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Winter Sabotage: The Three-Way Interactive Effect of Gender, Age, and Season on Public Bikesharing Usage

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Abstract: Public bikesharing is an environmentally friendly transportation mode that can remedy the urban "last mile" problem to some extents. Prior studies have investigated many predictors of the public bikesharing usage. For example, researchers find that gender, age, and physical conditions are significantly related to the public bikesharing usage. However, few studies have tested the characteristics of each ride and no integrative theoretical framework has been provided to explain these findings. In the current study, based on the conservation of resource theory, we suggest that the reason why these factors can predict public bikesharing usage is people's inner needs of resource conservation. Based on this theoretical framework, we propose that: first, gender, age, and season will have direct impacts on public bikesharing usage (i.e., distance and user type); second, gender, age, and season will interactively predict public bikesharing usage as well. A relatively large sample with 1,383,773 rides in 2018 from New York City is used to test our hypotheses. The results indicate that old females indeed use public bicycle less intensively in the winter than young males do in other seasons and thus support the three-way interaction effect. Implications for the emerging public transport systems and limitations of this study are also discussed.

Keywords: public bicycle; emerging public transport systems; mobility; predictor; three-way interaction

1. Background

Public bikesharing has been widely recognized as a healthy and environmentally friendly transportation mode, which is intensively investigated almost all over the world [1–6]. Public bikesharing provides people with a more flexible transportation choice that can efficiently adapt to the congested urban traffic [7–9]. Especially nowadays, more emerging public transport systems such as the public-sharing bicycle system in China and other countries facilitate much more new business modes and greatly solve the "last mile" transportation problem of urban citizens [7]. Moreover, with less amount of energy used, public cycling can help enhance the sustainability of public transportation and the environment [10], providing commuters with more freedom to use this vehicle

without many costs associated with purchasing a bicycle [11]. Public bicycles can also bring people a range of health and community benefits [5,12]. Therefore, it is theoretically and practically important for us to investigate the patterns of how people use this public bikesharing as their public transport tool for their "last mile" home.

Prior studies have shed light on the strategic designs of public bikesharing systems. In order to efficiently manage the sharing system and address the interests of both users and investors, two factors—characteristics of users and network structures of bicycle paths—have been considered simultaneously [13]. From this perspective, many researchers focus on predictors of urban citizens' utilizations of public bicycles [14]. For example, researchers suggest that safety and convenience concerns have profound impacts on the cycling behavior of riders [13] and that even perceived safety of the local neighborhood can influence local bicycle usages too [15,16]. Moreover, Fuller et al. [17] find that age, gender, and the distance from home are significantly related to public bicycle usage. Fuller et al. [18] examine health outcomes associated with the exposures to the public bikesharing system in Montreal and indicate that weather and recreational aims also influence the likelihood of public bikesharing usage. Moreover, as China is generally witnessed as the "Kingdom" of bicycle [19–21], there are plenty of studies investigating public bicycle systems in China. Scholars recently indicated a sharp decline in bicycle use and the emergence of a free-floating bikesharing system in China [21]. For example, Hazen et al. [20] declared that the ratio of cycling transport to urban transporter in Beijing has dropped greatly. Although some seed plans have been implemented by the Beijing municipal government to facilitate different public bikesharing systems, major operators actually experience large economic losses because of relatively low turnover rates. All these facts urge us to carefully analyze the characteristics of users and to figure out personal and environmental predictors of public bicycle usage.

2. Literature Review

Gender influences people's transportation choice. Among much research about public bikesharing, researchers have found that the determinants of choosing public bikesharing are quite complicated. Gender, age, income, occupations, trip purpose, and other factors can influence people's decisions [17]. Of all predictors, gender has been widely tested. For example, prior studies indicate that, different from males, females tend not to choose the public bicycle as their public transport means. Some explanations have been provided. For example, researchers indicate that women are generally risk-averse [22,23] and females are more likely to feel the safety concerns about cycling in traffic [24]. Females and males have different goals, behavioral styles, and obstacles when they try to use public bikesharing. Traffic safety might be one of the major constraints on public bikesharing for women [25]. Especially in cities with relatively poor traffic infrastructures [26], females are more easily to be influenced by the perceptions that employing public bicycles will bring them more risks rather than benefits. Empirical studies also find that public bicycle users were more likely to be males who are generally in low ages [27]. Moreover, some other researchers indicate that females prefer works that are close to their home in order to have a shorter commuting distance. Cai et al. [28] unveil that females are dominant by in-home activities that can be conducted within a short distance. Some studies find that females are generally more concerned about risk-related environmental issues [29]. These results can all be derived from the safety concern hypothesis that health and safety concerns are more salient to women than to men [30]. Generally, females hold the beliefs that the consequences of their behaviors are more likely to influence their own valued objects. Therefore, females have more conservative behavioral patterns that encourage them to engage in more habitual and automatic daily activities to avoid public bicycles in order to conserve their current resources.

