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Considering spatial mobility as an important dimension of human capability with direct implications for well-being, this study examines the link between individuals' socioeconomic status and their degree of mobility. We use data from the National Household Travel Survey (NHTS) conducted in United States in 2009 by the US Department of Transportation. We construct two complementary mobility variables: one translating the average distance individuals travel by day and the other capturing the average number of trips made by individuals in a day. Using both exploratory and multivariate linear regressions analyzes, our results show that socioeconomic status determines significantly individuals' degree of mobility. We found that mobility is significantly higher among the most educated individuals and those with high income levels. It also appears strong heterogeneity in the mobility according to gender or individuals' age. We found, in particular, that men are more mobile than women in terms of distance traveled. But conversely, women are much more mobile than men in terms of frequency of trips.

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Introduction

The understanding of the phenomenon of individuals' spatial mobility appears crucial in many areas such as urban transport networks planning or in the perspective of containing the spread of epidemic virus. However, the laws that govern this mobility are still poorly known. According to many authors, mobility remains a phenomenon essentially probabilistic which can be captured by a random walk model or a law of Lévy based model (Brockmann et al. 2006). However, authors like González et al, 2008 show, on the contrary, a strong regularity in individuals' mobility patterns by highlighting that, in general, individuals travel the same distances and frequent almost the same places. For these authors, mobility can be approached by a simple Gaussian probability (normal) model.

In this study, we consider the spatial mobility in human capabilities approach. Indeed, by conceptualizing mobility as the ability to move or travel with less constraints as much as possible, one can admit that this has direct implications in terms of individual's well-being. For example, it's widely recognized that people who have high degree of mobility are also those who have more access to opportunities (mainly in terms of access to employment, leisure, etc.). Therefore, in line with the capabilities theory (A. Sen), the spatial mobility can be considered an essential dimension of human well-being. We try thus to analyze the spatial mobility phenomenon with particular emphasis on individuals socioeconomic status. We assume, then, firstly, that individuals' socioeconomic status are key determinants of their mobility. However we also consider that these effects may differ according to various aspects of mobility. Indeed, we consider two aspects of spatial mobility: mobility by distance which correspond to the total distance traveled by an individual during a given time interval and mobility by frequency corresponding to the number of trips made by an individual on the same interval. These two types of mobility can be considered as two different aspects but complementary of spatial mobility.

In order to analyze the influence of individuals' socio-economic status on these two mobility variables, we adopt the following methodological steps. First, we analyze the distribution of mobility variables by the descriptive statistics tools. In a second step, we present the main socio-economic characteristics of individuals. Thirdly, we seek to establish some associations between individual characteristics and the degree of mobility. This third step is mainly done through graphical analyzes. And finally, we try to confirm these associations by the means of econometric analysis.

2- Data and methodology

- **Data**

The data used in this study are extracted the National Household Travel Survey (NHTS) conducted in United States in 2009 by the US Department of Transportation.

The database consists of four modules. The first module provides information on individuals' characteristics. A total of 308,901 individuals were surveyed. The second module contains information on households' characteristics. The third module was designed to inventory all the trips made by individuals during their survey day. And finally the fourth module (which was not used in this study) is a specific section which aims to provide information on the characteristics of vehicles owned by the households.

We decide to restrict the analysis to individuals aged between 15 and 85 years. Finally, our analysis database contains 247,753 individuals (almost 80.2% of the original sample). The list of the variables and their descriptions are presented in Table 3 in the Appendix.

- **Descriptive statistics**

As signaled previously, we consider two aspects of spatial mobility: mobility by distance and mobility by frequency. The first is a continuous quantitative variable measuring the total distance traveled by an individual during a day and the second is a discrete quantitative variable that measures the number of trip made by the individual. Table 1 below provides descriptive statistics on these types of mobility as well as on other variables relating to individuals characteristics.

