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Bike Rental System

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***Abstract*— facing the growth of urban mobility in the city of Sfax and the problems of traffic, congestion and pollution, the development of active transportation has become an unavoidable solution. In this context, a study on the promotion of the bike use at Sfax City is launched for the first time. The study is based on a survey done with a sample of 500 citizens. The first part of this work is addressed to know the traveling habits of citizens in order to better understand the state of the current use of the bike at Sfax. The second part is dedicated for the identification of factors influencing the choice of bike's rental through LOGIT model.**

Keywords— Shared transportation, sustainable urban mobility, active transportation, bike rental system, LOGIT model

I. Introduction

Nearly a million inhabitants, the city of Sfax is the second largest Tunisian governorate after the capital Tunis in terms of its demographic weight [1]. Sfax is known for its important economic dynamism and the diversity of its industrial sectors. However, the governorate of Sfax has suffered for decades from serious problems in the transportation and traffic system. These problems affect the three pillars of sustainable development (economic, environmental and social/societal). This transport system is a major generator of environmental nuisances and contributes significantly to the problems of congestion, pollution, and noise. At peak times (morning, afternoon and evening), and the eve of holidays, the problem of transportation is more and more accentuated, and always in city center [1]. Traffic congestion and problems are due to local concentration of economic activities and administrative services. It get worst by the increase in the use of private vehicles, the circulation of heavy trucks, the deterioration of public transport services, the uncontrolled parking due to the lack of parking spaces and the development of road infrastructure. Between 1984 and 2015, the modal split is marked by the dominance of privet cars and taxis compared to public transport and twowheeled vehicles usage. A share of only 1% proves the quasi-absence of the bike. [1]. Indeed, the transport sector is considered as one of the biggest sources of air pollution that degrades the viability of the city. The total emissions in Sfax territory amounted to 5.2 million tonnes of CO2, with a significant share attributed to the transport sector (persons and goods), which emits 54% of greenhouse gas emissions. (GES) [14].

In this context, it is necessary to find alternative solutions for a sustainable transportation system, tends to the energy independence, rather than a polluting and congestive transportation system by developing more environmental friendly transport such as public transport, bike and pedestrians [7]. For this purpose, we are interested on the bike usage as an alternative solution for evolution without harmful consequence. So, a study of bikes rental system "bike sharing" in the city of Sfax was done, where the bikes could occupy a dominant place of citizen's transport.

The objective of this study is to reconsider bikes as an alternative transport solution. Firstly, it aim to know the transportation habits of the citizens of Sfax and to study their opinion regarding this system of bikes renting, Secondly, to identify the factors influencing the choice of renting bikes.

II. Literature Review

The bike is reappeared in the last years with a phenomenal development on almost all continents after a long disappearance. Nowadays, the shared bike, represent an alternative solution to motorized mobility [19]. Since the launching of the first system in the 1960s in the Netherlands, four generations of bike sharing can be considered [4], [17], [10]. The first generation is known as Witte Fietsen "white bikes" This service is characterized by bikes randomly placed in a certain areas for free usage [17]. Unfortunately, this experience had failed, because bikes were simply harmed either thrown into channels or adapted for private use [4]. A second generation appeared in the early 1990 years, in Farsø, Grenå, and Nakskov to face the problems encountered during the first generation by integrating a financial fee to encourage users to bring the borrowed bike into a station to recover their deposit [2]. The third generation start in the beginning of 1996, the bike sharing system became more popular. This generation is characterized by a variety of technological enhancements, including the electronic locking barriers, telecommunication systems, smart cards or magnetic stripe cards, mobile phone access and embedded computers [3]. In May 2009, BIXI is the first shared fourthgeneration bike system appeared in Canada with its solarpowered mobile stations [15]. Other innovations emerged with the fourth generation including mobile stations, solar energy stations,

electrical assistance bikes and the setting up of self-regulation policy using smartphones applications [9].

In 2014, approximately 855 bike sharing programs was counted in almost every region of the world with about 946,000 bikes [12]. However, in the African continent, only two shared bike programs have been set up. The first is located in Marrakech in 2016 with 350 bikes and a dozen stations. The second was set up in Egypt in 2017 with 100 bicycles and 5 stations. In Tunisia, preparations are in progress in Sfax, Kairouan, and Tunis[1].

