *95*, 320–334. [CrossRef]
15. Madigan, R.; Louw, T.; Wilbrink, M.; Schieben, A.; Merat, N. What Influences the Decision to Use Automated Public Transport? Using UTAUT to Understand Public Acceptance of Automated Road Transport Systems. *Transp. Res. Part F Traffic Psychol. Behav.* **2017**, *50*, 55–64. [CrossRef]
16. Bansal, P.; Kockelman, K.M.; Singh, A. Assessing Public Opinions of and Interest in New Vehicle Technologies: An Austin Perspective. *Transp. Res. Part C Emerg. Technol.* **2016**, *67*, 1–14. [CrossRef]
17. Hohenberger, C.; Spörrle, M.; Welpe, I.M. How and Why Do Men and Women Differ in Their Willingness to Use Automated Cars? The Influence of Emotions across Different Age Groups. *Transp. Res. Part A Policy Pract.* **2016**, *94*, 374–385. [CrossRef]
18. Nordhoff, S.; de Winter, J.; Madigan, R.; Merat, N.; van Arem, B.; Happee, R. User Acceptance of Automated Shuttles in Berlin-Schöneberg: A Questionnaire Study. *Transp. Res. Part F Traffic Psychol. Behav.* **2018**, *58*, 843–854. [CrossRef]
19. Schuitema, G.; Steg, L.; Forward, S. Explaining Differences in Acceptability before and Acceptance after the Implementation of a Congestion Charge in Stockholm. *Transp. Res. Part A Policy Pract.* **2010**, *44*, 99–109. [CrossRef]
20. Sadaf, M.; Iqbal, Z.; Javed, A.R.; Saba, I.; Krichen, M.; Majeed, S.; Raza, A. Connected and Automated Vehicles: Infrastructure, Applications, Security, Critical Challenges, and Future Aspects. *Technologies* **2023**, *11*, 117. [CrossRef]
21. Kamata, M. Current Status and Future Outlook of Automated Driving. ClassNK Technical Journal, No. 4. 2021. Available online: https://www.classnk.or.jp/hp/pdf/research/rd/2021/04_e01.pdf (accessed on 8 March 2023).
22. Toyota. Intelligent Multi-Mode Transit System Tests Start: New Toyota System Features Automatically Operated Train-like Buses. 1999. Available online: https://global.toyota/en/detail/8079640 (accessed on 8 March 2023).
23. McFarland, M. The $75,000 Problem for Self-Driving Cars Is Going Away. *Washington Post*, 4 December 2015.

24. Kim, D.-Y.; Jung, M.; Kim, S. An Internet of Vehicles (IoV) Access Gateway Design Considering the Efficiency of the In-Vehicle Ethernet Backbone. *Sensors* **2020**, *21*, 98. [CrossRef] [PubMed]
25. Manoharan, S. An Improved Safety Algorithm for Artificial Intelligence Enabled Processors in Self Driving Cars. *J. Artif. Intell. Capsul. Netw.* **2019**, *2019*, 95–104. [CrossRef]
26. Paden, B.; Čáp, M.; Yong, S.Z.; Yershov, D.; Frazzoli, E. A Survey of Motion Planning and Control Techniques for Self-Driving Urban Vehicles. *IEEE Trans. Intell. Veh.* **2016**, *1*, 33–55. [CrossRef]
27. Cheng, S.; Chen, H.; Wang, Z.; Yang, B.; Lv, C.; Nakano, K. A Game Theoretical Chassis Domain Approach to Trajectory Tracking for Automated Vehicles. *IEEE Trans. Veh. Technol.* **2023**, *72*, 14051–14060. [CrossRef]
28. Alalwany, E.; Mahgoub, I. Security and Trust Management in the Internet of Vehicles (IoV): Challenges and Machine Learning Solutions. *Sensors* **2024**, *24*, 368. [CrossRef]
29. EU. Japan's Aging Society. 2021. Available online: https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/659419/EPRS_BRI(2020)659419_EN.pdfI (accessed on 10 October 2023).
