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Modeling the Deployment of Shared Autonomous Vehicles to Enhance Accessibility and Transport Equity

Authors:

Mohammad Amin Ebrahimzadeh[1, *], Shahriar Afandizadeh Zargari[2]

Abstract

This study investigates the impact of shared autonomous vehicles (SAVs) on social equity and accessibility in urban transport systems, focusing on vulnerable groups such as the elderly, children, and people with disabilities. Using a combination of survey data and logistic regression modeling, the research compares accessibility, travel costs, and satisfaction with transport services before and after the introduction of SAVs in Tehran. Results indicate that the deployment of shared autonomous vehicles significantly improves access to transportation, reduces travel costs, and enhances perceived fairness in service distribution for disadvantaged groups. Furthermore, scatter plot and Cook's distance analyses reveal that the predictive accuracy of accessibility models increases post-implementation, suggesting a stabilizing effect of SAVs on travel behavior. Overall, this study highlights that shared autonomous vehicles can serve as an effective tool for promoting social equity in urban transport and provides practical insights for policymakers aiming to integrate autonomous mobility solutions into public transport systems.

Keywords: Shared Autonomous Vehicles, Deployment, Binary Logistic Regression, Vulnerable Groups, Accessibility

1. Department of Civil Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran

2. School of Civil Engineering, Iran University of Science and Technology

*Corresponding Author: ebrahimzadehmohamadamin@gmail.com

1. Introduction

Recent studies indicate that shared autonomous vehicles (SAVs) can play a key role in enhancing spatial equity in urban accessibility. Research conducted in four European cities (Paris, Berlin, London, and Vienna) shows that factors such as educational attainment and income have a positive impact on improving accessibility, while high unemployment rates reduce it. The findings suggest that the deployment of SAVs can target underserved areas and help reduce existing inequalities in transportation access. However, realizing this potential requires supportive policies and regulations to promote social equity and ensure equal access (Eppenberger & Richter, 2021). Accessibility, for instance, refers to the extent to which land-use and transportation systems enable individuals to reach their activities or destinations, often through a combination of different transportation modes (Gelauff et al., 2019). It is a key concept for transportation policy. Enhancing accessibility and ensuring its equitable distribution across space and social groups are two primary objectives that influence the sustainability and equity of the transportation system (Geurs & Van Wee, 2004; Litman, 2017; Van Wee, 2016).

Recent advancements in transportation technology, particularly the development of shared autonomous vehicles (AVs), have the potential to fundamentally transform transportation accessibility and equity. While this technology can create new opportunities for enhancing urban mobility, its impact on different social groups and spatial inequalities remains a subject of debate. One of the most significant challenges in urban transportation is the inequality in access to vehicles and transport services, which can generate social gaps among various community groups. In this context, shared autonomous vehicles, as an innovative solution, have the potential to reduce these inequalities. By lowering transportation costs, improving accessibility, and increasing system efficiency, this technology can contribute to promoting social equity.

However, the extent of this technology's impact on vulnerable groups still requires more detailed investigation. This study aims to examine the role of shared autonomous vehicles in enhancing urban transportation equity, particularly for the elderly, people with disabilities, and children. This study aims to determine whether shared autonomous vehicles can serve as an effective tool for reducing transportation inequalities and promoting social equity. The main focus of this research is on four parameters: accessibility, cost, satisfaction with transportation service distribution, and social equity. To develop a social equity model within the transportation system, the primary parameters of the model were first identified through consultation and collaboration with 20 experts from various fields, including urban transportation, autonomous vehicle technology, social equity, and urban planning. These experts included transportation specialists, university professors, managers and professionals from public and private transportation sectors, technology experts, and legal advocates, who provided their insights on various parameters such as accessibility levels, costs, satisfaction with services, and the distribution of transportation services.

Data for this study were collected through a questionnaire designed for 823 participants from vulnerable groups. The data collection process lasted approximately six months, during which the challenges and needs of these groups in relation to shared autonomous vehicles were analyzed. In the questionnaire, the benefits of using shared autonomous vehicles were specifically explained for vulnerable groups, including the elderly, people with disabilities, and children.

This study aims to address two main research questions:

1. Can shared autonomous vehicles improve transportation accessibility for vulnerable groups, such as children, the elderly, and people with disabilities, and enhance social equity in urban transportation?
2. How does the use of shared autonomous vehicles for intra-city trips in Tehran affect individuals and households in terms of transportation costs and service distribution, both before and after the implementation of this system?

The remainder of the paper is structured as follows. Section 2 provides a review of the existing literature. Section 3 describes the data collection process, the research methodology, and data analysis. Section 4 is dedicated to modeling and its corresponding results. Finally, Section 5 presents the concluding remarks.