Moreover, age also influences people's choice of public bicycle [31]. Researchers generally agree that young people are more likely to use a public bicycle than elder ones. For example, Fishman et al. [32] find that people who are 18–34 years old are significantly more likely than others to become a member of a public bike project. Many studies attribute the influence of age on public bicycle choice to the increasing possibility of potential injuries [33]. The elders generally have low

physical and psychological resources that can be employed when using a public bicycle with potential health risks. Moreover, Hazen et al. [20] use a convenience-based model to predict the public bicycle adoption. They believe that perceived quality and convenience decide whether public bicycles will bring perceived values to people. Different from young people, the elders do not easily follow the tide of new technology, thus reducing their perceived value of public bicycle adoption.

Besides, physical environments are also an important predictor of public bicycle usage. For example, some researchers find that bad weather leads to relatively low public bicycle usage [33–39] and others find that the temperature and precipitation also have significant impacts on choice of bicycle travel mode. For example, Hanson et al. [40] link bikesharing to work to the morning temperatures and the cloud cover. Winters et al. [41] find that annual days of precipitation and days with freezing temperatures have strong relationships to public bicycle usage. However, although the general consensus has been reached that bad weather leads to less public bicycle usage, no theoretical explanation has been provided. In current studies, we try to employ an overarching theory to explain why physical conditions have significant relationships with public bicycle usage.

Although, prior studies have already revealed that household demographic factors such as age, gender, and environmental factors such as weather conditions will influence people's willingness to use public bicycle [42,43]. However, they omit some important concerns: Firstly, few prior studies have investigated the pattern of public bicycle choices from a solid theoretical perspective; Secondly, researchers generally investigate these effects independently. Relationships between age, gender, weather conditions and public bicycle usage have been investigated respectively without interactive effects found. Thirdly, most prior studies focus on the reasons why some people chose to use a bicycle, with only few investigations of the features of each ride. Since different kinds of people may have various behavioral patterns, the intensiveness of each public bicycle ride should also considered. For example, the distance and the user type of bicycle usage also needed to be considered when we try to thoroughly figure out the public bicycle usage. Therefore, in the current study, we tried to contribute to theories by: (1) figuring out the interactive effect of both demographic factors: age or gender and physical conditions on public bicycle usage; (2) highlighting the characteristics of each public bicycle usage; (3) employing the conservation of resources theory to explain the process through which and how people use public bicycles.

3. Theoretical Framework and Hypotheses

In the current study, conversation of resource theory is used to analyze the relationships between age, gender, season, and public bicycle usage. Conservation of resource theory (hereafter: COR) [44] indicates that people have basic needs to prevent resource loss. Resources that people cherish could be anything that one values such as objects, states, or conditions while the loss of these resources could lead people to stressful conditions. The principles of COR demonstrate that people are especially more vulnerable towards the loss of resources compared with a gain of resources and they tend to invest more potential resources in order to protect against the resource losses. Beside, since people have limited resources for their work and life [45], some stressful and dangerous environmental factors (e.g., bad weather) will lead them to lose their necessary resources and thus drive them to stressful conditions. At this time, people will proactively engage in resource investments in order to retrieve resources from the environment to their flexible resources store [44,46].

Since male and female users have different risk preferences [18], gender will influence people's choices with potential resource losses. The reason why prior studies indicate that females are generally more risk averse [22] may be due to the fact that females have relatively less physical and psychological resources than males have, while females are more sensitive to environmental threats. Thus, the theoretical explanation why safety concerns influence male or female public transport choices differently might be that females tend to protect their resources and behave more cautiously than males do. Therefore, in the current study, we suggest that females will have used public bicycles less intensively than males.

