

## **IDENTIFYING MOBILITY PATTERNS OF SOCIOECONOMIC CLASSES IN A TRANSPORTATION CONTEXT CASE STUDY: SÃO CARLOS -SP (BRAZIL)**

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### **ABSTRACT**

This article presents the results of a study in São Carlos (Brazil), whose goal was the characterization of mobility patterns associated with socioeconomic classes. This study helps to understand the relations between mobility patterns and socioeconomic classes and aims to demonstrate the modal choice distribution in an urban region by analyzing the socioeconomic characteristics of households. Information from an OD Survey, made in 2007, was used as database. After a geospatial location process, elaborated with a help of Geographic Information System (GIS), the database was analyzed qualitatively, in order to obtain the mobility patterns of each socioeconomic class, considering gender, age, modal choice and distance traveled. Results showed that (i) differences between modal choices in each daily trip depend on the user class; (ii) divergences between distance traveled and modal choice considering gender and age was observed in the daily trip.

### **1 INTRODUCTION**

In Brazil, an Urban Mobility System (UMS) is a system that integrates urban transportation and mobility infrastructure in a balanced way, in order to promote social inclusion and equal opportunities (Brasil, 2007). For planning an UMS, it is necessary to comprehend the daily trip patterns of the users. Every social group has a specific daily trip, whose pattern is submitted to some restriction, as income, or some conditions, as age or gender. These factors influence the daily trip behavior, especially the modal choice. Understanding how these factors influence the use of a specific modal helps to optimize the planning of a transportation system, adjusting the mobility infrastructure for the potential users.

Considering socioeconomic classes for planning the urban transport system is fundamental because socioeconomic condition (driver's license, private car, costs of public transport) influence the modal choice. Also, the age is important for the trip behavior due to needs and restrictions of each age group. For example, a trip behavior of a young student, whose displacement needs are mainly to go to school, is totally different of that of his mother, whose displacement needs are more complex (going to work, going shopping, taking children to school, etc.)

Gender differences influence on daily travel patterns as well. Because of cultural reasons and personal preferences, men and women have distinct daily trip patterns. Generally, men have regular travel routines based on their work requirements, different from women who have dynamic travel routines based on their several daily tasks: work, family and shopping, for example.

This article presents the results of a study in São Carlos (Brazil), whose goal was the characterization of mobility patterns associated with socioeconomic classes. This study helps to understand the relations between mobility patterns and socioeconomic classes and aims to demonstrate the modal choice distribution in an urban region by analyzing the socioeconomic characteristics of households. First, some transportation studies that consider gender differences in mobility patterns, urban model and social inequalities were presented; second, the methodological approach adopted in this work was explained; third, the results and analysis was reported. Finally, conclusions and suggestions for future approaches were presented.

## **2 BACKGROUND**

Gender differences in mobility patterns were analyzed in recent transportation studies (Barros et al, 2005; Dobbs, 2005; Matthies et al., 2002; Uteng and Cresswell, 2008; World Bank, 1999). These studies focus on feminine trip behavior and its connection with socioeconomic and environmental issues. They conclude that the mobility pattern of women is more flexible and dynamic than that of men, and, for this reason, it is necessary to reconsider some concepts in transport planning in order to meet the women displacement needs.