Table 1: Individuals and households characteristics

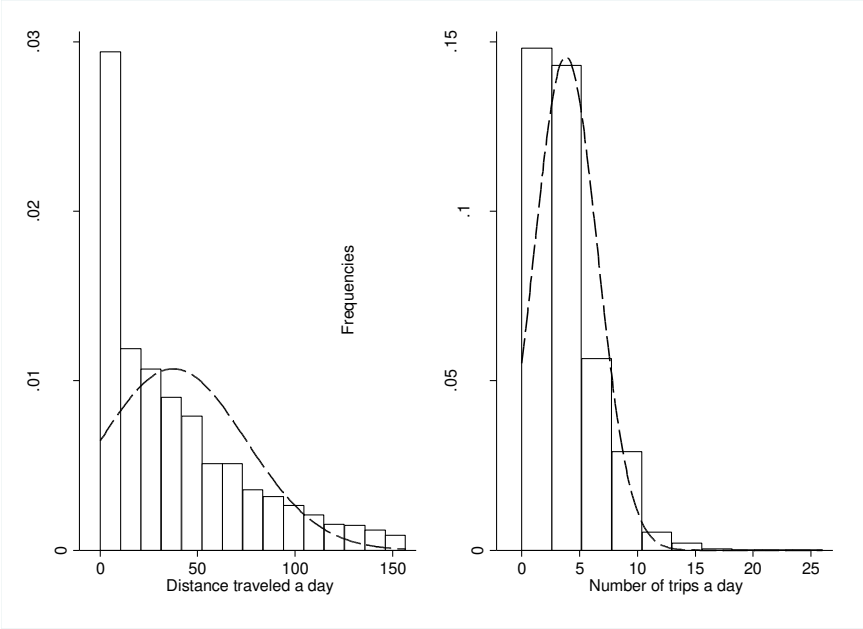
	Mean	St. Dev	Median	Q1	Q3	Min	Max
Quantitative variables							
distance (km/day)	37.50	37.27	25.92	6.43	57.92	0.00	156.8
number_of_trips/day	3.81	2.74	4.00	2.00	5.00	0.00	26.0
age	44.45	17.98	43.00	30.00	58.0	15.0	85.0
household_size	3.09	1.50	3.00	2.00	4.00	1.00	14.0
Qualitative variables							**(%)**
Male							48.39
worker							63.57
Driver							87.55
vehicle_in_hh							93.61
urban							76.95
Education level							
< High school							10.20
High school							28.88
College							28.74
Bachelor							19.04
Graduate							13.12
Household income categories							
Lowest quintile							28.71
Second quintile							19.30
Third quintile							15.51
Fourth quintile							36.47
Highest quintile							5.41
Number of obs.							247 753

We can see from Table 1 that individuals travel 37.5 km in average per day but with a very high standard deviation (almost equivalent mean itself, 37.27 km) shows, thus, that mobility by the distance is widely dispersed among individuals. The median shows, in turn, that the half of individuals travel less than 25.92 km a day. And regarding the first and third quartile (Q3 and Q1), it appears that 25% of individuals travel less than 6.43 km per day while 75% of individuals travel less than 57.92 km per day. Furthermore, analysis of the minimum and maximum shows that there are individuals who do not perform any displacement a day while some may travel up to 156.78 km / day. This situation shows why the distance is very highly dispersed and this dispersion remains even after eliminating outliers[2].

[2] Extreme values were eliminated by using the equations: L = Q1 - 3/2 (Q3-Q1) and U = Q3 + 3/2 (Q1-Q3) where Q1et Q3 represent respectively the first and the third quartile of the distance. We drop then all the observations whose distance is less than L (Lower bound) or higher than U (Upper bound).

Regarding the number of trips per day we see that individuals do 3.81 trips per day in average[3]. With a standard deviation of 2.74, a median equal to 4, the number of trips is highly dispersed among individuals. The minimum and the maximum are respectively 0 and 26 trip by day. The wide dispersions of mobility variables are confirmed graphical analysis. The two histograms below show respectively the distributions of distance and number of trips per day.

Graph 1: Distribution of mobility variables



We also see from Table 1 that individuals in the sample are aged of 44.45 years in average with a standard deviation of 17.98. Concerning the households' sizes, there are 3.09 individuals per household in average.