Similar theoretical framework can also apply to the influence of age. As the young people generally have more physical (e.g., healthier) and psychological (e.g., less sensitive) resources than the elder ones, young people will be more likely to choose public bikesharing than elder ones. Prior studies indicate that, with people's age increasing, the likelihood of resource losses will also increase [47]. Generally, elder people will suffer more chronic health problems or current-life diseases [48]. Thus, they need more supports from environments. According to the conservation of resource theory, people will engage in more resource-keeping practices when they are facing potential resource losses. As public bicycles tend to be related to potential safety concerns, especially in places with relatively poor infrastructures, age will decrease people's usage of public bicycle. Therefore, in the current study, we suggest that older citizens will use public bicycles less intensively than younger ones.

Although prior studies have tested the relationships between age or gender and public bicycle usage respectively, the interactive effect has not been revealed to our knowledge. However, based on the conservation of resource theory, high risk-averse people tend to protect their resources than do those with relatively high risk propensity. Applying this theory, we propose that, although females may use public bicycles less intensively than males because of the potential safety concerns, the relationship may be changed when they are younger. In another words, old females are even more sensitive than young ones because they tend to have less resources available for them to deal with the safety problems associated with public bicycles. Therefore, in the current study, based on the conservation of resource theory, we propose that: (1) females use public bicycles less intensively than males do; (2) younger people use public bicycles less intensively than older ones; (3) age will moderate the relationship between gender and public bicycle usage. That is, younger females use public bicycles more intensively than older females. The first three hypotheses are:

Hypothesis 1: *Females use public bicycles less intensively than males do.*

Hypothesis 2: *The elder people use public bicycles less intensively than the younger ones.*

Hypothesis 3: *Age will moderate the relationship between gender and public bicycle usage.*

Moreover, in the current study, we suggest that the season when riders ride the public bicycle should be considered simultaneously. Although prior studies indicate that bad weather conditions will reduce public bicycle usage, the theoretical explanation has not been provided. We suggest that conservation of resource theory can also be employed here. For example, the bad weather reduces available physical and psychological resources people could have to keep safe, increasing their perceived risks that their safety would be threatened if they do use the public bicycle. Similarly, season may also change people's perceived potential resource-losses when people try to choose the public transportation. Just like infrastructures of the city, season could bias people's feelings of their potential resource stock and urge them to engage in more resource-restoring behavior. Therefore, people will have less likelihood to use public bicycles in the winter intensively when the weather and temperature conditions are serious in public areas. In other words, winter increases users' safety concerns and reduces their public bicycle usage. Thus, based on the conservation of resource theory, we suggest that only in good seasons, males with relatively young ages will use public bicycles more intensively. A three-way interactive effect is proposed here that gender, age, and season will interactively predict public bicycle usage. Please see Figure 1 for the whole theoretical model. Therefore, our final two hypotheses are:
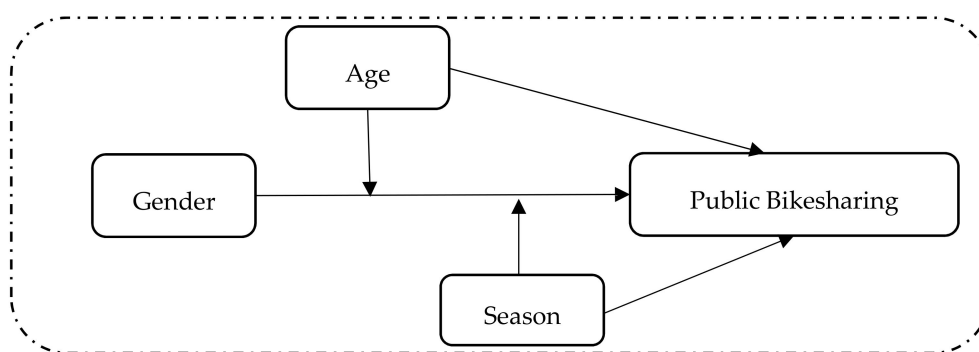
Figure 1. Whole Theoretical Model.

