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Walking and jobs: A comparative analysis to explore factors influencing flexible and fixed schedule workers, a case study of Rasht, Iran

Yaser Hatamzadeh, Meeghat Habibian*, Ali Khodaii

Department of Civil and Environmental Engineering, Amirkabir University of Technology, Hafez St., Tehran 15875-4413, Iran

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ABSTRACT

Although walking behavior has been the subject of debate in developed countries, much remains to be learned about this subject in developing countries. Furthermore, it seems likely that the effect of different factors on choosing walking as a commute mode varies across different job groups. Therefore, this research investigated and compared walking behaviors across two job groups with different schedule patterns in the city of Rasht, Iran. The first group is related to those who are flexible schedule (i.e., FLS) workers and the second group refers to people who identify as fixed schedule (FXS) workers. FXS workers attend/leave their workplace during specific period of time which is usually invariant and makes them more time constraint than the second group. Separate behavioral choice models are developed for trips to work using a range of explanatory variables including individual; household; travel; and environmental variables. Results show that females are more likely to walk than males in both groups. Another significant factor is the travel distance which was found with different effects across the studied job groups. Furthermore, it was found that land use features are directly related to walking choice probability of FLS workers.

1. Introduction

Walking as a transportation mode provides basic mobility, affordable transportation, access to motorized modes, physical fitness and enjoyment. These advantages, has led many local and regional authorities to promote walking in daily trips to various purposes. In order to effectively increase the overall use of walking as a mode of transportation, it is important to understand the influence of different factors on walking behavior. It seems likely that the utility of a particular mode of transportation will vary not only by the time, distance and degree of convenience, but also by type of their occupation. However, this issue has not been well established in previous studies. Therefore, the central focus of this research is to investigate walking behaviors in two job groups with different schedule patterns. Individuals in one group attend/leave their workplace during specific period of time which is usually invariant and makes them more time constraint than the other group. In other words, individuals in the second group are workers with a more flexible schedule than workers in the first group. A comparison between covariates that are expected to influence walking mode choice tendencies among different job groups could be interesting and beneficial in evaluating candidate policies for promoting walking as a mode of transportation.

Moreover, while walking has become a critical research topic in developed countries, it has not received enough attention in developing countries such as Iran. This study tries to overcome the gap in the current literature by studying the walking behavior to work within a typical city in Iran, Rasht. Rasht has experienced a rapid population growth and physical development particularly during the last three decades which transformed it from a medium sized city to a regional metropolitan in recent years. Such a rapid growth relinquished a balanced urban development and led to the emergence of various urban problems such as inadequate infrastructure, lack of basic services, traffic congestion, housing shortage and informal development (Azimi, 2004). The increasing rate of vehicle ownership during last decade and a poor public transit system has led to heavy traffic congestion especially in the core of the city. Therefore, promoting walking in daily trips especially in trips to work can bring many benefits ranging from reducing traffic congestion emissions and fossil fuel energy consumption to helping for increasing population-level physical activity. Exclud-

* Corresponding author.
E-mail addresses: y_hatamzadeh@yahoo.co.uk (Y. Hatamzadeh), Habibian@aut.ac.ir (M. Habibian), Khodaii@aut.ac.ir (A. Khodaii).

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ing the returning to home trips, trips for the purpose of work (i.e. trips to workplaces) constitutes the highest share of daily trips in Rasht. According to Rasht household travel survey in 2007 (Rasht comprehensive transportation planning study Final report, 2011), more than 17.5% of all daily trips made were for the purpose of work apart from trips for the purpose of returning to home which consisted 49% of all trips.

2. Literature review

The influence of different factors on active commuting has been studied extensively. Individual; household; travel; and environmental characteristics are found to have a significant association with walking behavior. Previous studies are reviewed in more details in this section.

2.1. Individual/Household socioeconomic characteristics

Age and gender are two demographic characteristics most widely investigated for their effect on walking travel behavior in previous studies. While some studies on trips to work, found higher odds of walking with respect to age (Teshome, 2007), some others stated the opposite (Rodrıíguez & Joonwon, 2004). The results in a study showed that individuals who are aged between 18 and 65 (i.e., active adults) are likely to walk more often to their work location than people of other age groups (Bhat, Guo, & Sardes, 2005). In another study, individual's over 60 years were more willing to walk in work trips (Hatamzadeh et al., 2014). Some researchers have examined the effect of gender on walking behavior and have come to different results. For example, in some studies on trips to work, males have been found with more positive attitude toward walking than females (Teshome, 2007; Rodrıíguez & Joonwon, 2004), but in some others the opposite has been stated (Hatamzadeh et al., 2014).

Previous studies indicate that household characteristics influence the travel behavior. In a study on trips to work, it was found that individual with lower number of vehicles owned by his/her household have a higher tendency to walk relative to one with more vehicles in his/her household (Rodrıíguez & Joonwon, 2004). Results in another study on trips to work showed that car availability has a negative and significant effect on choosing walk as a mode of transportation (Hatamzadeh et al., 2014). In a study by Bhat et al. on non-motorized trip frequency trips for three purposes including job, maintenance shopping, and pure recreation, it was found that individuals with lower car availability are more likely to walk than others (Bhat et al., 2005). However, in the latter study it was found that some other household characteristics such as household structure and household income, do not affect the frequency of non-motorized trips for the job. Rodriguez and Joo used data for student and staff commuters to the University of North Carolina at Chapel Hill to illustrate the relationship between mode choice and the objectively measured environmental attributes (Rodrıíguez & Joonwon, 2004). Their results show that the higher the number of vehicles available at home for individual with driving license, the higher the odds of choosing to drive to campus.