2. Literature Review

This section addresses the challenges and future research trends in accessibility within transport geography. Key issues include the impact of information technology on accessibility, transport system resilience, the comparison of perceived accessibility with traditional indicators, and accessibility in freight and air transport. It also discusses the evaluation of accessibility indices and related ethical aspects, suggesting directions for future research (Van Wee & Geurs, 2011). The impact of autonomous vehicles on urban accessibility has been examined, showing that these vehicles can produce significant improvements in access. The research further concludes that autonomous vehicles may contribute to urban sprawl and reduce the need for public transport outside densely populated urban areas (Meyer et al., 2017).

Additionally, the effects of vehicle technology on the accessibility of vulnerable groups (such as low-income individuals and the elderly) and their social isolation are explored. Increased levels of automation and shared vehicle usage can improve accessibility and social inclusion, although challenges such as the need for digital access and a lack of trust in new technologies may limit these advancements (Milakis et al., 2020). In the coming decades, autonomous vehicles (AVs) have the potential to bring significant changes in accessibility and to influence concepts related to transportation equity (Van Wee & Geurs, 2011; Meyer et al., 2017). Shared autonomous vehicles are independent vehicles that can be utilized in two ways: asynchronously, meaning they are used exclusively by one individual for a trip and then assigned to another user, or synchronously, meaning multiple individuals can share the vehicle for part of a trip, even if they do not know each other (Milakis & Van Wee, 2020).

A policy of synchronous sharing increases both fleet utilization and system efficiency (Parkhurst & Seedhouse, 2019). This study examined the impacts of autonomous vehicles in the Southern California region in terms of travel distance, emissions, and transportation equity. Using various models, the results indicated that the adoption of autonomous vehicles increases travel distance and emissions by 10% and worsens travel equity among different income groups. To mitigate these effects, a set of travel demand management policies was proposed, which helped reduce VMT and emissions while contributing to improved travel equity (Krueger et al., 2016). Autonomous vehicles can have either positive or negative impacts on the social equity of disadvantaged groups.

This study examines CAV-related policies in three main categories: accessibility, multimodal transportation, and social welfare. Most policies focus on shared-use models and economic impacts; however, issues such as the lack of attention to low-income individuals, people of color, safety concerns in shared vehicles, and rural communities are less addressed (Jiang & Ma, 2022). Transport policy discourse views shared autonomous vehicles (SAVs) as a sustainable solution, but their successful implementation depends on meeting user needs. Few studies have employed participatory methods, and this two-stage study indicates that accessibility equity, social cohesion, environmental protection, and concerns about social interactions are key factors influencing the acceptance of these services (Emory & Cao, 2022).

With increasing investment in autonomous vehicle (AV) technology, institutions are examining its impact on travel behavior and transportation inequalities. Kahn et al. (2019) introduced a regional travel demand model that evaluates transportation disparities for disadvantaged populations in Washington D.C. under various scenarios, using performance indicators such as job accessibility, travel time, travel distance, mode share, and vehicle miles traveled (VMT) (Paddeu et al., 2020). This study examines the impact of autonomous vehicles (AVs) on transportation equity and regulatory policies aimed at improving spatial and social equity within AV systems. A game-theoretic model was developed to represent the interactions between ride-hailing platforms, public transit agencies, and passengers with different income levels.

The results indicate that while AV deployment enhances transportation accessibility, these benefits are distributed unequally (Cohn et al., 2019). Dianin et al. (2021) analyzed the impacts of autonomous vehicles (AVs) on transportation accessibility and equity. Enhancing accessibility and ensuring its equitable distribution are two main objectives for achieving more sustainable transportation. Depending on AV characteristics (private or shared) and different contexts (urban or rural), their effects can vary. The study identifies four primary impacts of AVs on accessibility: (1) access polarization, (2) access dispersion, (3) exacerbation of social inequalities, and (4) reduction of inequalities (Gao & Li, 2024). Autonomous vehicles have the potential to either enhance overall transportation accessibility and create a more equitable future for disadvantaged groups or, by establishing transportation networks limited to specific users, deepen existing gaps (Dianin et al., 2021).

However, autonomous vehicle policies have the potential not only to prevent harm but also to provide benefits for disadvantaged populations (Wu, X et al., 2021). Achieving transportation equity is an important goal in transportation systems, aiming to ensure that benefits and costs are distributed fairly so that no group is disadvantaged due to limited access or negative impacts of infrastructure. This study reviews academic research and transportation planning practices, helping to establish a common language among professionals to promote transportation equity (Cohen et al., 2017).

Most studies have focused on examining the impacts of these technologies on different social groups, particularly disadvantaged populations such as low-income individuals, the elderly, and people with disabilities. Research has shown that autonomous vehicles may offer significant benefits in terms of enhancing transportation accessibility and reducing social gaps; however, these benefits may be distributed unequally. This study specifically focuses on the role of shared autonomous vehicles in improving accessibility for vulnerable groups in Tehran and examines how these technologies can either enhance or exacerbate social equity in transportation access for these populations.