Hypothesis 4: *People will use public bicycles less intensively in the winter.*

Hypothesis 5: *Age and season will interactively moderate the relationship between gender and public bicycle usage.*

4. Methods

4.1. Sample Descriptions

The sample in the current study was established by collecting public bicycle usage information of New York City in 2018. A Citi Bike dataset [49] allowed us to retrieve information of users and each ride. These kinds of information were carefully recorded and treated as our final sample. Detailed information of users such as demographical variables and the description of each ride were collected. Age, gender, and season were retrieved from this sample and used as predictors. The distance of each ride, user type, and district-cross were used as outcomes in our model. Information of user and all rides from 12 months in 2018 were used, so the size of our final sample was relatively large ($N = 1,383,773$). Of all users, 10.64% of them were males ($N = 111,976$) and 89.36% were females ($N = 940,545$). All participants were older than 17 years old and 76.27% of them were younger than 29 years old, so most of our participants were young people. The average distance of each ride was 1.72 miles ($SD = 1.27$) and the average time duration of each ride was 599.59 min ($SD = 340.43$); 73.66% of the rides were cross different districts ($N = 1,019,296$). Most of the participants were subscribers rather than customers (Subscriber: $N = 1,236,169$; Customer: $N = 147,604$). More descriptive statistics can be found in Table 1.

Table 1. Descriptive statistics of main variables.

Variables	Category	Size	Mean	Standard Deviation	Percentage
Age		1,383,773	37.72	12.11	
Gender	Male	111,976			10.64%
	Female	940,545			89.36%
Season	Spring	337,291			24.37%
	Summer	451,128			32.60%
	Autumn	387,942			28.04%
	Winter	207,412			14.99%
District	108 Districts in New York	1,383,773			
Distance of Each Ride		1,354,704	1.72	1.27	
Cross District or Not	No	364,477			26.34%
	Yes	1,019,296			73.66%
User Type	Customer	147,604			10.67%
	Subscriber	1,236,169			89.33%

4.2. Measures

Several coding processes were conducted for us to measure all relevant variable accurately. For example, several dummy variables were created. We coded winter variable as 1 if the time when people rode the public bicycle was during December, January, and February. Because New York City is located in the temperate zone of Northern Hemisphere and thus has four distinctive seasons (temperate continental climate) and there was no extraordinary climatic change in 2018, the coding of winter variable was appropriate. Gender was coded as 1 if the rider was female. Young variable was coded as 1 if the rider was older than 29 years old following the previous study [50]. District-cross was controlled and coded as 1 if the rider crossed different districts on this ride. User type was coded as 1 if the rider was a subscriber. Because customers were riders who rode public bicycles for instant needs, in the current study, we assumed that customers used public bicycles more intensively than subscribers. Therefore, gender, young, and winter were created as predictors while distance and user type were created as outcomes. The correlations of these variables can be found in Table 2.

Table 2. Correlations of main variables.

Variable	1	2	3	4	5
1. Young					
2. Gender	0.18 ***				
3. Winter	−0.02 ***	0.08 ***			
4. Distance	−0.01 ***	−0.06 ***	−0.05 ***		
5. District-cross	0.04 ***	0.01 ***	−0.02 ***	0.44 ***	
6. User Type	0.06 ***	0.74 ***	0.09 ***	−0.08 ***	0.00 **

Note: ** $p < 0.01$; *** $p < 0.01$.

4.3. Hypothesis Test

ANOVA and hierarchical regression analyses were conducted to test our hypotheses. Since the user type is a dummy variable, logistic regression was used when we treated this variable as the outcome. We also tested the collinearity statistics of models. The variance inflation factors (VIFs) for all the variables were less than 2.3 and below the recommended value (i.e., 10), as suggested by Chatterjee et al. [51]. Thus, no collinearity problems existed for these variables. Moreover, since all predictors (i.e., young, gender, and season) were exogenous, no endogenous problem existed here.