This system has multiple environmental, economic and social benefits. Bike share is a sustainable practice with minor negative impacts and even without any negative impacts compared to other transportation methods. The increased use of bikes can solve problems of congestion, fuel expenses, and greenhouse gas emissions [13]. A 312 000 km/day course by the users of Vélib' represents a reduction of about 57 720 kg of CO2 per day compared with the same usage by car [17]. Shared bike systems contribute to reduce air and noise pollution, as well as preserve urban spaces. Moreover, requested space for bike facilities is smaller than the infrastructures required for cars [6]. Furthermore, using bikes helps to reduce stress and make users more healthy18].

Some literature reviews, highlight a lot of variety of researches done on shared bike systems [12] [20], some of them was done with deep analysis to check if it is possible to implant similar system. Others study done by focusing on the environmental, socio-economic, geographic and psychological factors that influence the probability to use the bike. However, few studies have explored the characteristic of bike sharing users and the factors that encourage and discourage them to use it [21]. In our study, we will particularly focus on this innovative system.

III. Working Methodology

In order to analyze the characteristics of citizens' movements and to study their behavior towards a bike sharing system in the city of Sfax, we conducted an investigation based on sequence of four steps, described in Fig 1.

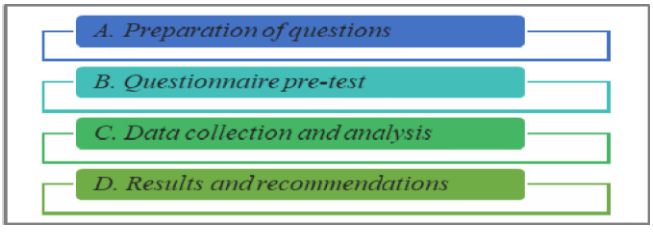


Fig. 1. Working methodology

A. Formulation of the questionnaire

After study of the literature and the consultation of university experts, a questionnaire has been proposed for citizens of the city of Sfax. The questionnaire consists of seventeen questions with different types, in which six of them are open-ended questions and the rest are closed. Closed questions have a unique choice and one of them is with a multiple choice. There is a semi-closed question that comprises a choice "other" in the event that respondents provide other proposals. It is made with different types of data like socioeconomic, traveling habit, and traveling by bike.

The table below represents the detailed information gathered via the questionnaire.

TABLE I. Information Gathered Via the Questionnaire

Type of information	Detailed information
Socio-economic data	Sex ; Age ; socio-professional category ; Number of vehicle possessed by family (Car, motorcycle, bike);
Traveling habit	Reason of trip ; Frequency (A / R) ; Type of transport used ; Distance traveled per trip (A or R) in km ; Travel time per trip (A or R) in mn ;
Traveling by bike	Obstacles encountered ; Traffic conditions ; Requirements for bike rental ;

B. Questionnaire pre-test

Before launching the questionnaire, it was pre-tested and validated with the help of academic experts, in order to assess the comprehension and coherence of the questions, also, to determine the required time for the questionnaire. After some modifications and improvements proposed by these experts, the questionnaire was validated. The main objects of this survey are:

- Know the characteristics and nature of the trips.
- Measure distance traveled and travel time per trip.
- Know the obstacles encountered when using the bike.
- Collect the opinion of the investigators about the bicycle rental system and the conditions of use

C. Data collection and analysis

The data were collected from a survey based on questionnaire for a sample of the governorate of Sfax on 2017. The sample consists of 500 citizens who represent 0. 1 % of the population of Grand Sfax [1]. The survey was done during three months: May, June, and July in several places and at different times. The questionnaire was completed by hand, where the answers were coded.

1) Statistical analusis

After collection, the data were analyzed using the statistical analysis software SPSS (Statistical Package for the Social Sciences). This software allowed us to do a descriptive and econometric analysis.

In order to better understand how the various responses are distributed and identify possible blockages, a descriptive analysis was carried out by analyzing the questionnaire question by question.

In this study, the proportion of the investigated men is more important than women and represent 60 % of the total surveyed peoples (Fig. 2).