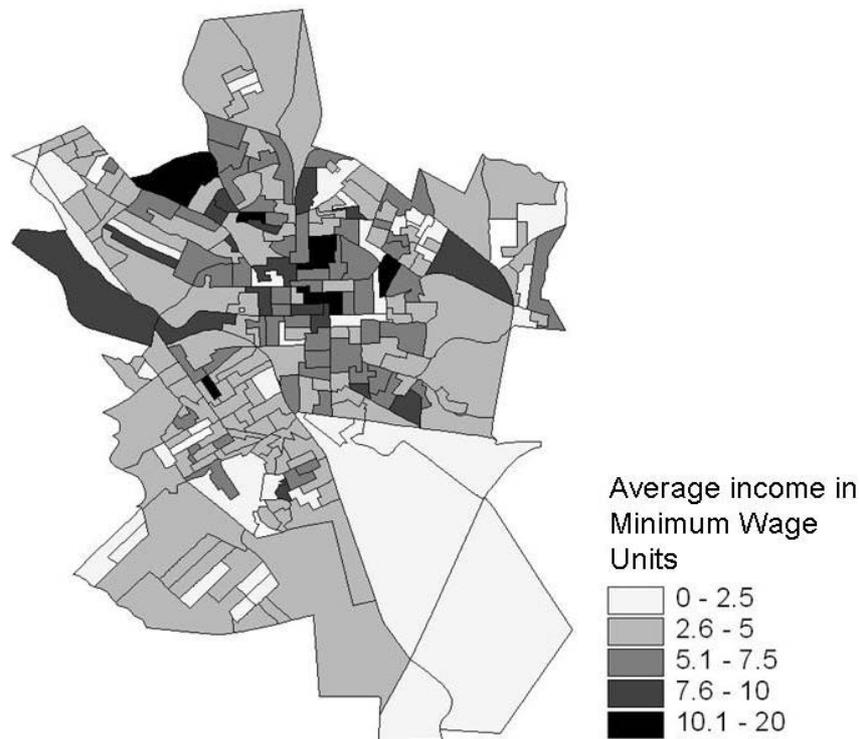
The relations between urban form and travel patterns were explored in several studies, (Boarnett and Crane, 2001; Jenks et al., 1996; Krizek, 2003; Newman et al., 1995; Pouyanne, 2004). These studies highlight how the urban sprawl and the private transport are interrelated. Mainly because of car use, that allows the city to spread, suburbanized areas with low density, restricted residential landuse and automobile dependence of their households were emerged. The “Compact City” as an efficient way to reduce car use and transport externalities was discussed in these studies.

Finally, mobility patterns and social inequalities were explored in Camarero and Oliva (2008), Gomide (2006) and Vasconcellos (2005). These studies investigate new forms of exclusion and social risks, taking account the socioeconomic conditions of the households and their mobility patterns. They conclude that the users who can use resources and skills without constraints, as owning a private car, for example, find a transport system organized to give to them greater comfort and speed, even with the increase of transport externalities, as fuel consumption and air pollution. Nevertheless, lowest income users, who have mobility constraints, spend a high share of their income on public transport, but have a very low mobility and contribute almost nothing to transport externalities.

## **2 METHODOLOGY**

### **2.1 Study Object**

São Carlos is a medium-size town located in the State of São Paulo. With 220 463 citizens and approximately US\$ 470.00 as average income (IBGE, 2009), São Carlos shows a high level of Municipal HDI (Human Development Index), 0.811 in 2000 (PNUD, 2000), while Brazilian HDI in the same year was 0.771 (UNDP, 2000). In the regional scenario, São Carlos represents an academic pool, with universities and research centers, and also a technological pool, with large industries. Figure 1 shows the income spatial distribution in São Carlos, whose data were based on socioeconomic characteristics of households in the OD Survey.



**Fig. 1 – Income Spatial Distribution in São Carlos (average data grouped by census sectors)**

Concerning urban transportation, the majority of daily trips have intraurban characteristics because this region does not have conurbations. As the public transport system is based on radial bus lines, without alternative routes, and with 34 motor vehicles per 100 people (the Brazilian average is 21 motor vehicles per 100 people) (Brasil, 2009), São Carlos shows an urban scenario in which the use of cars is motivated.

## **2.2 Data base characterization**

### 2.1.2 OD Survey in São Carlos (São Paulo – BR)

The OD Survey is one of main toolboxes used by transportation and urban planning to recognize and to evaluate the people and product movements in intraurban and interurban trips.