The effect of household's income has also been studied previously. In a study by Tin Tin et al. on differences in patterns of active commuting to work stratified by region, age, gender and personal income it was found that walking is more common in lower income groups, whereas socioeconomic status does not appear to influence cycling (Tin Tin, Woodward, Thornley, & Ameratunga, 2009). The results of a study on walking distance and duration among various trip purposes showed that lower income people walked longer distances for work but shorter distances for recreation (Yang & Diez-Roux, 2012). A study examined individual and contextual characteristics associated with walking distances and found that walking was higher for individuals with higher household incomes compared to the less affluent (Wasfi, Ross, & Ahmed, 2013).

Due to limitations in recording household income (Tourangeau & Yan, 2007), some studies have used proxies for it. For example, Scheiner used education level and employment status as rough proxies for income (Scheiner, 2014). Some studies have shown that higher number of vehicles owned by household is positively related with income (e.g., (Dargay, 2001)). In this context, there are studies which have interpreted the effect of vehicle ownership in terms of the income effect (e.g., (Rahul & Verma, 2014)). In a study on utilitarian walking, variables showing auto dependency and income were used simultaneously in a structural regression model. It was found that having a higher income (which was expressed as the square root of income) is associated with higher levels of the auto dependency factor (as a latent factor). Auto dependency factor was also found to have the highest level of direct effect on walk factor, with walking decreasing as auto dependence increases (Coogan, Adler, & Karla, 2012).

2.2. Travel and environmental characteristics

Many studies have used travel distance as an independent variable beside other factors and have found that an increase in trip distance decreases the likelihood of walking for all trip purposes (Hatamzadeh et al., 2014; McMillan, 2007; McDonald, 2008; Ermagun & Samimi, 2012; Cervero & Duncan, 2003), Some other studies have examined the relation between walking distance as a dependent variable and other factors (Yang & Diez-Roux, 2012; Millward, Spinney, & Scott, 2013 Larsen, El-Geneidy, & Yasmin, 2010). In general, research on walking behavior for different trip purposes show that a distance of 400 meter (0.25 miles) which is about five minutes walk is often used as an acceptable walking distance (e.g., (Krizek, 2003; McCormack., Giles-Corti, & Bulsara, 2008)). However, research has also suggested that walking trips longer than 400 meter may not be uncommon (McCormack et al., 2008; Hoehner, Brennan Ramirez, & Elliot, 2005).

There are many environmental factors which could influence non-motorized travel such as mixed uses of land, street connectivity, residential density, employment density, sidewalk continuity, sidewalk width, presence of cycling and walking paths, and local topography. Previous studies have incorporated explicit measures of these attributes, or have developed composite factors for exploring their relation to active transportation behavior.

Altogether, previous studies have reported inconsistent findings on the association between environmental factors and walking behavior. For example, in a study in Hong Kong, China, relationships between walking behavior and population design, land-use mix and street intersection density were examined. It was found that land-use mix and street connectivity were not significantly related to any domains of walking (transport vs. leisure) and population density, was only positively related to walking for transport and walking for leisure in the lower range of density, while is negatively related to walking for leisure in the higher range of density (Cervero, Sarmiento, Jacoby, Gomez, & Neiman, 2009).

Some studies have given attention to environmental features at both origins and destinations. According to the results found by Hempel et al., the physical design of places where people live and work affects their travel choices and how much they walk or bike for utilitarian travel (Humpel, Owen, & Leslie, 2002). In a study by Cervero and Duncan on non-work trips, land use was found effective on the use of non-motorized modes at the trip origin end but not at the destination end (Cervero & Duncan, 2003). Rodriguez and Joo in a study on commuting trips to university found that individual's (including students and employees) residential density was statistically insignificant in a mode choice analysis (Rodrıíguez & Joonwon, 2004). Their results led them to conclude that mode