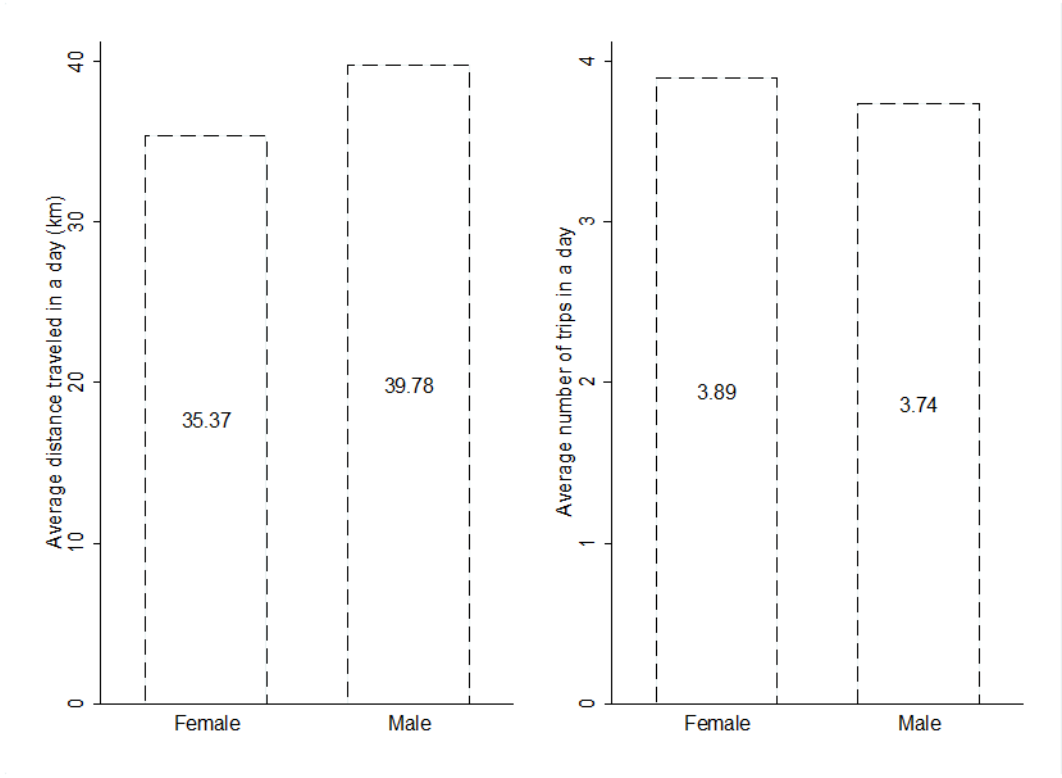
Furthermore, the sample is constituted 51.31% of women and 48.39% of men. And in terms of education level, 10.20% of individuals have a level less than high school; 28.88% have high school level; 28.74% have college or advanced professional training course level; 19.04% have achieved the bachelor level and 13.12% of individuals have graduate (Master and above).

Regarding employment status, the figures in Table 1 show that about 63.57% of individuals are worker. Regarding the place of residence, we notice that 76.95% of individuals are living in urban areas against 23.05% in rural areas. It also appears that 87.55% of individuals are driver on regular basis, and there are at least one vehicle in 93.61% of households.

[3] The trip is defined in the survey as by the fact that individual move from one address to another address. Thus, an entire round trip is considered two distinct trips.

In a second step, beyond these univariate descriptive statistics, we also try to analyze the associations that may exist between individual characteristics and mobility variables. Thus, we analyze first the mobility by gender. Figure 2 below shows in comparative ways mobility for men and women.