3. Methodology

3.1. Data Collection Method

In this study, data were collected through fieldwork via direct interaction with the target groups. Questionnaires were distributed and completed in person at rehabilitation centers for people with disabilities, schools for children, and social security organizations for the elderly. These questionnaires included questions related to the economic and social status of each target group. In the following section, the data collection instrument is described, detailing the design and implementation of a questionnaire aimed at qualitatively assessing three key parameters in the urban transportation system: accessibility, cost, and the distribution of transportation services. regarding social equity in the transportation system. In this study, a five-point Likert scale was used to measure participants' attitudes and perceptions toward three parameters: accessibility, cost, and the distribution of transportation services. The Likert scale is a standard tool in social science research, employed to measure individuals' attitudes, feelings, and opinions. Introduced in 1932 by Rensis Likert, a social psychologist, this scale allows researchers to evaluate the degree of agreement or disagreement of respondents with the statements presented in the questionnaire (Joshi et al., 2015).

3.2. Data Analysis Method

Binary logistic regression is a statistical model used to predict the probability of an event occurring based on one or more independent variables. This model is particularly useful for classification or prediction problems where the dependent variable is defined as a binary outcome (e.g., yes/no or success/failure), which is commonly applied in social, economic, and human research. Logistic regression models the relationship between independent variables and a binary dependent variable using the logistic regression function. The general form of the model is expressed as in Equation (1):

$$\ln\left(\frac{1-P}{P}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n \tag{1}$$

Where P represents the probability of the event occurring, β0 is the model intercept, and β1,β2,…,βk are the coefficients of the independent variables X1,X2,…,X_k (Wright, 1995). This model predicts the likelihood of the event—specifically, the status of social equity—before and after the introduction of shared autonomous vehicles, based on a combination of social, economic, and demographic factors.

3.3. Case Study

In this study, data were collected from selected transportation and traffic statistics of Tehran for the year 2021, as well as population and housing information from the 2023 census. The overall population of Tehran is approximately 14 million, with a population density of 129 people per hectare. The city comprises 22 districts, with 26.7% of the population employed and 22.6% engaged in education. The total number of daily trips in Tehran is around 19.8 million. Trip purposes are distributed as follows: educational 18%, work-related 43%, shopping 13%, recreational 19%, and other, 7%. The modal share of urban transportation in Tehran includes private cars and pickups 49%, ride-hailing taxis 2%, motorcycles 7%, buses and metro 19%, minibuses 2%, traditional taxis 18%, and other modes, 3% (Tehran City Council, 2021).

3.4. Descriptive Analysis

In the descriptive analysis of this study, the socio-economic characteristics of three target groups—people with disabilities, the elderly, and children—were examined. Table 1 presents the frequency analysis of the socio-economic variables collected through the questionnaire.

Table 1. Frequency Analysis of Socio-Economic Variables Collected from the Questionnaire

No.	Variable	Category / Range	Frequency	Percentage (%)
1	Age	7–18	442	29.47

		19–30	174	11.60
		30–40	145	9.67
		40–60	176	11.73
		60+	563	37.53
		Total	823	100
2	Gender	Male	827	55.13
		Female	673	44.87
		Total	823	100
3	Monthly Income	Less than 10 million IRR	400	26.67
		10–20 million IRR	543	36.20
		20–30 million IRR	273	18.20
		30–40 million IRR	140	9.33
		More than 40 million IRR	144	9.60
		Total	823	100
4	Occupation	Student	442	29.47
		University Student	102	6.80
		Public Sector Employee	177	11.80
		Private Sector Employee	150	10
		University Professor	23	1.53
		Homemaker	55	3.67
		Retired	195	13
		Teacher	77	5.13
		Doctor	60	4
		Shopkeeper / Seller	68	4.53
		Unemployed	98	6.53
		Entrepreneur	53	3.53
		Total	823	100

The following Table 2 presents the results for the three parameters: accessibility, cost, and transport service distribution, using a five-point Likert scale. This table shows the frequency and percentage of respondents for each scale level of each parameter.