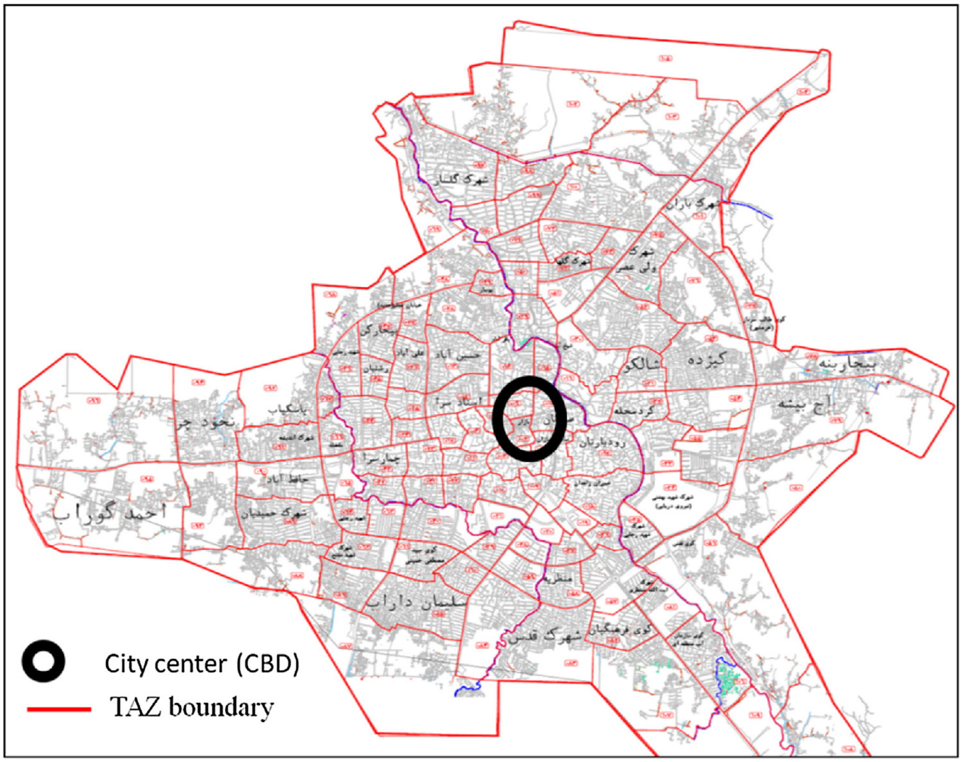


Fig. 1. City of Rasht containing 112 TAZs.

choice appears to be more related to employment density at destinations than on residential densities at origins. In another study by Srinivasan, it was found that attributes related to pedestrian route between home and work, rather than the attributes of the endpoints themselves, appear to matter most in the decision to walk for work trips (Srinivasan, 2002). In a study in Bogota, Colombia, it was found that factors such as road facility designs, like street density, and connectivity are associated with physical activity, but other attributes of the built environment, like density and land-use mixtures, are not (Lu, Xiao, & Ye, 2016).

In a study, Frank et al. incorporated three factors including mixed uses of land, street connectivity and residential density into a single 'walkability index' and examined its relation with individual's physical activity (Frank, Schmid, Sallis, Chapman, & Saelens, 2005). This index varies in its details and sub-index weightings in different studies. Manaugh and El-Geneidy examined the correlation of different indices of walkability with walking behavior for two trip purposes including trips to school and shopping trips. They suggested that different walkability indices should be used when trying to understand the level to which the built environment encourages walking to various destinations (Manaugh & El-Geneidy, 2011).

As can be seen, previous studies have come to different results on walking behavior which could be a reason that this topic is very much related to the place and the society of the study area. Altogether, this study addresses two gaps in the current literature by (Azimi, 2004) focusing on walking behavior across two job groups with different schedule patterns which have not been well established in previous research, (Rasht comprehensive transportation planning study Final report, 2011) providing an insight into the case of walking in Iran, as a developing country which has not been addressed in previous research. Our focus is on the city of Rasht in which the increasing rate of vehicle ownership during last decade and a poor public transit system has led to heavy traffic congestion. Furthermore, purpose of work constitutes the highest share of daily trips. Thus, understanding these differences could be beneficial in evaluating candidate policies for promoting walking as a mode of transportation.

3. Method

3.1. Area of study

The urban area in Rasht contains 112 traffic analysis zones (TAZs) which is presented by Fig. 1. Unplanned settlements with disordered pathways, low quality and condensed houses and weak infrastructure constitute a major part of spatial structure in the city. Radiating streets from the city center in conjunction with ring roads shapes the main structure of street layout which gives a significant role to the city center. The traditional bazaar as the main retail center is located in the core of the city and causes heavy congestion. Over the past decades, there has been a change in the spatial pattern of activities in Rasht. With the development of the city and limited space of the bazaar, some commercial activities have moved out from the city center and the traditional bazaar (Azimi, 2005). A poor transit system has made the automobile and taxi as the most favorable modes of transportation in daily trips.

3.2. Data description

Data for the analysis comes from Rasht household travel survey in 2007 (Rasht comprehensive transportation planning study Final report, 2011). As a part of that survey, a questionnaire was designed and distributed among more than 5000 households to collect detailed information about every trip made by all members of each participating household. Each household member was asked to fill out a trip diary for one day including the mode of travel, starting and ending time of the trip and the trip purpose. Household and individual socio-demographic information were also collected.

For the purpose of this study, trips which had origin/destination (O/D) outside the municipal boundaries of Rasht were excluded. As the focus of this study is on active adults and presumably as the working group of the population, individuals who are younger than 18 were excluded from further analysis.

According to the survey, occupation types were classified into distinct categories. Individuals' were allowed to select only one of these categories to show their occupation status. For the purpose of this study, two groups of occupations were selected for the analysis. The first group contains those who are fixed schedule (FXS) workers such as official staff or personnel of an office or institution. The second group refers to people who identify as flexible schedule (FLS) workers such as traders, vendors and marketers. The working time period of FXS workers is usually between 7:30 A.M to 14:30 P.M which makes them more time constraint (especially in morning) than individuals in the second group. Individuals in the second group (i.e., FLS workers) can start their work later in morning and finish later in evening. Hypothetically, decision to choose walking as a mode of transportation to work may vary across job groups with different schedule patterns and this was the main reason in separating the mentioned two groups. In this line, it is assumed that the effect of various factors such as car ownership, distance, etc. on walking mode choice of the two groups would be different. For example, as FXS workers start their trips to work later in the morning, it is expected that they would be more dependent on their cars because the traffic congestion is not a barrier as much as it could be for the FLS workers who start their trips at the peak hour. In the sample studied it was found that on the way to work about 12% of the FXS workers choose walking as a mode of transportation while more than 29.5% of FLS workers choose walking to work.