Among several characteristics, the OD Survey highlights a detailed trip behavior data base of users in an urban area. Furthermore, it allows to identify factors that affect, directly or indirectly, the daily displacement dynamics. The OD Survey is the most adequate research to considerer precise information about trip behavior of an urban population, because the daily trips are associated with socioeconomics conditions and the localizations of households and destiny displacement (workplaces, schools, etc.).

To obtain information about daily trip behavior in São Carlos, this work uses data from the OD Survey made in 2007 (São Carlos, 2007), especially data from household interviews. The interviews, which were done on workdays, used a geospatial household database, where all collected information – as address, socioeconomic conditions, trip modal choice and origin/destiny of trips – is joined in a GIS point database (Silva, 2008). This allowed this research to correlate the OD Survey spatial information with other geospatial databases, as socioeconomic and demographic Census data (IBGE, 2000), whose results were important for data analysis

### 2.3 Data Treatment

#### 2.3.1 Routes location in GIS data base

As the OD Survey only collects the origin-destiny address point, and not a detailed track, a possible trip route was estimated by using TransCAD Software with Route System Application (Caliper, 2005; 2006). To find this route, the shortest path between origin and destiny was considered, using the road network geospatial database. This database is a GIS line file of street axis that contains the displacement restrictions about directions allowed in each street, for example, one-way street or two-way street. Each route has information about the user, as socioeconomic household conditions and modal choice. Figure 2 shows the trip database structure and the location of a route found by the shortest path algorithm.

	A	B	C	D	E	F	G
1	HH_ID	PER_NUMPER_ID	ACT_NUM	ACT_ID	NODE	STOP	
2	1	1	1	1 11	40132	1	
3	1	1	1	2 12	47942	1	
4	1	1	1	3 13	47942	1	
5	1	1	1	4 14	40132	1	
6	1	1	1	5 15	40132	1	
7	1	1	1	6 16	64645	1	
8	1	1	1	7 17	64645	1	
9	1	1	1	8 18	40132	1	
10	2	1	2	1 21	65556	1	
11	2	1	2	2 22	39296	1	
12	2	1	2	3 23	39296	1	
13	2	1	2	4 24	118858	1	
14	2	1	2	5 25	118858	1	
15	2	1	2	6 26	39296	1	
16	2	1	2	7 27	39296	1	
17	2	1	2	8 28	65556	1	
18	3	1	3	1 31	26553	1	

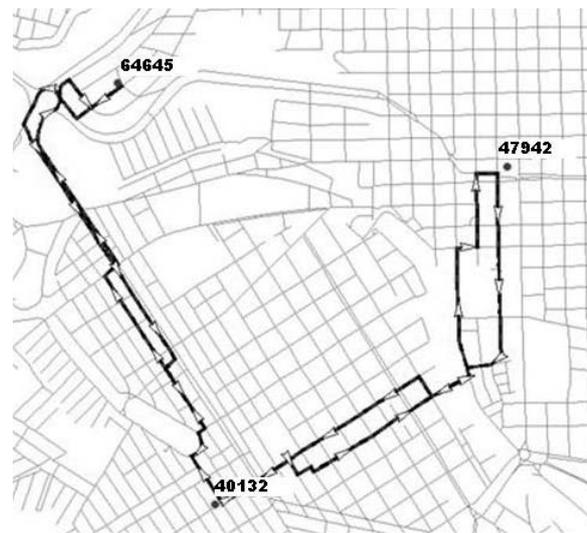


Fig. 2 – Trip Database Structure and route location in GIS platform

#### 2.3.2 Socioeconomic Classification

As information about household income in this OD Survey has some flaws, as, for example, more than 50% of household registers did not have information about income values (Azevedo, 2008), this work uses the socioeconomic characterization to classify the households. This classification was based on the Brazilian Economic Classification Criteria (ABEP, 2009). To facilitate the analysis, the households were classified in five classes, A, B, C, D and E, without the sub-classification proposed by ABEP. Tables 1, 2 and 3 describe these classification criteria.