Table 2. Analysis of Shared Autonomous Vehicle Questionnaire Responses

No.	Question	Response Options (Before SAV Introduction)	Frequency (%)	Response Options (After SAV Introduction)	Frequency (%)
1	How would you describe accessibility to the public transport system in your area?	Very Poor	235 (28.56)	Very Low	79 (9.6)
		Poor	268 (32.59)	Low	115 (14)
		Average	201 (24.41)	Medium	128 (15.6)

		Good	87 (10.58)	High	298 (36.2)
		Very Good	32 (3.89)	Very High	203 (24.7)
		Total	823 (100)	Total	823 (100)
2	How do you evaluate the cost of using the public transport system in your area?	Very Low	67 (8.14)	Very Low	77 (9.4)
		Low	95 (11.54)	Low	83 (10.1)
		Medium	126 (15.33)	Medium	149 (18.1)
		High	295 (35.84)	High	281 (34.2)
		Very High	240 (29.14)	Very High	233 (28.3)
		Total	823 (100)	Total	823 (100)
3	Are public transport services available at different times of the day?	Very Poor	218 (26.5)	Very Low	59 (7.2)
		Poor	255 (31)	Low	83 (10.1)
		Average	198 (24.1)	Medium	134 (16.3)
		Good	97 (11.8)	High	292 (35.5)
		Very Good	55 (6.7)	Very High	255 (31)
		Total	823 (100)	Total	823 (100)
4	How adequate is the diversity of semi-public vehicles (taxis, ride-hailing, etc.) in your area?	Very Poor	234 (28.5)	Very Low	69 (8.4)
		Poor	295 (35.8)	Low	81 (9.85)
		Average	189 (22.9)	Medium	121 (14.7)
		Good	76 (9.2)	High	285 (34.7)
		Very Good	29 (3.5)	Very High	267 (32.5)
		Total	823 (100)	Total	823 (100)
5	How would you assess the fairness of the transport system in your area?	Very Poor	238 (28.91)	Very Poor	126 (15.3)
		Poor	194 (23.57)	Poor	138 (16.76)
		Average	176 (21.38)	Medium	205 (24.9)
		Good	119 (14.45)	Good	251 (30.49)
		Very Good	96 (11.66)	Very Good	217 (26.36)
		Total	823 (100)	Total	823 (100)

The findings presented in Table 2 demonstrate notable improvements in accessibility, cost, and transport service distribution following the implementation of shared autonomous vehicles (SAVs). Respondents reported enhanced access to transportation services, increased availability across different times and modes, and higher satisfaction regarding associated costs. These results indicate that SAVs have the potential to promote social equity in urban mobility, particularly for vulnerable populations such as children, the elderly, and persons with disabilities. Overall, the evidence underscores the role of shared autonomous vehicles in reducing disparities and fostering a more equitable urban transport system.

4. Results

4.1. Logistic Regression Results

The interpretation of logistic regression results is typically conducted using a summary table of the model. In statistics, the log-likelihood coefficient represents the likelihood function evaluated at specific values of the model parameters and plays a central role in inferential statistics. The likelihood function indicates the probability of observing the given data for particular parameter values. Table 4 presents the characteristics and statistics related to the fit of the regression model. As shown in Table 3, the table includes three columns, where the first column displays the log-likelihood coefficient, and the other coefficients exhibit an ideal correlation structure.

Table 3. Summary of the Model Before and After the Introduction of Shared Autonomous Vehicles

Scenario	-2 Log-Likelihood	Cox & Snell R^2	Nagelkerke R^2
Social equity status of the transport system before the introduction of shared autonomous vehicles	491.859	0.390	0.552
Social equity status of the transport system after the introduction of shared autonomous vehicles	429.324	0.294	0.801

For the interpretation of the regression results, the model coefficients from Table 4 were used, representing the most important outputs of the modeling process. Table 5 presents these coefficients as follows:

Table 4. Model Coefficients Before the Introduction of Shared Autonomous Vehicles

Variables	Coefficients (B)	Standard Error	Wald Statistic	df	Significance (p)	Exp(B)
Constant	0.618	0.232	6.18	1	0.073	0.054
Accessibility level of people with disabilities	0.148	0.065	7.23	1	0.056	0.064
Accessibility level of children	0.207	0.087	4.54	1	0.039	0.032

Accessibility level of the elderly	0.321	0.232	7.47	1	0.037	0.062
Travel cost level for children (monthly)	0.308	0.165	3.24	1	0.048	0.023
Travel cost level for people with disabilities (monthly)	0.197	0.033	5.06	1	0.029	0.011
Travel cost level for the elderly (monthly)	0.254	0.132	6.23	1	0.047	0.016
Satisfaction level of children with transport equity	0.189	0.123	5.27	1	0.027	0.038
Satisfaction level of people with disabilities with transport equity	0.165	0.065	5.23	1	0.078	0.027
Satisfaction level of the elderly with transport equity	0.172	0.035	6.01	1	0.036	0.023