[1] http://www.codatu.org/actualites/le-velo-dans-les-villesmediterraneennes-du-sud-il-est-temps-de-passer-la-seconde

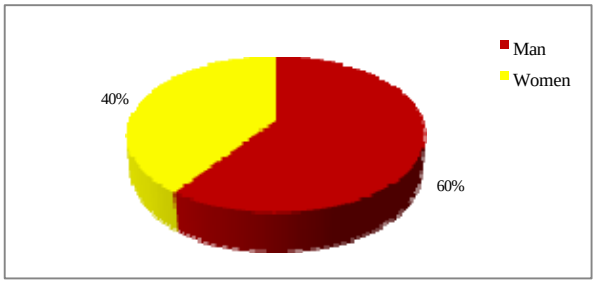


Fig. 2. Persons surveyed by gender

As Figure 3 shows, the majority of people in this survey are students (36%) and executives (30%).

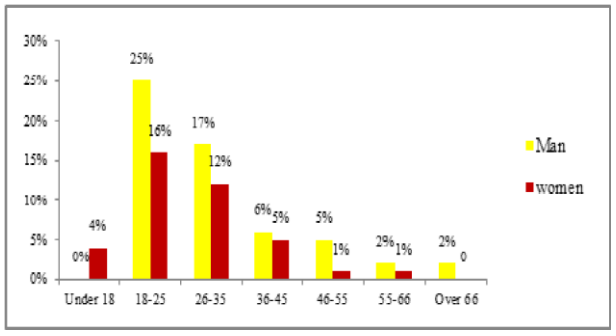


Fig. 3. People surveyed by age and gender

Figure 4 shows a high motorization rate, as nearly 80% of the respondents have at least one car, compared to 40% possessing bike.

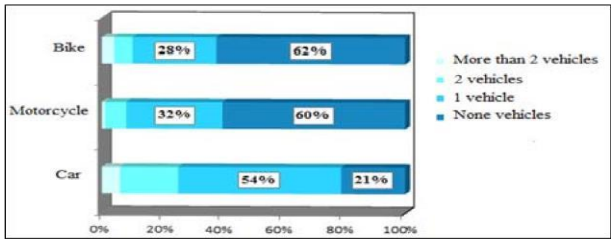


Fig. 4. Motorization rate

Figures 5 and 6 represent the daily frequency of travel for work or school/University and other stuff (leisure, shopping, etc.). As per the results, the majority of respondents make between one and two travel per day for both reasons.

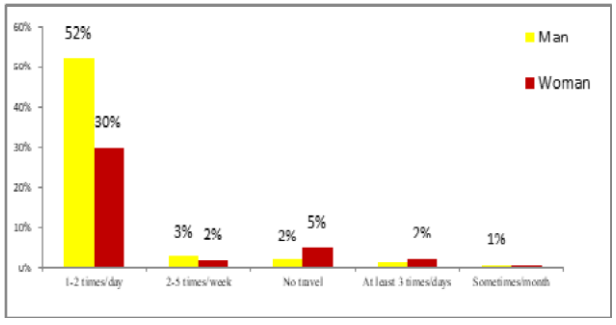
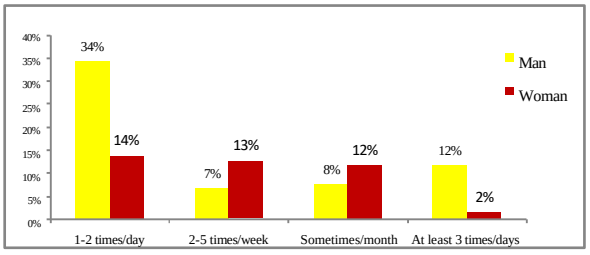


Fig. 5. Frequency of travel (A/R) to work or school/university by gender



According to figures 7 and 8, we can notice that the car is the most used way of transport and the bike is the least used one. We can also notice a small share is attributed to bus users comparing to taxi users. This proves that very few citizens use active transport, such as walking and biking, to carry out their travels. Thus, the low percentage of public transportation usage is due to the poor quality of the offered service.