**Table 1 – Socioeconomic Scoring system – Household items (ABEP, 2009)**

<i>Items</i>	<i>Household items</i>				
	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4 or more</i>
Colour TV	0	1	2	3	4
Radio	0	1	2	3	4
Bathroom	0	4	5	6	7
Private car	0	4	7	9	9
Washing machine	0	2	2	2	2
Video recorder or DVD player	0	2	2	2	2
Fridge	0	4	4	4	4
Freezer	0	2	2	2	2

**Table 2 – Socioeconomic Scoring system - Breadwinner's level of education (ABEP, 2009)**

<i>Breadwinner's level of education</i>	
<i>Level</i>	<i>Score</i>
Illiteracy / Until 3rd year of Elementary School	0
Until 4th year of Elementary School	1
Completed Elementary School	2
Completed High School	4
Completed Higher Education	8

**Table 3 – Socioeconomic Scoring System – Classification Intervals (Adapted from ABEP, 2009)**

<i>Class</i>	<i>Score</i>
A	46 to 35
B	34 to 23
C	22 to 14
D	13 to 8
E	7 to 0

São Carlos is a medium-size town, that is why the results show a more homogenous social distribution pattern than the distribution found in big cities, as São Paulo with low representation of classes A and E, suggesting a more balanced modal choice distribution. Nevertheless, the modal distribution in the São Paulo Metropolitan Area (RMSP) seems to be more balanced than São Carlos, because the results in São Carlos highlight a predominant car use, contrary to the distribution in RMSP. This reinforces the idea that the urban model adopted in São Carlos induces the use of private rather than public transport or non-motorized modals. Table 4 shows the social class distribution in São Carlos compared to the São Paulo Metropolitan Area. Table 5 shows the modal choice distribution in daily trips in São Carlos and in the Sao Paulo Metropolitan Area.

**Table 4 – Social Class distribution (2007)**

<i>class</i>	<i>São Carlos - % population (São Carlos, 2007)</i>	<i>São Paulo Metropolitan Area - % population (ABEP, 2009)</i>
A	1,85	4,74
B	28,15	33,39
C	56,46	45,01
D	12,85	15,97
E	0,69	0,90

**Table 5 – Modal choice distribution in daily trips**

<i>Modal</i>	<i>São Carlos - % trips (São Carlos, 2007)</i>	<i>São Paulo Metropolitan Área - % trips (Vasconcellos, 2005)</i>
Private transport	38,10	32,30
Public transport	27,13	33,30
Non-motorized transport	34,77	34,40

### 3 RESULTS AND ANALYSIS

To facilitate the analysis, this study adopted two simplifications: (i) the modal choice was classified in three categories: (1) Private transport, including automobile and motorcycle; (2) Public transport, including bus service, school transport and taxi; (3) Non-motorized transport, including bicycle and displacement on foot; (ii) The age variable was divided in eight 10-years spaces.

#### 3.1 Socioeconomic conditions and modal choice distribution

The idea that the use of private transport increases when the income level increases was confirmed in this work. While classes A and B showed a predominant use of private transport, more than 50% of daily trips in classes D and E used non motorized transport. Public transport was not predominant in any of the classes, but was more frequently found in classes C and D. Only class C showed a more even distribution in modal choice and, as dominant socioeconomic condition in São Carlos, this distribution influences the modal choice distribution in this town as a whole. Fig. 3 shows the modal choice distribution in the different socioeconomic classes.

#### 3.2 Gender and daily trip behavior

The main difference between men and women in daily trip behavior concerns in modal choice and distance traveled. Women use more public transport than men and their distance traveled is shorter. In the case of São Carlos, women show, in average, a distance traveled 15% shorter than men. These results indicate a feminine trip behavior already found in previous studies (see Background item): Different from men, that have more routine and less diverse mobility, women have greater mobility obligations that induces several small trips during the day and even more flexible means of transport. Figure 4 shows the gender distribution. Figure 5 shows the distance traveled in different means of transport.