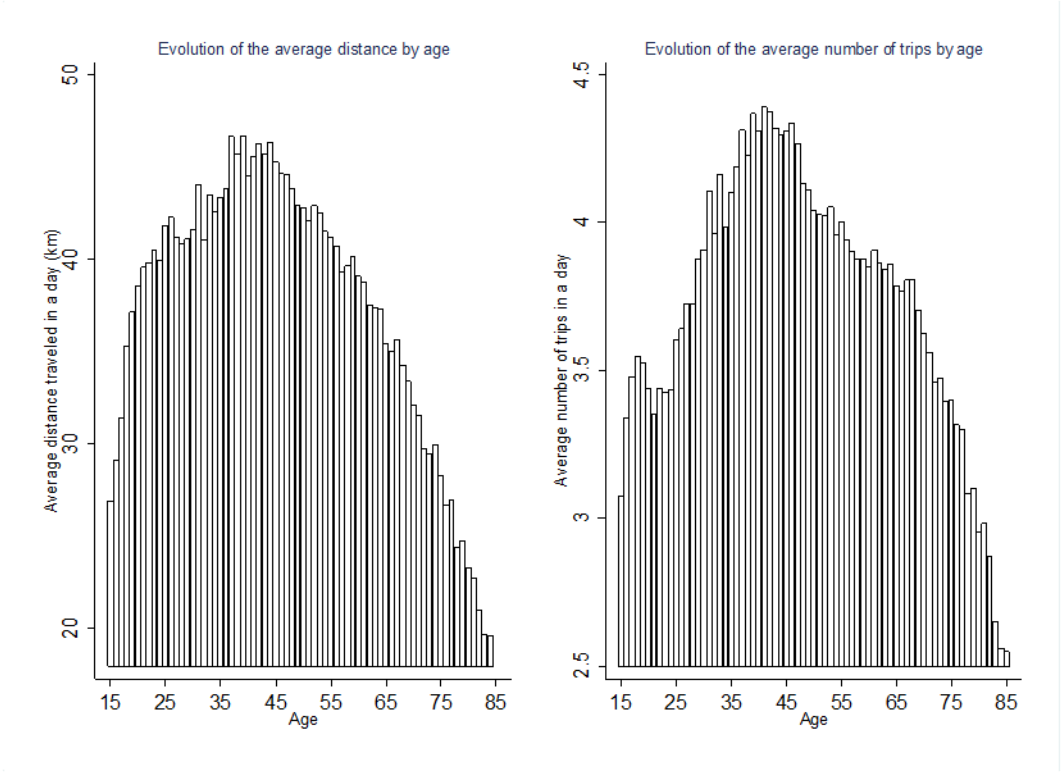
Graph 2: Mobility by gender



We see from graph 2 that women travel an average of 35.37 km / day while the men travel 39.78 km / day. In terms of the number of trips, women make on average 3.89 trips / day while men do about 3.78. These results suggest that men travel more distance than women, and that women move more frequently than men.

Graph 3 below shows the variation of mobility according to individuals' ages.