3.3. Modeling process

In this study, separate models were developed for fixed schedule FXS workers and flexible schedule (FLS) workers trips to work. The decision to make a trip by foot for the purpose of work was modeled as a dichotomous variable in a binary logit model. In other words we are trying to understand what will affect the likelihood of walking versus not walking for a whole trip to work. Explanatory variables are divided into four main categories: individual characteristics, household characteristics, travel characteristics, and environmental factors. Coding definitions, specifically developed for each of the variables are given in Table 1. Individual factors include characteristics of the trip-maker such as age and gender. Dummy coding for age was used because considering age intervals better describes the travel behavior of different age groups. All age groups were compared with a reference age group of 19 to 24. Household factors include characteristics of the trip-makers family such as vehicle ownership and number of children. Children aged between 7 and 18 were divided into two groups of 7-11 and 12-18 in order to represent the elementary and middle/high school students, respectively.

In the absence of individual distance, the distance between the TAZ centroids of origin and destination of the trip was taken as the trip distance which is not uncommon in transportation studies (Ortuzar & Willumsen, 2011). GIS was used to calculate travel distances on the traffic network of the study area. It is worth noting that the average radius of the TAZs was about 0.26 mile which seems that the distance considered is an appropriate proxy for the travel distance. About the intra-zonal trips which are the shortest trips in the data set, the equivalent/approximate radius of each TAZ was considered as the travel distance which was in the range of 0.12-0.84 miles. Seven intervals were defined for trip distance taking trips less than 0.25 miles as the reference level (Table 1). Hypothetically, defining distance intervals allowed the researchers to examine 'non-linear' associations with walking behavior.

Environmental factors used in this study were divided into two main categories including: connectivity and land use. In previous studies, several variables have been used as measures of network connectivity. According to the literature, variables such as intersection density (Frank et al., 2005; Christian et al., 2011), percentage of four way intersections (Southworth & Owens, 1993; Dill, 2004), ratio of minor links to major links (Dill, 2004), cul-de-sac density (Schlossberg & Brown, 2004), link density (Dill, 2004), the ratio of intersection per all of nodes in network (including dead end or cul-de-sac nodes) (Dill, 2004), the ratio of number of links to number of nodes (Ewing & DeAnna, 2016), Gamma index[1] (Kofi, 2010), and Alpha index[2] (Dill, 2004; Zhang & Kukadia, 2005) have been used as indicators of network connectivity. Those interested in more information about these variables are referred to the references mentioned. In this study, all of the nine connectivity variables mentioned were drawn for each of the 112 zones of the study area based on GIS database by means of Arc GIS 9.3.

To avoid colinearity and comprising independent set of variables representing connectivity, a correlation test was performed to find out high correlated variables. Therefore, among variables which were highly correlated with each other (i.e., correlation coefficients higher than 0.8 and significant at 90% level), one variable was removed from further analysis. To identify conceptually meaningful connectivity factors out of the remaining connectivity variables, a principal component analysis (PCA) with Varimax rotation (which assumes the factors are uncorrelated) was performed. Two clear factors emerged which could explain more than 70 percent of the variance. Table 2 shows factor loadings for the mentioned variables. The variables "percentage of four way intersection" and "the ratio of intersections to all nodes" loaded most highly on factor 1 labeled "node connectivity" and the variables "ratio of minor roads to major roads" and "link density" loaded most highly on factor 2 labeled "link connectivity" (see Table 2). For further analysis, two new variables 'Factor 1′ and 'Factor 2′ were created using factor loadings.

Network pattern also reflects the visual form of network and tells us so much about the underlying effects of network on walkability. Southworth and Owens classified various patterns into five descriptive patterns as shown in Fig. 2 (Southworth & Owens, 1993). The decision for assigning one of five network patterns to each of 112 zones was made according to expert judgment using the guidelines below Table 2. While the first three patterns were almost clear by their street patterns, the other two patterns (i.e., Netp4 and Netp5) were detected by number of loops & cul-de-sacs which is considerably higher for them.

In walking through different patterns, there is a transferring from more connected areas to less ones which is caused by more auto oriented areas (Southworth & Owens, 1993). The grid network (Netp1) is an example of most connected network giving the pedestrian more alternative routes (Ewing & Cervero, 2010; Ewing et al., 2014). On the other hand, the cul-de-sac pattern (Netp5) has been more observed in sub urban areas and provides longer and wider roads accompanying by more houses which often ends in a circle for vehicles to turn around (Southworth & Owens, 1993). For the case of this study, one of the five network patterns in Fig. 2 was assigned to each of 112 TAZs.

[1] The Gamma index is defined based on graph theory and calculated by dividing the number of links of a network by the most possible links. The value of this index is between 0 and 1, with higher values representing more connected network (Kofi, 2010).

[2] The Alpha index is the ratio of network circuits (a closed, finite path starting and ending at the same node) to the most possible number of circuits (Dill, 2004; Zhang & Kukadia, 2005). Values and interpretation of this index is similar to the gamma index.

Table 1
Description of examined variables.