### 3.3 Age and trip behavior

During their lives, users change the means of transport according to their age and their socioeconomic condition. For example, a young student that used to travel by bus because his age did not allow him to have a driver's license, after some years probably he changes his conditions and can even possibly afford a private car. Thus, these lifecycles influence the user patterns in each means of transport.

In São Carlos, the main age group in public transport is between 11 and 30 years, representing 48% of trips in this modal. Users between 0 and 20 years represent 55% of trips in non-motorized modals. In private transportation, users between 21 and 50 years represent 59% of the trips. Table 6 shows the age distribution in each modal.

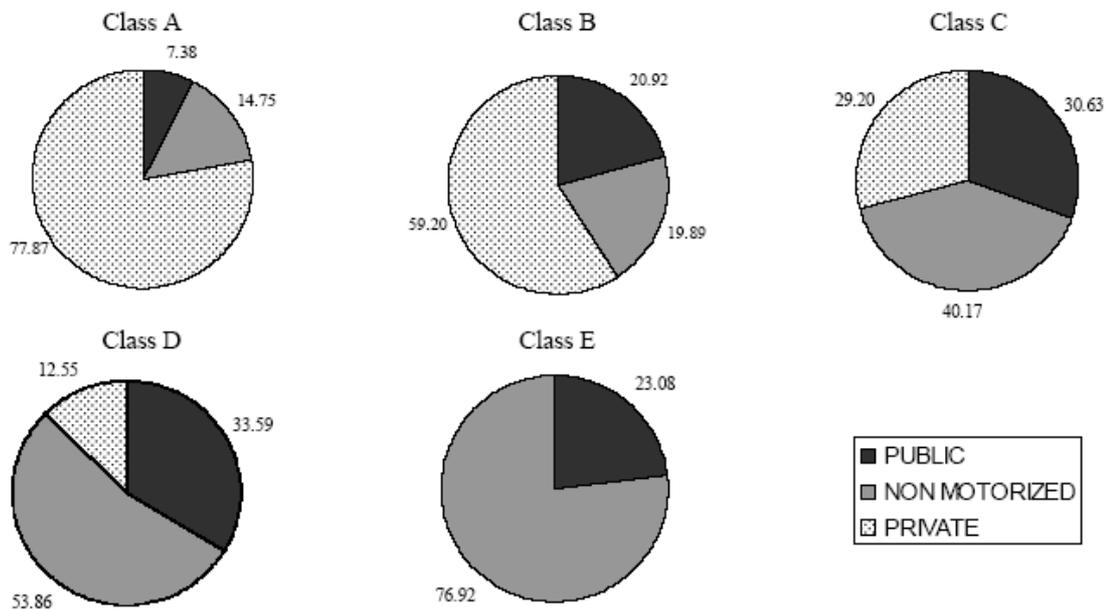


Fig. 3 – Modal choice distribution

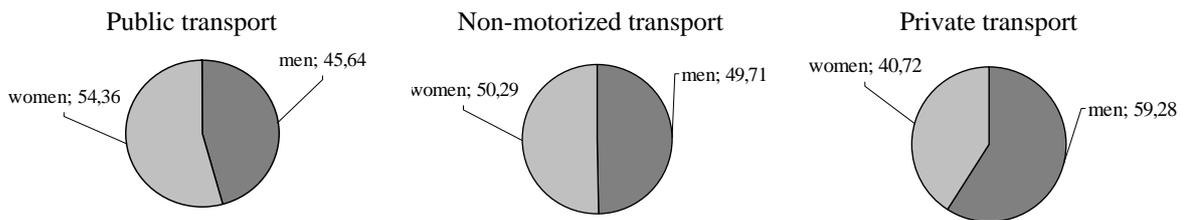
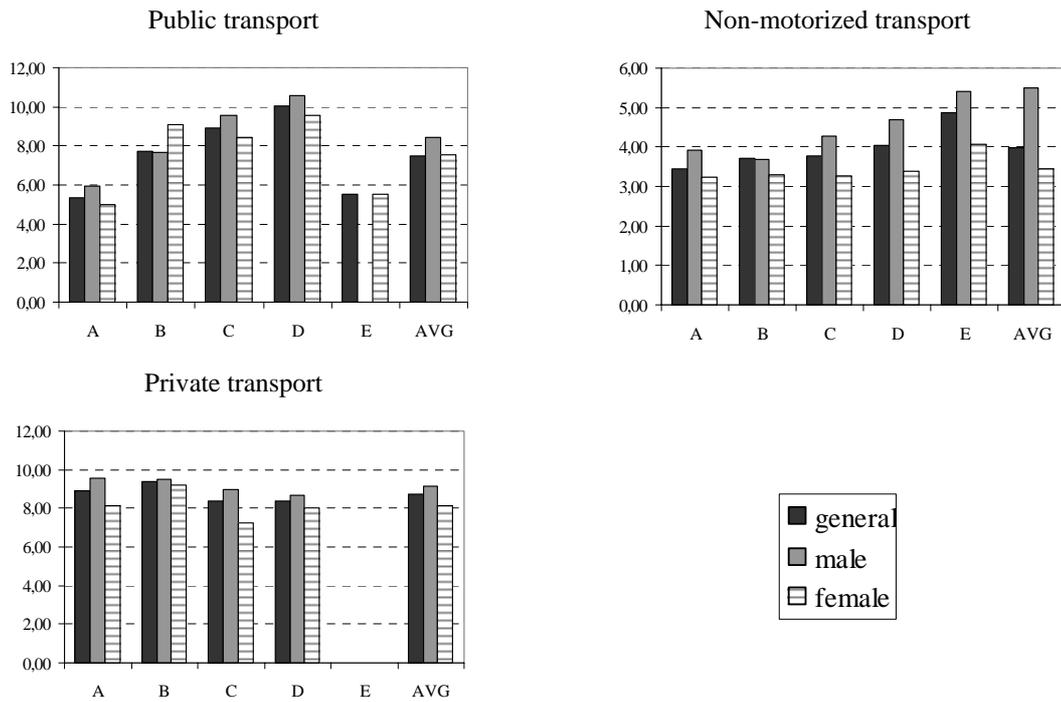


Fig. 4 – Gender distribution



**Fig. 5 – Distance traveled in different means of transport (units in kilometers)**

**Table 6 – Age distribution in modal**

Age	Trips (total)	Non-motorized transport (% of total)	Public transport (% of total)	Private transport (% of total)
0-10	1344	54.99	21.28	23.74
11-20	2533	50.65	26.65	22.70
21-30	2379	26.65	26.90	46.45
31-40	1592	20.48	21.80	57.73
41-50	1422	19.97	23.21	56.82
51-60	955	27.12	21.15	51.73
>60	875	24.69	26.17	49.14

#### 4 CONCLUSION

Through the analysis it is possible to conclude that (i) differences between modal choices in each daily trip depend on the user class; (ii) divergences between distance traveled and modal choice considering gender and age were observed in the daily trips. These conclusions agree with the results found in previous studies, pointing to the fact that the trip behavior found in São Carlos is similar to other medium-size towns, not only in Brazil, but also in international scenario, possibly because of the urban model based on automobile.

For further research, the authors emphasize the importance of investigating the relation about modal choice and social class spatially, considering the attractive trip centers. This approach allows spatial variables, as, for example, urban landuse and parking facilities, that, besides socioeconomic conditions, gender and age, influence the behavior of daily trips in an urban context.

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