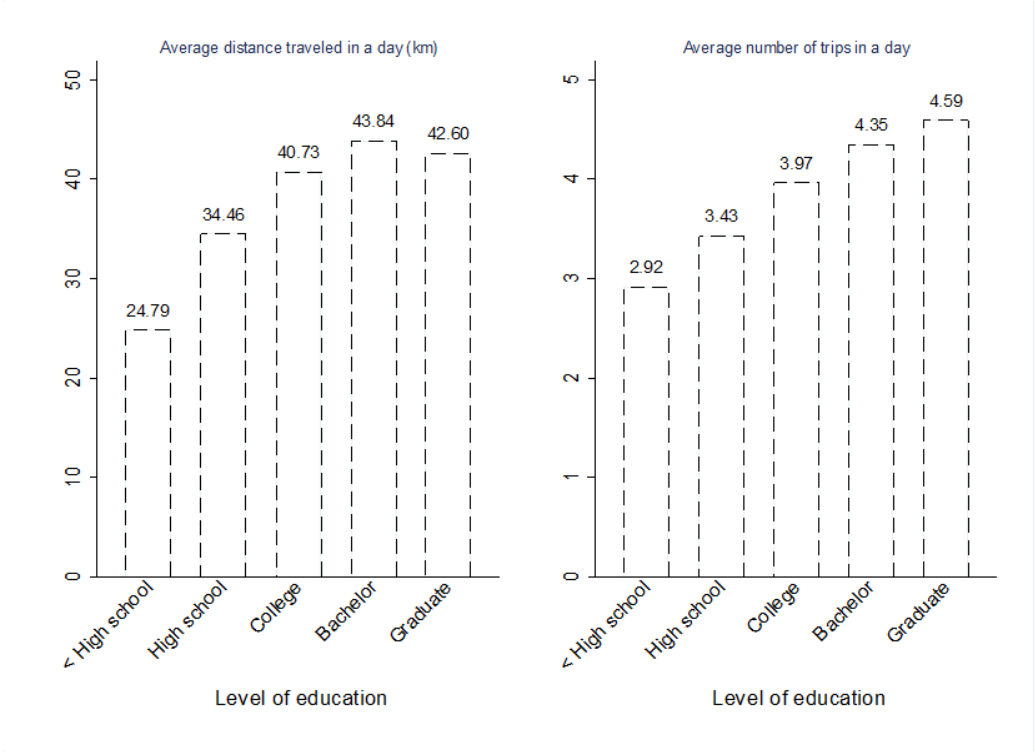
Graph 3: Mobility by age



What we see of particular on this graph is that the traveled distance increases with age. But from a certain threshold the distance decreases. This situation is similarly for the number of trips. We see that the average number of displacement increases initially with age and begins to decrease from a certain threshold. These results indicate that there is a quadratic relationship between mobility between mobility and age. Which therefore means that in econometric estimation we must consider the age and squared age as predictors of mobility.

The analysis of mobility by the level of education tends to show that mobility is higher among the most educated individuals. This result appears in the graph 4 below.

Graph 4: Mobility by education level



We see for example that individuals with a level of education less than high school travel in average 24.79 km and make 2.92 trips a day, while those with a graduate level travel 42.60 km and move 4.59 trip by day.

3. Econometric estimations

In order to confirm the associations previously highlighted, we estimate a linear econometric model whose equation can expressed as follows:

$$y_i = \alpha + \beta_1 \, x_{1,i} + \beta_2 \, x_{2,i} + \cdots + \beta_k \, x_{k,i} + u_i \;\; with \;\; i = 1, 2, \ldots \, N$$

Where y_i represents the mobility variables (distance or number of trips) et $x_{k,i}$ represents the variables that represent the socioeconomic status of the individual (age, sex, education, employment, income, etc...) and u_i the regressions residuals. Given two potentially correlated dependent variables, the econometric model is estimated using the multivariate regressions method. The results of these estimations are presented in Tables 2 below.

Table 2: Regressions results

VARIABLES	Distance traveled	Number of trips
Education level		
high school	2.186***	0.168***
	(0.000)	(0.000)
college	5.380***	0.500***
	(0.000)	(0.000)
bachelor	5.908***	0.748***
	(0.000)	(0.000)
graduate	4.569***	0.981***
	(0.000)	(0.000)
worker	9.360***	0.334***
	(0.000)	(0.000)
Income level		
second quintile	4.201***	0.036**
	(0.000)	(0.037)
third_quintile	5.067***	0.116***
	(0.000)	(0.000)
fourth_quintile	8.632***	0.198***
	(0.000)	(0.000)
highest_quintile	1.761***	-0.320***
	(0.000)	(0.000)
Other characteristics		
sex (1=male)	2.034***	-0.280***
	(0.000)	(0.000)
age	0.455***	0.049***
	(0.000)	(0.000)
age2	-0.005***	-0.001***
	(0.000)	(0.000)
household_size	0.658***	0.072***
	(0.000)	(0.000)
vehicle_in_hh	9.653***	0.135***
	(0.000)	(0.000)
driver	12.965***	1.233***
	(0.000)	(0.000)
urban	-10.343***	0.431***
	(0.000)	(0.000)
black_dummy	3.445***	-0.065***
	(0.000)	(0.000)
hispanic_dummy	-1.205***	-0.586***
	(0.005)	(0.000)
Constant	-9.375***	-0.198***
	(0.000)	(0.000)
Survey day dummies	yes	yes
Observations	234,878	234,878
R-squared	0.117	0.087
Correlation between distance_traveled and number_of_trips = 0.4241***		
Breusch-Pagan test of independence of equations: chi2(1) = 42253.702, Pr = 0.0000		

Pvalues in parentheses, Significance levels *** p<0.01, ** p<0.05, * p<0.1

The results of the econometric analysis clearly confirm those of the descriptive analysis. It appears from regressions that there is a significant heterogeneity of mobility by gender. As a binary variable coded 1 for men and 0 for women, the sex variable shows a positive effect on the distance traveled and a negative effect on the number of trips. This means that men travel more distance than women (positive sign) and make fewer trips than women (negative sign). These results allow thus to establish that there is a significant difference in mobility between men and women.