The analysis of the model coefficients before the introduction of shared autonomous vehicles indicates that various factors, such as accessibility to transportation for vulnerable groups, travel costs, and satisfaction with the equity of transport services, significantly affect the dissatisfaction of these groups. Positive coefficients were observed for accessibility to transportation for people with disabilities, children, and the elderly; however, these values are not high enough to indicate adequate satisfaction with transport accessibility. In fact, these relatively low coefficients highlight the existing challenges in providing sufficient access to transportation for these groups. Moreover, the positive coefficients for travel costs, particularly for children, people with disabilities, and the elderly, suggest an additional financial burden on these groups due to high transportation expenses. These travel costs may limit access to transportation and reduce satisfaction with transport services among these groups. Specifically, travel costs for people with disabilities and the elderly have the most negative impact on the model. Regarding satisfaction with the equity of transport service distribution, it appears that these groups, particularly people with disabilities and children, are concerned about the unfair allocation of transport services. The positive coefficients for satisfaction with equity indicate dissatisfaction with how transport services are distributed, which may result from unmet specific needs or barriers in accessing transport facilities. Consequently, it can be concluded that vulnerable groups, such as people with disabilities, children, and the elderly, face significant challenges related to accessibility, travel costs, and equity in service distribution. These factors contribute to their dissatisfaction with the public transport system and underscore the need for policy revisions and targeted interventions for these groups. Analysis of the model coefficients after the introduction of shared autonomous vehicles is presented in Table 5 below.

Table 5. Model Coefficients After the Introduction of Shared Autonomous Vehicles

Variable	**Coefficient**	**Standard Error**	**Wald**	**df**	**Significance (p)**	**Exp(B)**

Constant	0.724	0.215	7.07	1	0.105	0.097
Accessibility for persons with disabilities	0.378	0.150	6.74	1	0.127	0.089
Accessibility for children	0.356	0.290	7.89	1	0.218	1.022
Accessibility for the elderly	0.348	0.258	9.04	1	0.135	1.047
Children’s satisfaction with equity in transport distribution	0.345	0.142	4.45	1	0.119	1.056
Persons with disabilities’ satisfaction with equity in transport distribution	0.365	0.323	6.67	1	0.123	1.024
Elderly satisfaction with shared travel costs	0.487	0.323	10.4	1	0.121	1.005
Persons with disabilities’ satisfaction with shared travel costs	0.369	0.135	6.47	1	0.118	1.038
Children’s satisfaction with shared travel costs	0.386	0.238	7.23	1	0.132	1.067

In the analysis of the model coefficients after the introduction of shared autonomous vehicles, notable improvements are observed in accessibility, satisfaction with transport equity, and travel costs among the vulnerable groups. The first important point is the positive coefficients for improved accessibility to transportation for persons with disabilities, children, and the elderly, indicating the beneficial effects of shared autonomous vehicles in this regard. In this model, accessibility for these groups has improved compared to the previous model, which showed significantly negative results, providing evidence of greater satisfaction with transport access. Additionally, compared to the previous model, the coefficients related to satisfaction with equity in transport distribution have also improved. These changes are particularly notable for children, persons with disabilities, and the elderly, who experienced lower satisfaction levels in the previous model. The new model indicates that after the introduction of shared autonomous vehicles, these groups report greater satisfaction with the equitable distribution of transport services compared to the past. Furthermore, satisfaction with the shared travel costs of autonomous vehicles has increased among vulnerable groups. The positive and significant coefficients in this section, especially for persons with disabilities, the elderly, and children, indicate that these groups are more satisfied with the costs associated with using this mode of transport after the introduction of shared autonomous vehicles, suggesting that this system has made travel costs more manageable for them. Overall, the model after the introduction of shared autonomous vehicles demonstrates a significant improvement in accessibility, equitable distribution of transport services, and satisfaction with travel costs for vulnerable groups, indicating the positive impact of this technology in reducing access gaps and enhancing social equity in transportation. The results suggest that shared autonomous vehicles can generate positive changes in social inequalities. These findings are derived from various assessments, including the evaluation of access to public transport in underserved areas, mobility access for persons with disabilities, and satisfaction levels with the transport system among children and the elderly in Tehran. The analyses highlight substantial social and economic changes resulting from the implementation of such technologies. By comparing conditions before and after the deployment of shared autonomous vehicles, it can be concluded that these changes have had particularly positive effects for vulnerable groups in Tehran.

4.2. Model Validation and Testing

To assess the validity and reliability of the shared autonomous vehicle (SAV) model, two established tests were employed. First, the omnibus test of coefficients was used to evaluate the significance of the model's coefficients, allowing us to analyze the impact of each independent variable on the dependent variable. The omnibus test typically examines whether the coefficients of independent variables in a regression model or a similar model are statistically significant. This test helps determine whether an independent variable has a meaningful effect on the dependent variable. Table 6 presents the results of the omnibus test for the model before and after the introduction of shared autonomous vehicles.