Category Name	Variable Name	Definition	
Individual Characteristics			
	Age_1924 (ref.)	1:if age is between 19-24;	0: otherwise
	Age_2545	1:if age is between 25-45;	0: otherwise
	Age_4660	1:if age is between 46-60;	0: otherwise
	Age_O60	1:if age over 60 years;	0: otherwise
	Female	1:if individual is female;	0: otherwise
Household Characteristics			
Structure	Child_U7	1:if child under 7 years in household;	0: otherwise
	Child_711	1:if child between 7 to 11 years in household;	0: otherwise
	Child_1218	1:if child between 12 to 18 years in household;	0: otherwise
Vehicle Ownership	Veh1_Auto	1:if one (or more) automobile(s) in household;	0: otherwise
	Veh2_Motor	Number of motorcycles in household	
Trip Characteristics			
Time of travel	Time_15-17	1:if trip is between 3-5 PM;	0: otherwise
Travel distance	Dist_r (ref. level)	1:if distance is less than 0.25 miles;	0: otherwise
	Dist_0.25-0.50	1:if distance is between 0.25 to 0.5 miles;	0: otherwise
	Dist_0.50-0.75	1:if distance is between 0.5 to 0.75 miles;	0: otherwise
	Dist_0.75-1.00	1:if distance is between 0.75 to 1.0 miles;	0: otherwise
	Dist_1.00-1.50	1:if distance is between 1.0 to 1.50 miles;	0: otherwise
	Dist_1.50-2.00	1:if distance is between 1.50 to 2.0 miles;	0: otherwise
	Dist_Ov2.00	1:if distance is over 2.0 miles;	0: otherwise
Environmental Characteristics *(Land Use mix)*			
Entropy	ENT_O	Value of entropy index for origin zone	
Job population	Jobpop_O	Value of job population balance index for origin	
(Connectivity)			
Connectivity Factors	FAC1_O	Value of factor 1 for origin zone (based on Table 2);	
	FAC2_O	Value of factor 2 for origin zone (based on Table 2);	
Network patterns	Netp1_O	1:if the pattern of origin zone is like pattern 1 in Fig. 2;	0: otherwise
	Netp2_O	1:if the pattern of origin zone is like pattern 2 in Fig. 2;	0: otherwise
	Netp3_O	1:if the pattern of origin zone is like pattern 3 in Fig. 2;	0: otherwise
	Netp4_O	1:if the pattern of origin zone is like pattern 4 in Fig. 2;	0: otherwise
	Netp5_O	1:if the pattern of origin zone is like pattern 5 in Fig. 2;	0: otherwise
(Other measures)			
Population density	PopDen_O	Population per square kilometer of origin zone	
	PopDen_D	Population per square kilometer of destination zone	
Trip to CBD	CBD (Bazaar)	1:if trip destination is located in the CBD;	0: otherwise

Table 2
Principal component analysis of connectivity measures: factor loadings.

Variable indicating network connectivity	Factor 1 (Node connectivity)	Factor 2 (Link connectivity)
Percentage of four way intersection	0.817	.089
The ratio of intersections to nodes	0.817	−.028
The ratio of minor roads to major roads	−.204	0.862
Link density	.363	0.762

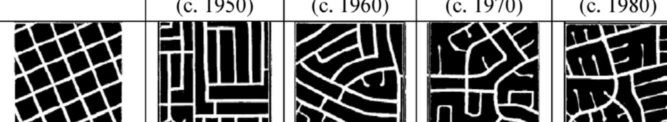
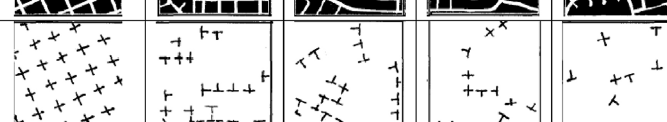
	Gridiron (c.1900)	Fragmented Parallel (c. 1950)	Warped Parallel (c. 1960)	Loops and Lollipops (c. 1970)	Lollipops on a Stick (c. 1980)
Street patterns					
Intersections					
Lineal Feet of Streets	20800	19000	16500	15300	15600
# of Blocks	26	19	14	12	8
# of Intersections	26	22	14	12	8
# of Access Points	19	10	7	6	8
# of Loops & Cul-de-Sacs	0	1	2	8	24
Variable Name	Netp1	Netp2	Netp3	Netp4	Net5

Fig. 2. Different types of network patterns (*31*).

Table 3
Gender-specific binary logit models for the purpose of work.

Variable	Fixed schedule (FXS) workers model		Flexible schedule (FLS) workers model	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Constant	1.17612*	–	1.74087***	–
Age_2545	−0.67173	−0.03551	−.81749***	−0.11644
Age_4660	−.13119	−0.00867	−.80785***	−0.11541
Age_O60	−.62547	−0.03369	.18703	0.035473
Female	.62089***	0.032226	1.27023***	0.208778
Child_711	–	–	−.31391**	−0.03409
Veh1_Auto	−1.05363***	−0.0565	−.80338***	−0.09326
Veh2_Motor	−1.22085***	−0.05407	−.97357***	−0.11148
Time_15-17	–	–	.39801***	0.049809
Dist_0.25-0.50	.33075	0.081111	−.23652	−0.05466
Dist_0.50-0.75	−.19298	−0.04505	−.99593***	−0.24208
Dist_0.75-1.00	−1.17752**	−0.22747	−1.66143***	−0.39112
Dist_1.00-1.50	−2.18783***	−0.32661	−2.45963***	−0.51934
Dist_1.50-2.00	−3.01317***	−0.36373	−3.86594***	−0.62395
Dist_Ov2.00	−3.78829***	−0.38024	−4.95474***	−0.64991
PopDen_O	−.00303**	−0.00013	–	–
Netp4_O	–	–	−.45455***	−0.04983
ENT_O[a]	–	–	1.15022***	–
Number of observations		1521	2095	
Log likelihood at zero		−362.01947	−770.35260	
Log likelihood at convergence		−528.49084	−1205.02901	
McFadden Pseudo R-squared		.3149939	.3607186	

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.
[a]For these variables, as it is mentioned in section 4, marginal effects do not make much sense; consequently, they were not calculated.