Regarding the effect of age on mobility, the regressions confirm a quadratic relationship (or inverted U-shaped relationship) between mobility and age. We found that the mobility increases with age (positive sign), but from a certain threshold, it decreases significantly (negative sign associated to the coefficients of squared of age). . These results seem very logical since one can imagine that the younger and older people have a relatively low mobility compared to the rest of the population.

In addition, the variables reflecting the education level, the income, the household size, or the existence of a vehicle in household, appears with a positive and significant influence on the two aspects of mobility. One can simply note that the variable related to area of residence shows a differential effect on the two aspects of mobility. We find that living in urban decreases the distance compared to rural areas (negative sign) while its increases significantly the number of trips (positive sign).

4. Conclusion

Considering that the spatial mobility is an essential aspect of individuals' well-being, this study aimed to investigate the role of some socioeconomic factors. For this purpose, we use a sample of 247,753 individuals aged from 15 to 85 years from the National Household Travel Survey database (NHTS) conducted in United States in 2009. By using both descriptive and econometric analyzes, we found that the social, demographic and economic characteristics have direct influence on individuals' degree of mobility. For example, we found that age, education and income have significant effects on distance traveled and number of trips made by day. However, these effects vary significantly depending on these variables of mobility. In particular, we found that men are more mobile according to the distance while women are more mobile according to the frequency of displacements. Furthermore, it appears that living in urban areas tends to decrease the distance traveled but increases the frequency of trips. Finally, this study recommends the consideration of socioeconomic factors in the perspective of the improvement of individuals' mobility taken an essential dimension of their capability.

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Appendix

Table 3: Presentation of the variables

Variable	Description
distance_traveled	Total distance traveled by the individual (in km per day)
number of trips	Number of trips made by the individual in a day
Household_income	Variable capturing household income divided into 18 slices coded from 1 to 18 as follows: 01 = < $5000 02 = $5000 - $9999 03 = $10000 - $14999 04 = $15000 - $19999 05 = $20000 - $24999 06 = $25000 - $29999 07 = $30000 - $34999 08 = $35000 - $39999 09 = $40000 - $44999 10 = $45000 - $49999 11 = $50000 - $54999 12 = $55000 - $59999 13 = $60000 - $64999 14 = $65000 - $69999 15 = $70000 - $74999 16 = $75000 - $79999 17 = $80000 - $99999 18 = > = $100,000
Household_size	Number of individuals in household
driver	Binary variable that takes 1 if the individual is regular vehicle drive and 0 otherwise
education	Individual's level of education. This variable is coded as follows: 01 = Less then high school graduate 02 = High school graduate, include GED 03 = Some college or Associate's degree (Vocational) 04 = Bachelor's degree (BA, AB, BS) 05 = Graduate or Professional Degree (MA,MS,MBA,MD,PHD,EdD,JD)
age	The age of the individual (in years)
sex	Sex of the individual (recoded 1 = Male; 0 = Female).
urban	Place of individual's residence (urban = 1; 0 = Rural)
worker	Binary variable of individual work status taking 1 if the individual is working and 0 otherwise
vehicle_in_hh	Binary variable that takes 1 if there is at least one vehicle in the household and 0 otherwise. The vehicle definition includes several means of transport: car, autobus, motorcycle, truck, etc.

Internet links to 2009 NHTS database and materials

http://nhts.ornl.gov/download.shtml
http://nhts.ornl.gov/2009/pub/Questionnaire.pdf
http://nhts.ornl.gov/2009/pub/ExtendedInterview.pdf
http://nhts.ornl.gov/2009/pub/Codebook.pdf
http://nhts.ornl.gov/2009/pub/UsersGuideV2.pdf
http://nhts.ornl.gov/2009/pub/DerivedVariables.pdf
http://nhts.ornl.gov/publications.shtml