To test all direct effects (hypotheses 1, 2, and 4), pair-wise comparison was conducted. From Table 3, we can find that the females riders' distance was significantly less than males' (Male = 1.91, Female = 1.68, Difference = 0.23, $p < 0.001$). Moreover, few females riders were customers for instant needs, while most males were customers who use public bicycles for instant needs (Customer: Male = 81.90%, Female = 3.78%, $p < 0.001$). These results supported Hypothesis 1.
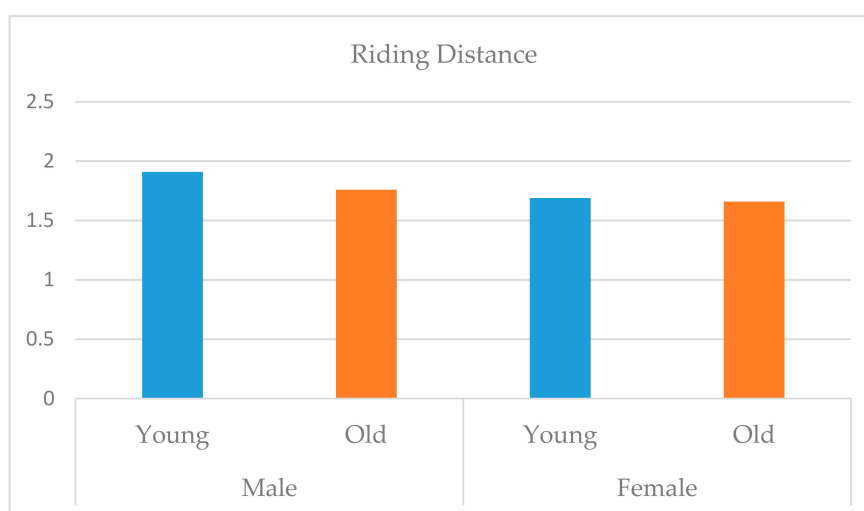
Table 3. Public bicycle usage in different conditions.

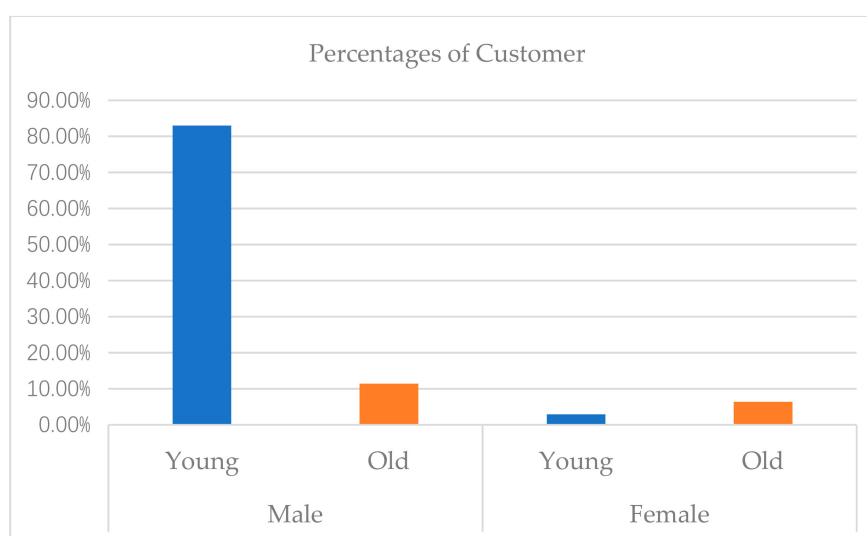| Predictors	Category	Distance		User Type	
		Mean	**Standard Deviation**	**Customer**	**Subscriber**
Gender	Male	1.91	1.25	81.90%	18.10%
	Female	1.68	1.27	3.78%	96.22%
Young	Yes	1.72	1.29	11.68%	88.32%
	No	1.70	1.19	7.40%	92.60%
Winter	Yes	1.57	1.17	4.19%	95.81%
	No	1.74	1.28	11.81%	88.19%

Moreover, we found that the young riders' distance was significantly longer than older riders' (Young = 1.72, Old = 1.70, Difference = 0.01, $p < 0.001$). Moreover, few old riders were customers than young riders (Customer: Young = 11.68%, Old = 7.40%, $p < 0.001$). These results supported Hypothesis 2. Besides, we found that the riders' distance in winter was significantly less than in other seasons (Winter = 1.57, Other Seasons = 1.74, Difference = 0.17, $p < 0.001$). Moreover, fewer riders were customers in winter than in other seasons (Customer: Winter = 4.19%, Other Seasons = 11.81%, $p < 0.001$). These results supported Hypothesis 4.

Two-way ANOVA (Gender * Age) was conducted to test Hypothesis 3 and we found that the interactive effect of gender and young on distance and user type were significant (Distance: $F_{(1, 1,029,853)}$ = 17.61, $p < 0.001$; User type: $F_{(1, 1,052,517)}$ = 20,116.28, $p < 0.001$). Pair-wise comparisons (Bonferroni) were also conducted. For ride distance, the difference between young and old male riders was significant (Difference = 0.16, $p < 0.001$) but the difference between young and old female riders was smaller (Difference = 0.02, $p < 0.001$). However, we did not find that young female riders are more likely to be customers. Please refer to Figures 2 and 3, Table 4 for more details. So, Hypothesis 3 was only partially supported.