Mixed land use is found to be one of the most correlated characteristics with walking travel behavior in previous studies. More mixed areas tend to create more propensities towards walking and, therefore, less relying on motorized transportation (Frank & Pivo, 1994). A review by Maghelal and Capp in 2011 on the last two decades studies shows that mixed land use criterion has the most influence on walking as 16 studies out of 25 emphasize on the effect of mixed land uses (Maghelal & Capp, 2011). Previous researchers have used different land use indices. Entropy as a measurement of mixed land uses has been used in some walking studies (Frank et al., 2005; Ewing et al., 2014; Cervero & Kockelman, 1997; Frank et al., 2010). Entropy is defined as equality between different land uses in an area and is calculated using Equation (Azimi, 2004) in which p_i is the percentage of i-th land use and n is the number of different land uses (Frank, Andresen, & Schmid, 2004). This index varies between 0 and 1 in which 0 indicates one land use type and 1 indicates the equal distribution of multiple types of land use in area.

$$\textit{Entropy} = -\sum_{i=1}^{n} p_i \log p_i / \log n \quad (1)$$

Job-population balance is another variable which measures the level of mixed land uses and is introduced as an influential variable in examining walking. Ewing et al. used this variable beside the entropy to assess the mixed land uses (Ewing et al., 2014). This index evaluates the balance between jobs and inhabitant population of an area and is calculated by Equation (2) in which *Job* shows the employment opportunities of a zone and *Pop* is the population of that zone. The value of 0.2 is suggested by Ewing et al. in order to maximize the explanation power of this index.

$$Job - popbalance = 1 - \left|\frac{\text{Job} - 0.2 \times \text{Pop}}{\text{Job} + 0.2 \times \text{Pop}}\right| \quad (2)$$

This index varies between 0 and 1 in which 0 is related to the areas which have either of residential or employment land use and 1 indicates the optimized ratio of jobs to inhabitants of an area (Ewing et al., 2014). Values between zero and one shows areas with unbalanced residential and employment land uses. According to Ewing et al. zones with just one land use (residential or nonresidential) has no attraction for pedestrians to make walking trips (Ewing et al., 2014).

The variables entropy and Job-population balance were calculated for each TAZ in the study area as indicators for land uses and are introduced in Table 1. Beside the mentioned variables used as measures for connectivity and land use, the effect of other environmental variables such as population density of the origin/destination zone and the effect of making a trip to the Central Business District (CBD) were also examined (see Table 1).

4. Results

Binary logit models have been estimated across two job groups with different schedule patterns which were introduced in the previous section. Final models have been presented in Table 3, and are further discussed in this section.

As the coefficients and the levels of significance only highlight associations and do not provide much insight for planning, marginal effects were calculated to determine the effect of a one unit change in the independent variable (or change for binary variables) on the probability of walking (Ben-Akiva & Lerman, 1985). We estimated marginal effects of the probability of choosing the alternative pattern for each measure, maintaining all other variables at their means. It is worth noting that calculating marginal effects for variables which have values between zero and one have no practical sense. Therefore, for the land uses indices which have values between zero and one, marginal effects were not calculated.

4.1. Individual/Household socioeconomic characteristics

As mentioned before, all age groups entered in the final models are actually being compared with individuals in the age group of 19 to 24. Results show that workers aged 25 to 45 and 45 to 60 years are less likely to walk to work regardless of the job category. However, the difference of the two mentioned groups was significant among FLS workers but not among FXS workers. Moreover, according to the marginal effects, the negative effect was more pronounced among FLS workers. For example, the marginal effects show that being 25-45 years decreases the probability of walking by 3.5% points for FXS workers and 11.6% for FLS workers. The difference is much higher among individuals aged 46-60 years with only 0.08% points for FXS workers but with 11.54% points for FLS workers. The variable (Age_O60) representing individuals over 60 years appear with different signs in each model but its effect is not statistically significant in neither models.

In accordance with previous studies (Teshome, 2007; Rodríguez & Joonwon, 2004; McDonald, 2008), it was found that walking is affected by individual's gender. Results show that females' tendency toward walking is higher than males in both job categories. However, the influence of being female is much stronger among FLS workers. As an FXS worker, being female increases the probability of walking by 3.2% points but the increase to the probability of walking is almost 21% points among FLS workers. A previous study has mentioned that a reason behind the gender difference may be that females view working trips as an opportunity to socialize (Hatamzadeh et al., 2014). Another reason may be due to car accessibility which is probably limited by other persons in family who go to work especially in morning.