30. Sakai Town. Sakai Town Population Vision. 2020. Available online: https://www.town.ibaraki-sakai.lg.jp/data/doc/1618913507_doc_18_1.pdf (accessed on 10 October 2023).
31. mACNiCA. The First in the Country, a Local Government Has Put Autonomous Driving Buses into Practical Use on Public Roads. 2020. Available online: https://www.macnica.co.jp/business/maas/news/2020/133985/ (accessed on 12 March 2024). (In Japanese)
32. Autonomous Driving Lab. Considering Utilization for Commuting! Additional Bus Stops for Autonomous Driving Buses in Sakai Town, Including Schools. 2021. Available online: https://jidounten-lab.com/u_autonomous-bus-school (accessed on 24 February 2021).
33. Forbes Japan. Mayor as a Marketer: The Reasons Why Sakai Town in Ibaraki Prefecture Continues to Evolve Through Furusato Nōzei. 2023. Available online: https://forbesjapan.com/articles/detail/66519 (accessed on 10 October 2023).
34. Furusato Choice Award. Introduction of Initiatives from the Award-Winning Municipality. 2022. Available online: https://award.furusato-tax.jp/2022/ (accessed on 10 October 2023). (In Japanese)
35. Cabinet Secretariat. Degiden Menubook. 2024. Available online: https://www.cas.go.jp/jp/seisaku/digitaldenen/menubook/0024.html (accessed on 12 March 2023). (In Japanese)
36. Morikawa, T. In Japan, Practical Experimentation Venues Are Limited, Whereas Worldwide, the Practical Application of Autonomous Driving Is Progressing. The Conservative Culture in Japan Poses Challenges to Bold Experimentation—This Characterizes the Present Situation in the Country. *Interview on Tokai Television*, 28 July 2023.
37. Smart-Flash. In Cities Where 'Autonomous Driving Buses' Operate, 'Bus Stops in front of Homes' Have Become a Reality! With over Two Years of Implementation, There Have Been Almost Zero Accidents Involving Autonomous Driving. 2023. Available online: https://smart-flash.jp/lifemoney/232193/2/1/ (accessed on 8 March 2024). (In Japanese)
38. Chinen, K.; Sun, Y.; Matsumoto, M.; Chun, Y.-Y. Towards a Sustainable Society through Emerging Mobility Services: A Case of Autonomous Buses. *Sustainability* **2020**, *12*, 9170. [CrossRef]
39. NHK. How to Utilize Autonomous Driving Level 4 Route Buses? Sakai Town, Ibaraki Prefecture's Plan. 31 March 2023. Available online: https://www3.nhk.or.jp/news/html/20230331/k10014025391000.html (accessed on 8 April 2024). (In Japanese)
40. NikkeiXTrend. A Town Where Autonomous Driving Buses Can Be Called via LINE—What Is the Sustainable "Sakai Town Model"? 2021. Available online: https://xtrend.nikkei.com/atcl/contents/18/00529/00010/ (accessed on 12 March 2024). (In Japanese)
41. NHK Fukui. Level 4 Autonomous Driving Unlocked—What's Impressive? What Are the Challenges? 2023. Available online: https://www.nhk.or.jp/fukui/lreport/article/000/49/ (accessed on 23 March 2024). (In Japanese)
42. Nikkei, B.P. Regional Revitalization and Mobility 2020. Available online: https://project.nikkeibp.co.jp/atclppp/PPP/052500076/122600018/ (accessed on 10 March 2024). (In Japanese)
43. Asahi Shimbun. Fully Automated Driving Begins on Public Roads—Domestic First, Operation without Constant Monitoring. 21 May 2023. Available online: https://www.asahi.com/articles/ASR5P6FXGR5LPISC00N.html?iref=ogimage_rek (accessed on 9 April 2024). (In Japanese)
44. Nishihori, Y.; Morikawa, T. Analysis of the Important Factors Affecting The Acceptance of Autonomous Vehicles Before and After Test Ride: Considering the Awareness Difference for Technology and Contents of Test Ride. *Toshi Keikaku Rombunshu (J. City Plan. Inst. Jpn.)* **2019**, *54*, 696–702. (In Japanese) [CrossRef]