Table 6. Omnibus Test of Coefficients for the Model Before and After the Introduction of Shared Autonomous Vehicles

Case	Step	Chi-Square	df	Significance
Social equity status before the introduction of SAVs	Step	670.136	7	0.000
	Block	670.136	7	0.000
	Model	670.136	7	0.000
Social equity status after the introduction of SAVs	Step	480.918	6	0.000
	Block	480.918	6	0.000
	Model	480.918	6	0.000

Analysis of Social Equity Status Before and After the Introduction of Shared Autonomous Vehicles (SAVs):

- Before SAVs: The high Chi-square value of 670.136 indicates a strong model effect in predicting social equity. With 7 degrees of freedom and a significance level of 0.000 (<0.001), the model is statistically significant, confirming that the included variables meaningfully influence the predicted outcomes.
- After SAVs**:** The Chi-square value decreased to 480.918, reflecting a notable change in the effect of the variables. This reduction suggests an improvement in social equity, as disparities in access to transportation have been mitigated after the introduction of SAVs. The model has 6 degrees of freedom, one less than before, and remains statistically significant ($p < 0.001$), indicating that the predictors still have a meaningful impact.

4.3. Scatter Plot Analysis

In this section, the impact of shared autonomous vehicles (SAVs) on social equity and equal access to transportation for different social groups is examined. Scatter plots (Figures 1 and 2) were used to analyze these effects, illustrating the relationship between the variable **Chev** (which represents decisions related to vehicle usage) and the predicted probabilities before and after the introduction of SAVs. Figure 1 specifically presents the analysis before the deployment of SAVs, with data collected from the pre-introduction period. At this stage, particularly for disadvantaged groups (persons with disabilities, the elderly, and children) and social groups with limited access to transportation, the lack of access to suitable or more affordable vehicles was highlighted.

The predictive model results indicated a lower likelihood of using transportation systems among these groups, reflecting existing gaps in access to sustainable transportation. Figure 2 presents the analysis after the introduction of shared autonomous vehicles. Following the widespread adoption of shared autonomous vehicles, significant changes in access patterns and vehicle usage were observed among specific groups, particularly persons with disabilities, the elderly, and children. According to the predictive model results, the likelihood of using shared autonomous vehicles in these groups increased significantly. The scatter plot illustrates that, especially compared to the pre-introduction stage, these individuals gained access to more suitable transportation options and made broader use of these vehicles. The observed differences in the scatter plots indicate the positive impact of shared autonomous vehicles on enhancing social equity and reducing disparities in transportation access. Shared autonomous vehicles, particularly for individuals with special needs and disadvantaged social groups, provide an effective solution for promoting social equity and ensuring equal access to transportation services. The results of the analyses suggest that shared autonomous vehicles can play a significant role in increasing social equity. This technology has the potential to reduce existing gaps in transportation access and help disadvantaged groups benefit from more affordable and convenient mobility options. These findings can inform future urban planning and transportation policies that prioritize equitable access to transportation resources.

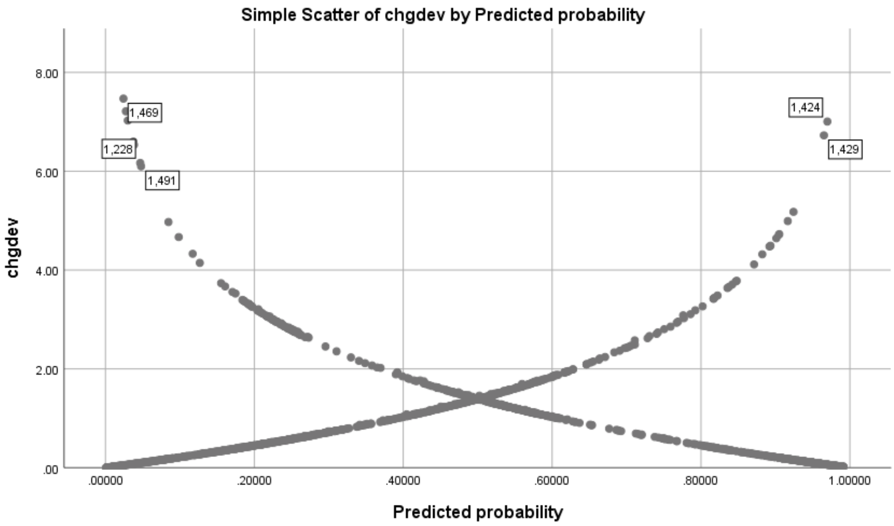

Figure 1. Scatter Plot of Social Equity Status Before the Introduction of Shared Autonomous Vehicles