Availability of car in a household is a significant variable in all models, showing that individuals with car availability in family are less likely to walk to work. Such results are consistent with previous studies on various trip purposes (Rodríguez & Joonwon, 2004; Bhat et al., 2005; Cervero & Duncan, 2003; Park, Noland, & Lachapelle, 2013). The variable (Veh2_Motor) indicating number of motorcycles in household also significantly decreases the likelihood of walking in both models. As indicated in Table 2, the negative effect of car ownership and number of motorcycles in household on walking mode choice is more pronounced in trips made by FLS workers. For example, the probability to walk decreases by more than 5.5% points for FXS workers and by 9.3% points for FLS workers. A reason behind this finding could be that FXS workers start their trips to work later in the morning and are faced with lower traffic congestion (as a barrier to use car as a mode of transportation) relative to FLS workers who start their trips at the peak hour.

Analyses of data suggest that presence of children in household has no significant effect on the likelihood of walking for FXS workers. However, results show that having elementary school age children in household (child aged between 7 to 11) has significant and negative effect on the likelihood of walking to job for FLS workers. Having a child in the mentioned range in household, decreases the probability of walking by 3.4% points. A reason behind this finding may be due to more parental concerns about younger children. Therefore, parents may prefer to accompany their children to school on the way to their workplace by a motorized mode. Accompanying other household members have been pointed as a walking barrier in previous studies as well (Bopp, T.Kaczynski, & Besenyi, 2012). It has also been reported in previous studies that older children have more independence and freedom in trips to school (McDonald, 2008).

4.2. Travel/Environmental characteristics

The results show that for FLS workers, making a trip to work during 3-5 PM, has a significant positive effect on propensity to walk in comparison to other times of day. Making a work trip between 3-5 PM increases the probability to walk by about 5% points. Time of travel is not a significant factor among FXS workers which is a reasonable result. FXS workers do not have options as much as FLS workers and should attend their workplaces at particular times.

Another variable related to travel is distance. As mentioned earlier, travel distance was categorized in six intervals relative to a base level (i.e., distances less than 0.25 miles). Therefore, it is logical to find the estimated coefficients with negative signs in the models. Generally, the results for various purposes were consistent with other studies showing that an increase in trip distance decreases the likelihood of walking (McMillan, 2007; McDonald, 2008; Ermagun & Samimi, 2012; Cervero & Duncan, 2003). As shown in Table 2, different coefficient values are determined for the assumed distance intervals. This finding confirms the appropriateness of assuming the distance variable in several intervals. The results also show that all distance intervals are significantly different from the reference level (i.e., under 0.25 mile) except the first interval (i.e., 0.25-0.5 mile) in both models and also the second interval in the FXS model. These finding imply that flexible schedule workers (i.e., FLS workers) in Rasht never mind walking distances up to 0.5 mile in trips to work because the sensitivity to walk between 0.25 to 0.5 mile is not statistically significant relative to distances less than 0.25 mile. On the basis of this judgment, fixed schedule workers (i.e., FXS workers) are not sensitive to walk distances up to 0.75 miles which is 0.25 mile higher than the FLS workers. Moreover, it is also interesting to see that the first interval (i.e., 0.25-0.5 mile) in the model developed for FXS workers has a positive sign with respect to the reference level. This shows that an increase in trip distance not only does not decrease the likelihood of walking for such individuals but also positively affects the probability of walking. This may be due to the reason that some people enjoy longer walks and it may be related to their values and different attitudes about walking. While this finding is interesting, it also tends to support rethinking the assumption of the universality of utility-based models of decision-making, a central assumption in the planning and research of transportation networks, which does not fully account for the personal motivations or preferences of travelers. This has also been pointed out in recent studies (e.g., (Manaugh & El-Geneidy, 2013)).

Assessing environmental factors showed that the effect of various variables is different across job groups. For example, land use features in origin zone of a trip were not found with any significant effect on walking behavior of FXS workers but in line with previous studies (e.g., (Frank et al., 2005; Ewing et al., 2014; Cervero & Kockelman, 1997; Frank et al., 2010)), they are directly related to walking choice probability of FLS workers. Results show that travel zones with higher level of mixed land uses (i.e., higher entropy and job population balance) increase the propensity to walk among FLS workers. While this study is concerned with the connectivity measures, none of the connectivity measures appeared in the final models developed. Network pattern was only found with significant effect on walking mode choice of FLS workers. Our findings show that FLS workers living in areas which look like the fourth pattern in Fig. 2 (i.e., pattern which contains more cul-de-sacs and curvilinear links in comparison with perfect grid pattern) are less likely to walk in trips to work. It seems likely that network pattern which consist the arrangement of links and nodes could be used as a measure of network connectivity. Results also showed that increase in population density of the trip origin zone decreases the likelihood of walking for FXS workers but it has no significant effect on FLS workers. Our

5. Policy implications

Results found for travel and environmental characteristics give some policy issues for future planning. For example, distance is one of the most important factors on the propensity to walk to work. According to the marginal effects calculated, the effect of distance on walking behavior is different across the studied job groups. Results show that each level increase in distance intervals has more negative effect on probability of walking for FLS workers than FXS workers. For example, while the probability of walking to work for the second distance level (i.e., distance between 0.5 to 0.75 miles) decreases by 4.5% points for FXS workers, it decreases by more than 24% points for FLS workers with respect to the refer-