Figure 2. Public bicycle usage (distance) for the interactive conditions (two-way).

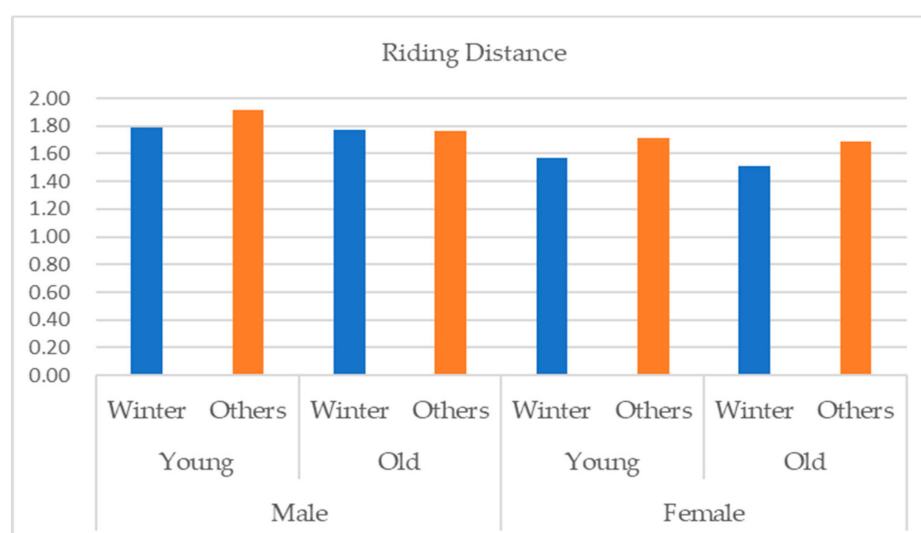**Figure 3.** Public bicycle usage (user type) for the interactive conditions (two-way).

Table 4. Public bicycle usage in the interactive conditions (two-way).

| Predictor	Moderator	Distance		User Type	
		Mean	Standard Deviation	Customer	Subscriber
Male	Young	1.91	1.25	83.00%	17.00%
	Old	1.76	1.29	11.43%	88.57%
Female	Young	1.69	1.30	2.93%	97.07%
	Old	1.66	1.72	6.39%	93.61%

Moreover, a three-way ANOVA test was conducted (Gender * Age * Winter) and we found that there was a significant interactive effect of these three variables on distance (F (1, 1,029,849) = 3.90, $p < 0.05$) and user type (F (1, 1,052,513) = 56.14, $p < 0.001$). Moreover, pair-wise comparisons show that young males used public bicycle more intensively than in any other conditions (Distance = 1.92; Customer = 84.36%) and old females used public bicycles shorter than in any other conditions (Distance = 1.51). However, we found that young females were least likely to be the customer (Customer = 1.11%) in the winter. Therefore, Hypothesis 5 was generally supported. For more details, please see Table 5, Figures 4 and 5.

Table 5. Public bicycle usage in the interactive conditions (three-way).

Predictor	Moderator	Moderator	Distance		User Type	
			Mean	Standard Deviation	Customer	Subscriber
Male	Young	Winter	1.79	1.2	65.86%	34.14%
		Others	1.92	1.25	84.36%	15.64%
	Old	Winter	1.77	1.47	4.27%	95.73%
		Others	1.76	1.26	12.43%	87.57%
Female	Young	Winter	1.57	1.21	1.11%	98.89%
		Others	1.71	1.31	3.30%	96.70%
	Old	Winter	1.51	1.04	3.00%	97.00%
		Others	1.69	1.19	6.97%	93.03%