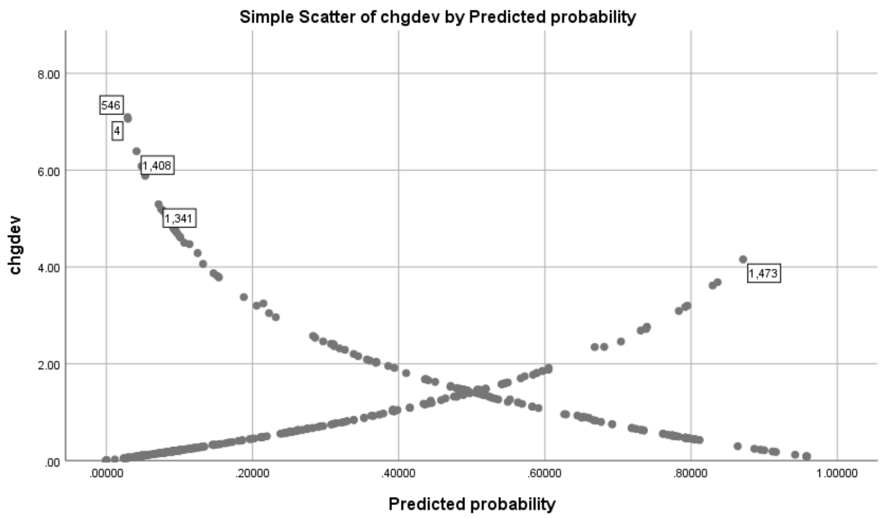

Figure 2. Scatter Plot of Social Equity Status After the Introduction of Shared Autonomous Vehicles.

4.4. Cook's Distance Analysis

In this section, a descriptive analysis of the scatter plot is presented for three specific social groups, including people with disabilities, children, and the elderly, covering 823 individuals from the study population. This analysis specifically examines the impact of shared autonomous vehicles on transportation access and social equity before and after their implementation for these groups. Cook's scatter plots, Figures 3 and 4, illustrate the situation prior to and after the introduction of shared autonomous vehicles. Figures 3 and 4 illustrate the impact of shared autonomous vehicles on transportation access and social equity for three vulnerable groups, including people with disabilities, children, and the elderly.

Prior to the implementation of this system, individuals with disabilities were positioned at lower levels in the scatter plot, indicating a lower probability of using transportation services. Accessibility and convenience barriers were the main obstacles limiting their usage. However, after the introduction of shared autonomous vehicles, the data show a significant increase in the likelihood of use for this group, reflecting a reduction in transportation inequalities for these individuals. Children also had limited access to public transportation before the implementation of the autonomous vehicle system, mainly due to the need for accompaniment and age-related restrictions. In the scatter plot, their points were often located in the lower sections, indicating a lower likelihood of usage. However, after the introduction of shared autonomous vehicles, the points for this group shifted to higher levels in the plot, reflecting an improvement in transportation conditions and increased access to these services. Regarding the elderly, they also faced challenges prior to the implementation of the autonomous vehicle system, such as physical limitations and a greater need for comfort in transportation. These factors resulted in a lower likelihood of using public transport. However, after the introduction of shared autonomous vehicles, a significant increase in accessibility for this group was observed, indicating that this technology can better meet the mobility needs of older adults. Overall, the analysis demonstrates that shared autonomous vehicles can substantially reduce transportation inequalities for specific groups.

Scatter plot analyses and Cook's influence assessments further indicate an increased impact of these groups' data on predictive models after the deployment of autonomous vehicles. These improvements directly contribute to enhancing social equity, suggesting that shared autonomous vehicles can be an effective tool for improving access to transportation, particularly in areas with infrastructure limitations.

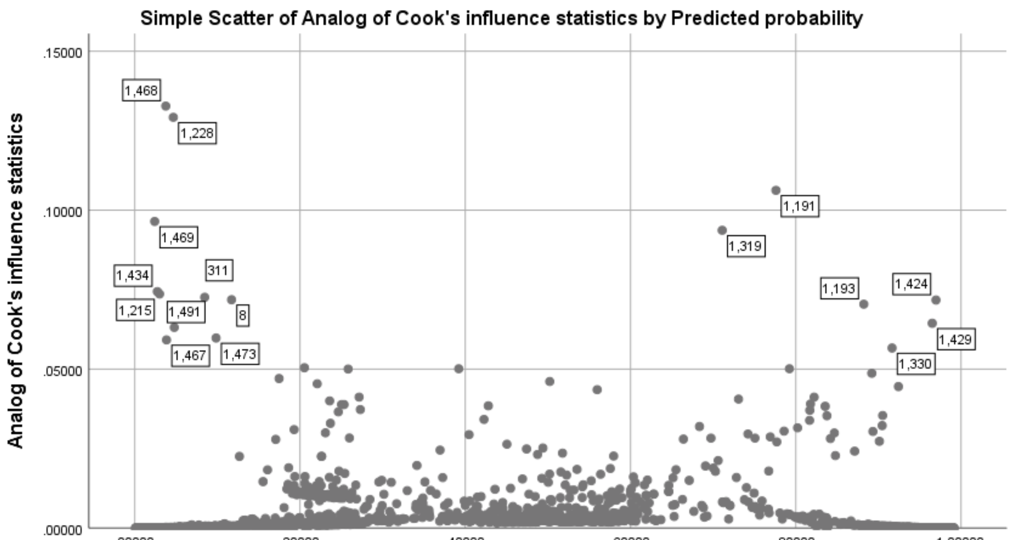

Figure 3. Cook's Distance Plot before the Introduction of Shared Autonomous Vehicles