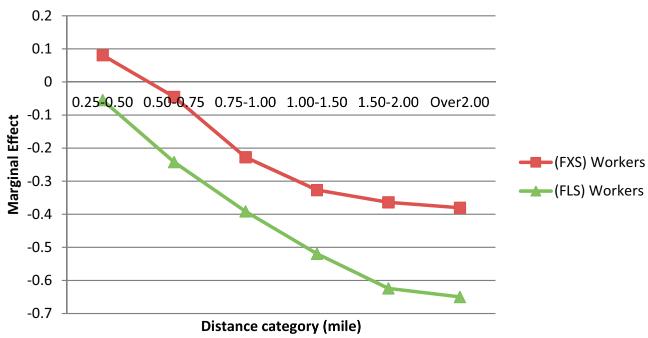


Fig. 3. Effects of distance on propensity to walk across job groups for work trips.

ence level (i.e., less than 0.25 mile). Marginal effects calculated for distance intervals are plotted in Fig. 3 to show the variation of distance effect across different job groups. As it can be seen in Fig. 3, the negative effect of distance is more pronounced among FXS workers. Moreover, the slope of decrease is higher among FLS workers. These findings and the mentioned differences should be considered in future planning if policy makers hope to increase rates of walking in trips to work. The marginal effects estimated throughout this work are helpful for planners, policymakers, and the public, in understanding to what extent behaviorally-based models predict shifts toward and away from making trips by foot.

One of the policies that can be suggested based on the results found is to plan for higher mixed-use developments especially among FLS workers. A higher mixed-use could provide more accessibility for workers which could itself increase the propensity to walk. Network connectivity measures also give some implications. Moving toward network patterns which have more resemblance to grid network patterns could also be effective. Areas with higher cul-de-sac density are deterrent to walking. Furthermore, increasing connectivity of pedestrian infrastructure (e.g., fill network gaps with sidewalks, multi-use trails, and roadway crossing facilities) should be considered in future programs. Furthermore, the negative effect of car availability shows that improving walking infrastructure can be enhanced by transportation demand management push policies (i.e., policies discourage car usage) especially for FLS workers to encourage people to walk more.

6. Summary and conclusion

The utility of a particular mode of transportation will vary not only by the time, distance and degree of convenience, but also by the characteristics of decision makers and type of their occupation. The main purpose of this research was to examine factors affecting the walking behaviors in trips to work across two distinct job groups with different schedule patterns. It was hypothesized that the effect of different factors on choosing walking as a commute mode varies across different job groups. The first group is related to those who are fixed schedule (FXS) workers and the second group refers to people who identify as flexible schedule (FLS) workers. The working time period of FXS workers is usually between 7:30 A.M to 14:30 P.M which makes them to be more time constrained (especially in morning) than individuals in the second group. Individuals in the second group (i.e., FLS workers) start their work later in the morning and finish later in the evening. Despite the limitations to this study, many variables were created and examined in two behavioral models and interesting results were obtained. It is suggested that job schedule patterns and individuals limitations in trips to work need to be addressed if policymakers hope to effectively increase the overall use of walking in daily trips.

Moreover, while walking behavior and its relationship to various factors has been the subject of debate in developed countries, much remains to be learned about this topic in developing countries. This study addresses gaps in the current literature by providing an insight into the case of walking to work in Iran as a developing country. Results in this study confirmed that the topic of walking behavior is very much related to the place and the society of the study area.

Results in this study show that females are more likely to walk to their workplace regardless of job group. Also, it was found that age intervals considered in this study have different effects on walking behavior of individuals in each group. Analyses of travel suggest that the presence of children in household has no significant effect on the likelihood of walking for FXS workers. However, having elementary school age children in household (child aged between 7 to 11) has significant and negative effect on the likelihood of walking for FLS workers. Altogether, descriptions provided inside the text are not conclusive and the relation between the presence of children in households and walking behavior in trips to work should be more investigated in future research. Moreover, a limitation to this study was that household's income was not gathered in the data collection stage so it was not possible to evaluate the effect of income on walking behaviors. According to findings in this study, car availability in household was a negative factor on walking mode choice across both groups with a greater effect on FXS workers.

Seven intervals were defined for trip distance taking trips less than 0.25 miles as the reference level. It was found that travel distance has a negative effect on walking in all models. Different coefficient values were determined for the assumed distance intervals which confirms the appropriateness of assuming the distance variable in several intervals. From the results found, it was concluded that FLS workers are more sensitive to distance than FXS workers. It was concluded that FLS workers do not mind walking up to 0.5 mile (800 meter) in their trips to work. However, FXS workers are not sensitive to distances up to 0.75 mile (1200 meters). Moreover, it was found that the reduction in the probability to walk by an increase in travel distance is higher for FLS workers than FXS workers. Furthermore, while some environmental variables were controlled in this study, they are limited. Various path attributes such as average incline, adjacent traffic volumes, and presence (and width) of sidewalks, and the elevation difference could be helpful in reflecting some key factors influencing walking mode choice in school trips. According to environmental factors examined in this study, travel zones with higher level of mixed land uses (i.e., higher entropy and job population balance) increase the propensity to walk among FLS workers only. Overall, distances and environmental factors were calculated in zonal based form which was an appropriated proxy. However, the analysis could be improved in future studies by using information about the actual origin and destinations of trips.

Altogether, it should be borne in mind that data on travel behavior in developing countries like Iran is minimal. This is especially true for the city of Rasht. Therefore, despite descriptions provided in this study, another set of analysis could more clearly relate the job status to schedule patterns and its role on walking mode choice behavior. Therefore, this subject is still interesting and open for future studies.

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