Figure 4. Public bicycle usage (distance) for the interactive conditions (three-way).
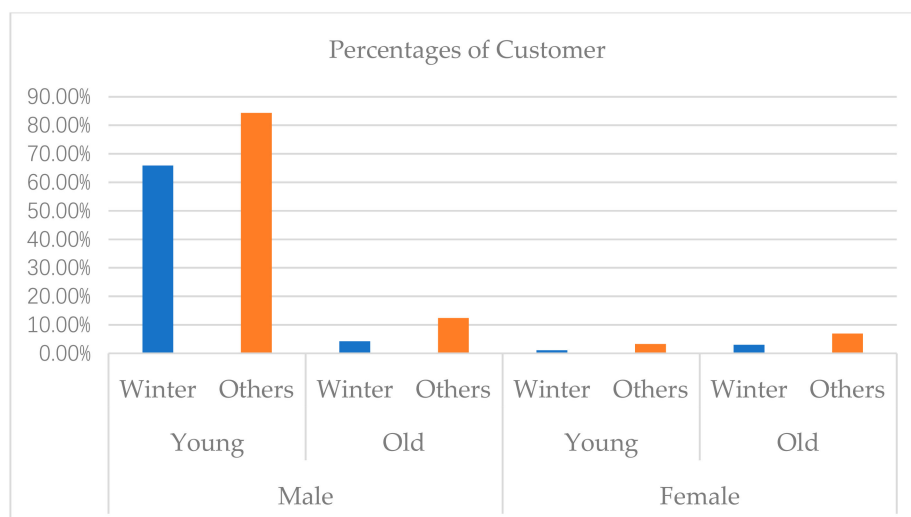
Figure 5. Public bicycle usage (user type) for the interactive conditions (three-way).

4.4. Additional Analyses

We also conducted hierarchical regressions to test proposed hypotheses and logistic regressions were used when user type was treated as the outcome. From Table 6, we can find that: first, gender, young, and winter generally have a negative relationship with distance and user type, except that young people were more likely to be the subscriber than old people. This result indicated that hypotheses 1, 2, and 4 were supported, confirming the analyses from Table 3. Moreover, we found that the effects of interaction between gender and age on riding distance ($\beta = 0.09$, $p < 0.01$) and user type ($\beta = -4.42$, $p < 0.01$) were significant. These results supported Hypothesis 3 and confirmed our analyses derived from Table 4. Besides, we also found that the interaction among gender, young, and winter on distance was significant ($\beta = -0.18$, $p < 0.05$), which partially supported the three-way interaction proposed in Hypothesis 5. Therefore, from these additional analyses, we can confirm the results from prior analyses.

Table 6. Hierarchical regressions.

Variables	Distance		User Type	
	Model 1	**Model 2**	**Model 3**	**Model 4**
Predictors				
District-Cross	1.29 (0.00) ***	1.29 (0.00) ***	−0.05 (0.01) ***	−0.05 (0.01) ***
Gender	−0.18 (0.00) ***	−0.19 (0.00) ***	4.92 (0.01) ***	5.06 (0.01) ***
Young	−0.08 (0.00) ***	−0.17 (0.00) ***	−0.63 (0.01) ***	3.64 (0.08) ***
Winter	−0.12 (0.00) ***	−0.14 (0.00) ***	1.03 (0.02) ***	1.03 (0.03) ***
Interactions				
Gender * Young		0.09 (0.03) **		−4.42 (0.08) ***
Gender * Winter		0.03 (0.01) *		0.09 (0.04) *
Young * Winter		0.14 (0.09)		0.13 (0.04)
Gender * Young * Winter		−0.18 (0.09) *		−0.36 (0.35)

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.01$.

5. Discussion

5.1. Theoretical Contributions

In the current study, we find significant relationships among age, gender, season, and public bicycle usage. These results have some important contributions to theories. First, we find that females use public bicycles less intensively than males. Although several prior studies have indicated that females are less likely to choose public bicycles than males, few have investigated the characteristics of each ride.

In this study, we find that females' ride distance is shorter than males' and they have less possibility to be the customer who use public bicycles by coincidence or for instant needs. Second, we find that young people also have greater intensive public bicycle usage than old people. Besides, season is also an import predictor of public bicycle usage and winter might be the worst season in which people will use public bicycles.

Moreover, another important contribution is that we find some interactive effects of three predictors. First, we find that the interactive effect of gender and age is significant. Based on the conservation of resource theory, we suggest that even though females use public bicycles less intensively, age may reverse this relationship. For females who are generally younger, they may use public bicycles more intensively than older female riders. Second, we also find a three-way interactive effect of gender, age, season. According to our results, public bicycles are generally used by people in seasons with good environments and winter is not a good condition for people to ride public bicycles. Conservation of resource theory is also used here to support the effect of season. These results contribute to theory because few prior studies have provided convincible theories to integrate different predictors of public bicycle usage. Although researchers indicate that weather is an important impactor, in the current study, we find that public bicycle usage also has seasonal changes. We suggest that future studies employ larger samples to investigate whether this effect also functions in other years.