Fig. 6. The frequency of movements (A/R) for other stuff by gender

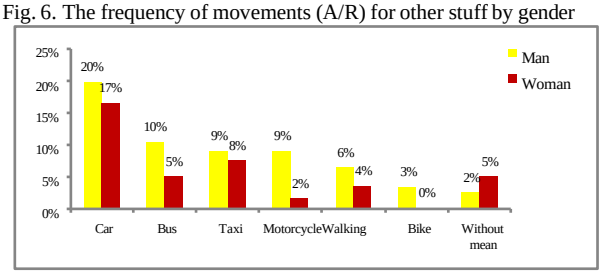


Fig. 7. The method of transportation used to go to work or school/university by gender

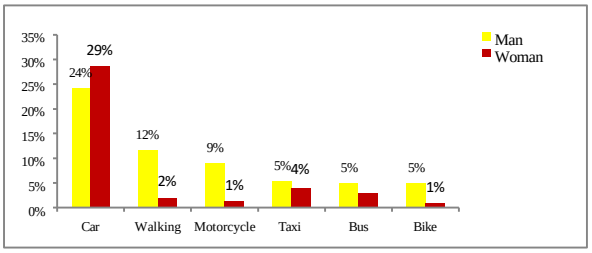


Fig. 8. The method of transportation used for other stuff by gender

The below Fig 9 shows that the majority of respondents agree to use the bike (45% men and 24% women).

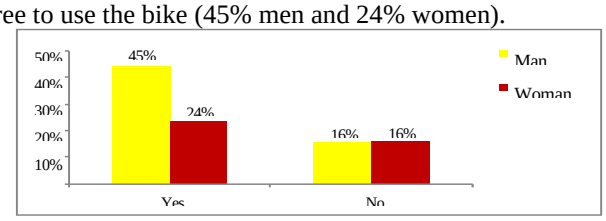


Fig. 9. Acceptance to use the bike by gender

The various problems mentioned for the rejection to use bikes are illustrated in Fig 10. The main reason is the road insecurity with 43% followed by the problem of discomfort related to traffic of vehicles (noise, pollution) with 15%. Other problems are also mentioned by respondents such as the shameful image, the need for physical effort, high maintenance costs, etc.

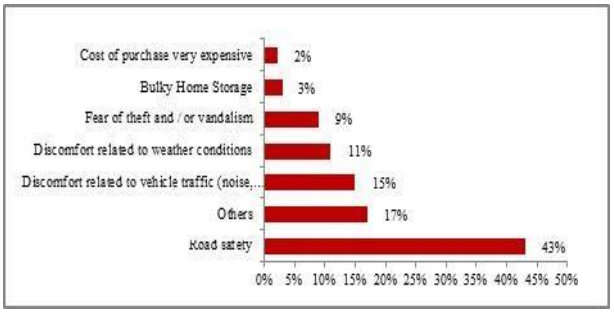


Fig. 10. Reason to reject the usage of bike by gender

To guarantee their safety, 66% of respondents said they would cycle if there is separate bike path as shown in Fig 11.

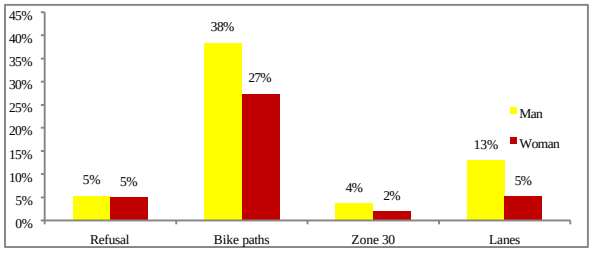


Fig. 11. Bike traffic conditions by gender

In the case of the implementation of a bike rental system, a short-term rental is more requested than a long-term rental. More than a quarter of respondents refuse to rent (Fig 12).

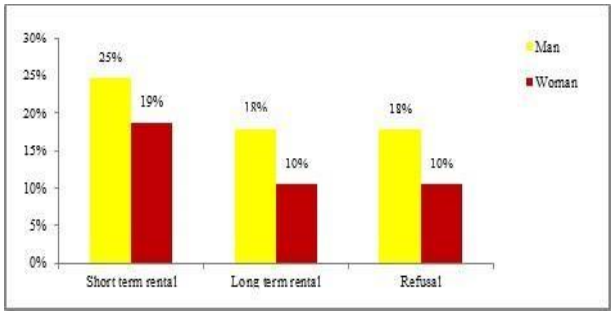


Fig. 12. Requirement of bike rental by gender

2) Econometric analysis

In our study, 28% of respondents refused to rent a bike. This justifies the choice to use a LOGIT model for a better understanding of the different factors influencing the choice of bikes rental and to model the probability of renting a bike. We used LOGIT to model the probability of renting a bike. The reason of this model is to be used for studies aim to check if the independent variables can predict a dichotomous dependent variable. The independent variables can be qualitative or quantitative variables [5]. Thus, the objective of the model is to explain the behavior yi observed through a series of independent variables. The variable yi follows Bernoulli's law:

$$y_i = \square\square 1 \textit{with probability } p_i$$

$$\square 0 \textit{ with probability } 1 - p_i$$

In our case, the people surveyed have two possible choices: «YES», they would agree to rent a bike for their trips or «NO» they would refuse to rent the bike. Therefore, in our case, "y" is the binary dependent variable identifying the choice of the person being surveyed ie (yi = 1) if the individual i chose to rent the bike and (yi = 0) if not. The use of such a model seems interesting to model the probability of renting bicycles taking into consideration certain independent variables that influence the variable to be explained.

Four explanatory variables were selected and included in the model: "csp", "moy-n", "n-use" and "ni-meteo". These variables were selected via the chi-two statistical test. Significant variables accepted are those with a calculated pvalue below the significance level set at 0.05. The variables

Name of variables	modalities	Descriptions
CSP	CSP1	The person surveyed is a high school student.
	CSP2	The person surveyed is a student.
	CSP3	The person surveyed is a worker.
	CSP4	The person surveyed is an executive.
	CSP5	The person surveyed is a craftsman.
	CSP6	The person surveyed is a liberal profession
	CSP7	The person surveyed is jobless
	CSP8	The person surveyed is retired
MEAN-N	MEAN-V	Respondent uses the car for the other reason.
	MEAN-B	Respondent uses the bus for the other reason.
	MEAN-T	Respondent uses the taxi for the other reason.
	MEAN-M	Respondent uses the motorcycle for the other reason.
	MEAN-A	Respondent uses the bike / MAP for the other reason.
N-USE	1-USE	Respondent wants to use the bike.
	0-USE	Respondent refuse to use the bike.
NI-WEATHER	1I-WEATHER	Problem of discomfort related to weather conditions
	0I-WEATHER	No problem of discomfort related to the weather conditions

TABLE II. THE EXPLANATORY VARIABLES SELECTED FROM THE LOGIT MODEL

"csp" and "moy-a" are polytomic with respectively eight and five modalities, while the two others, "n-use" and "nimeteo", are dichotomous with two modalities. Table 2 below represents the number of explanatory variables used in the model with their modalities The estimates obtained from the SPSS software from the LOGIT model are presented in Table 3.

As previously mentioned, the LOGIT model allowed us to calculate the probability coefficients that a surveyed individual chose to rent a bike. As a result, we proceed by interpreting the exponential regression of coefficient β which corresponds to the odds ratio (exp β, also called the odds ratio). If β is negative and the odds ratio is less than 1, then the event is less likely to appear in relation to the reference modality of the variable. If β is negative and the odds ratio is less than 1, then the event is less likely to appear than the reference category of the variable. On the other hand, if β is positive and the odds ratio is greater than 1, then the event is more likely to appear compared to the reference category of the variable [11].

For a qualitative variable, the exponential of the regression

coefficient associated with a modality corresponds to the odds ratio between the reference category and the modality considered [8]. As a result, a reference category is chosen for each type of variable. For example, the variable «moy-n» takes the modality «moy-a» as the reference modality with respect to the modalities «moy-v», «moy-b», «moy-t» and
«moy-m».

R2 Nagelkerke allows judging the quality of a model. [5]. The resulting model explains 33.1% of the bike rental variability, which is considered satisfactory.