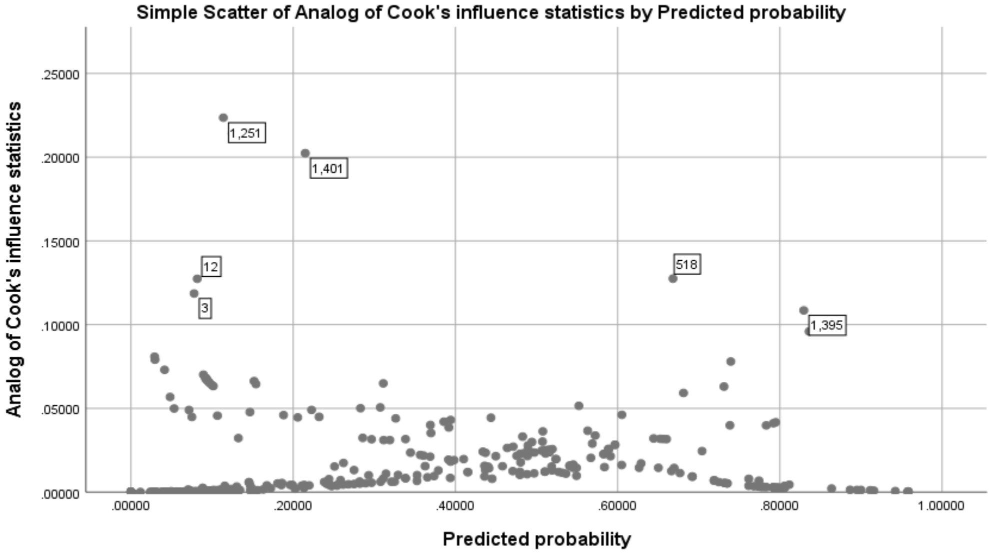

Figure 4. Cook's Distance Plot after the Introduction of Shared Autonomous Vehicles

5. Conclusion

This study examined the impact of the deployment of shared autonomous vehicles (SAVs) on social equity and access to transportation for vulnerable groups, including the elderly, children, and individuals with disabilities, using a logistic regression model. The results indicate that the introduction of SAVs has generally led to improvements in social equity and access to public transportation for these groups. Comparing data before and after the implementation of this technology reveals a significant reduction in existing gaps in transportation access. Notably, the use of shared autonomous vehicles positively influenced the travel patterns of the target groups and, in many cases, enhanced their access to various transportation services. This study emphasizes that the implementation of shared autonomous vehicles (SAVs) can serve as an effective tool for improving social equity and reducing disparities in transportation access.

The key conclusion is that, if properly designed and implemented, this technology has the potential to play a pivotal role in promoting sustainable development and social justice. Both the scatter plots and Cook's distance analyses indicate reduced dispersion after the adoption of SAVs, reflecting an overall improvement in model performance and increased predictive accuracy. In other words, following the introduction of shared autonomous vehicles into the transportation system, the model's predictions align more closely with observed data and exhibit lower variability. The reduced dispersion demonstrates that the model better captures the behavior of specific groups, such as individuals with disabilities, children, and the elderly. This likely indicates that the new data and usage patterns associated with shared autonomous vehicles (SAVs) are more predictable, enabling the system to provide more accurate forecasts of these groups' behavior. The reduced variability observed in the post-SAV data points may suggest that these vehicles have contributed to more stable travel behavior among specific groups. For example, individuals with disabilities and the elderly, who previously faced significant barriers to transportation access, now have a more convenient and reliable mobility option through SAVs. The lower dispersion in both scatter plots implies that shared autonomous vehicles effectively reduce existing gaps in transportation access for these groups, thereby diminishing disparities in the use of transportation services.

The reduced dispersion in both scatter plots after the implementation of shared autonomous vehicles (SAVs) indicates a significant improvement in access to and utilization of this technology for specific groups. These positive changes are directly linked to the impact of SAVs on enhancing social equity. With lower dispersion, the model achieves higher accuracy in predicting the behavior of these groups, reflecting improved access and transportation conditions after the introduction of shared autonomous vehicles. Overall, the findings of this study suggest that the deployment of SAVs has a positive effect on social equity in transportation by improving access, reducing costs, and promoting a more equitable distribution of services. Based on these results, policymakers and urban managers in Tehran are encouraged to prioritize the development and integration of this technology into the public transport system. Citizens—especially vulnerable groups—expect the government to provide the necessary infrastructure to enable wider access to shared autonomous vehicles, thereby further enhancing social equity in urban transportation.

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