The most important contribution of this paper might be that a theoretical explanation and perspective were provided to investigate public bicycle usage. Although many researchers have tested some relationships we propose in the current study, no integrative theoretical framework has been employed to facilitate our understandings. This constrains researchers to investigate the interactions among these variables. We suggest that future studies use this perspective to test more potential factors that may profoundly influence public bicycle usage. Moreover, in the current study, rather than public transportation choice, we use public bicycle usage as outcomes. We believe that, not only researchers, but also business owners, need to understand the specific behavioral patterns of public bicycle users. In the current study, riding distance and user type are used and represent some characteristics of public bicycle rides.

5.2. Policy Implications

As more and more emerging public transport systems provide people with various choices nowadays and competition between different public transportation modes has become much fiercer than ever before, a sustainable and financially available public transport design should be employed by service providers. In the current study, we carefully analyzed different predictors of public bicycle usage and their interactions. We suggest that all providers of urban public bikesharing should consider their potential audiences' needs in order to refine their services. For example, we find that although old female riders do not ride for a long distance, they really want to become the subscriber. Therefore, more promotional activities can be made for this group in the future. Only by employing these kinds of subtle but carefully designed policies, providers can penetrate the market more accurately and therefore maintain a sustainable business mode. Moreover, we suggest that policy makers such as government officials should also consider the needs of different groups when trying to make public transport policies, because all stakeholders such as business owners, urban citizens, and officials can receive their own benefits only when sustainable services and business modes suitable for local environments can be created and implemented.

5.3. Limitations

Although a relatively big sample size ($N = 1,383,773$) was used to test our model, the current study still suffers some limitations. For example, we only use data from 2018 in the current study. Future studies could use data from other years to retest whether our hypotheses can also be supported. Moreover, despite the fact that the independent variables are all exogenous, the causalities between

each pair of variables still cannot be concluded. We suggest that future studies should use experimental designs to demonstrate causal relationships.

Besides, we find that 10.64% of users of public bikesharing are male users. We acknowledge that other studies may have different distribution patterns [19,52] and our sample may therefore be skewed. However, since whole public bikesharing data in 2018 is used here, we suppose that specific physical or other conditions may determine the gender composition of public bikesharing users in New York City in 2018. Besides, 23.94% of all users did not report their gender information. These results may explain the skewed gender distribution of our final sample. Notwithstanding, considering that we emphasize the characteristics of each riding (e.g., distance or user type), gender distribution would not change our findings. We suggest that future studies could collect more balanced data to investigate similar issues.

Moreover, although most hypotheses are supported by results, some confusions should be further addressed in the future. For example, the average riding distance for old male riders in the winter is longer than in other seasons. We believe that there might be alternative explanations that can predict these findings through other theoretical perspectives. For example, since most old male riders are subscribers (i.e., 88.57%), one possible explanation is that old male riders may use public bicycle as their winter exercise tool rather than for commuting. Thus, most old male riders' riding distance may not be influenced by winter. Moreover, we find that old females are more likely to be customers than young females (Young: 2.93%; Old: 6.39%). This may be due to the different usage patterns of young and old female users. Generally, young female users' riding routines are relatively settled. For example, they tend to use public bikesharing between their home and workplace on workdays. However, old female users may have various travel goals. Thus, more of them might ride public bicycles for their instant needs. We suggest that future studies can further differentiate riders' usage patterns to confirm our results.

6. Conclusions

In the current study, employing a large sample of public bicycle usage from New York City, we established relationships between gender, age, season, and public bicycle usage. Based on the conservation of resource theory, we first proposed theoretical hypotheses and then used statistical methods to test these hypotheses. We found not only significant direct effects of gender, age, and season, but also their interactive effects. For example, old females may use public bicycles less intensively in the winter than young males in other seasons. We tried to contribute to the conservation of resource theory by testing different relationships and emerging public transport systems literatures by figuring out more specific kinds of customers of public bicycles. In addition, we also managed to make some policy implications by suggesting sustainable business modes. We hope we can call for more studies on this topic in the future.

Author Contributions: All authors were involved in preparing the manuscript. J.Z. and T.W. contributed to the design of the research framework and conceptualization. J.Z. developed the methodology and constructed the empirical study. X.H. and C.J. conducted data analysis.

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

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