TABLE III.RESULTS OBTAINED FROM THE LOGIT MODEL

Explanatory variables	β	Exp β	Sig
CSP1	0.767	2.153	0.311
CSP2	1.887	6.598	0.005
CSP3	1.115	3.050	0.140
CSP4	1.661	5.263	0.013
CSP5	1.962	7.113	0.047
CSP6	1.223	3.397	0.097
CSP7	1.950	7.026	0.011
CSP8	Ref		
1-USE	2.182	8.860	0.000
0-USE	Ref		
0I-WEATHER	1.018	2.767	0.014
1I-WEATHER	Ref		
MEAN-V	0.721	2.057	0.009
MEAN-B	1.331	3.784	0.008
MEAN-T	2.001	7.399	0.000
MEAN-M	-0.989	0.372	0.040
MEAN-A	Ref		
Constant	1587		
Khi-2 (13) = 131.044 P = 0.000	R 2 from Nagelkerke = 0.331	Khi-2 (8) = 7.176 P = 0.518	

The Hosmer-Lemeshow test evaluate the quality of model adjustment according to the data. It corresponds to Khi-Deux statistic between observed and expected probabilities. If the degree of significance p is greater than 0.05, then the fit to the data is considered good [16]. In our case p = 0.518> 0.05 so the model is acceptable. Thus, the main findings from odd ratios are:

- Before interpreting the odds ratios, we excluded three categories (high school students, workers and those with a liberal profession) because they were not significant since the p-value value calculated for these methods was higher then the level of significance of 0.05. On the other hand, the other modalities were significant. Students, executives, craftsmen and those with no profession are more likely to rent a bike than retirees. In first and second position, we find the craftsmen (β = 1.962) and the unemployed (β = 1.950) whose odds ratios are respectively 7.113 and 7.026. Then, students (β = 1.887) and executives (β = 1.661) with odds ratios respectively 6.598 and 5.263.
- Those who agree to use bicycle are more likely accept to rent a bicycle (β = 2.182) compared to those who do not use the bike, the odds ratio being 8.860 times higher.

Being a weather-sensitive person increases the possibility of renting a bike (β = 1.018), with the odds ratio being 2.767. As a result of the analysis obtained from the survey, some actions are recommended:

- Greater awareness among citizens to encourage them to use the bicycle as a means of transportation. Indeed, we found a considerable lack of awareness regarding active mobility. The bike is almost absent in the traveling of citizens compared to other modes of motorized transport. Less than one percent of citizens travel by bike.
- A better motivation: it will overcome the main obstacles encountered by citizens when using the bike. First, it will improve the comfort and safety conditions of bike users by creating a favorable and safe environment for users (a majority of 43% suffer from unsafe roads and 15% others have problems related to discomfort due to vehicle traffic). In order to encourage citizens to massively use bicycles, it seems necessary to provide adequate infrastructure for cycling. On the one hand, it will be necessary to offer bike lanes by physically separating the bicycle traffic from the car traffic (65% of the respondents declare that they would

ride by bicycle if they could make their journey on bicycle paths separated from the car traffic). On the other hand, it will be necessary to trace the bike lanes (18% of the respondents want to ride if the bands are present). In addition, it is recommended to develop zones 30 because 6% of respondents find that zones 30 can be as a solution to guarantee their security. Then, it seems interesting to put bike accessories to fight against cold, rain and heat because 11% of respondents have problems related to weather conditions.

- Promoting the use of bicycles by setting up an

IV. CONCLUSION

This study aims to guide the city of Sfax towards sustainable transport. Initially, we developed a survey to learn the travel habits of the Sfaxiens, check the state of use of the bike in Sfax, identify the constraints and know the requirements of citizens for a bike rental system in Sfax. In a second step, we used a LOGIT model to identify the factors influencing the choice of bicycle rental. As results, according to the socio-economic categories of surveyed peoples, artisans, unemployed, students and executives are the most favorable for bike rental. At the level bike rent efficient bike rental system is justified since 72% of respondents agree to rent a bike.

Nevertheless, it is also clear there are some limitations. Firstly, one limitation of the study is related to a random sampling approach. The second limitation is that, the statistic explains nothing, but provides potential elements for the explanation. Also the term explanatory variable or variable to explain is probably not the most judicious [22]. A different study and a different approach more complex and sophisticated are needed to model bike travel and rental choice by this special population.

system implementation, the rent for short duration is more requested than the long-term rental. Efforts to raise awareness and solve problems related to bicycle use are necessary to change the position of the 28% who refuse to rent a bike.

In future work, we will make a techno-economic feasibility study that will propose the best formula for the implementation of a bike rental system.

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