

CHARACTERISTICS OF THE TRIPS GENERATED BY A TRIP GENERATION HUB

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Abstract: This paper shows the modal choice to one shopping center, which is currently the only development of great size in a Brazilian medium sized city, and uses the results of a survey in a sample of 300 trip makers to the shopping. The questionnaires asked the trip makers on their personal characteristics, the transportation mode, the trip undertaken by them, and the results were complemented by the surveyor, who observed the characteristics of the environment surround the enterprise. A qualitative table shows the impacts generated by the shopping, before and after its development, in the environmental, social, economic, spatial, and due to traffic factors using data from the municipality and from field research. It is expected that this work will be useful in the characterization of the trips to shopping centers, when verifying the impacts of the hub in the traffic of its vicinities and in the city as a whole.

Keywords: Urban transportation planning, Modal split, Trip Generation Hubs, Shopping Centers, Qualitative matrix.

1. INTRODUCTION

One of the stages of urban transportation planning models deals with the modal choice, which includes the available means of transportation to people when they decide to make trips for many reasons. According to the income of the traveler and the available mean of transportation in the cities, people may have one or more transportation mode to make the trips and they make choices depending on the characteristic of the trip and the convenience in using one or another mode.

The decision of an individual in choosing a transportation mode to be used for his/her daily trips is related to a number of characteristics. The trips attracted to Trip Generation Hubs (TGH), particularly to shopping centers, can be related to the characteristics of the individuals (sex, age, income, educational level etc.), to the characteristics of the available transportation mode for the accomplishment of the trips (cost, trip time, comfort, safety etc.), to the characteristics of the trip *per se* (length, schedule, motive etc.), and to the characteristics of the urban environment (accessibility to the TGH, topography, land use, urban density etc.).

Trip Generation Hubs are places which concentrate one or more activities, attract and produce great amount of trips and, as a result, must be particularly studied. The trips attracted and generated for any mode have an impact in the traffic in the entire region where the hub is located and must be quantified when an enterprise is deployed in an urban area. Retail centers, or shopping centers, are examples of TGH

because they attract and generate great amount of trips, mainly for the purchase and leisure purposes.

This paper shows the modal choice to one shopping center, which is currently the only development of great size in a Brazilian medium-sized city and uses the results of a survey done with a sample of trip makers to the shopping. The enterprise, which has a leasable floor area of approximately 31.000m², is surrounded by a supermarket, located near the downtown area and is a strong competitor of the commerce of this region in terms of places availability for purchasing goods and services.

The survey was made with a sample of 300 people randomly selected in the entrance of the shopping, on Fridays and Saturdays of 2004, who were questioned on his/her personal characteristics, on the characteristics of the transport mode, on the characteristics of the trip undertaken by them and complemented by the surveyor, who observed the characteristics of the environment surround the development.

A qualitative table shows the impacts that the development generated in the vicinities of the shopping, before and after its development, in the following issues: environmental, social, economic, spatial, and of traffic, using data from the municipality and from field research. To these impacts, qualitative indicators show the time of occurrence (implementation, operation and previous to the establishment), effect (positive and negative), the materialization form (direct or indirect), the degree of importance (high and medium), the scale (great, medium and small), durability (short, medium and long), the degree of reversibility (reversible, partially reversible and irreversible) and others. The data processing of the research and the analyses of the qualitative table were made in electronic spread sheets.

The research also investigated if there was any legislation in the city dealing with the approval to implement trip generation hubs, such as shopping centers. The idea was to verify how the city evaluates the impacts caused by the development in an environmental way and by the generated traffic. Also, what would be the parameters of quantification and qualification of the impacts and the process of study dealing with the interaction between the city's departments? Finally, it was investigated if there was any public participation in the decision making process.

It is expected that this work will be useful in the characterization of the trips to shopping centers, when verifying the impacts of the hub in the traffic of its vicinities and in the city as a whole. This research could also validate the trend in Brazil in attracting more non motorized trips and trips by public transport when one looks to the great amount of pedestrian trips attracted by shopping centers, which is different from of what one can see in trips attracted by those hubs in developed countries, which are mostly car-based.

2. CHARACTERISTICS OF THE TRIPS ATTRACTED TO COMMERCIAL CENTERS

Developed and underdeveloped countries present different realities in relation to the modal split to commercial centers. In the United States, for example, most of the trips are attracted by the motorized mode, mainly the automobile. In Brazil, on the other

hand, the amount of trips by the transit mode (buses) and pedestrian trips is significant, making the modal split different in both countries.

Hsu (1984) surveyed 10 shopping centers in California, U.S.A., chosen according to the importance in the traffic system, and quantified the bus routes to the enterprises using questionnaires to determine the characteristics of the trip, like purpose and distance. The author concluded that the modal split indicated that, on average, only 5.8% of the trips were made by the transit mode.

Research by Kittelson and Lawton (1987) shown that a commercial center of 14,000m² gross square meters of floor area in the United States attracted up to 87.5% of the trips for the automobile mode, remaining only 12.5% for other modals, including the pedestrian trips (9.6%), by bus (1.1%) and by bicycle and other modals (1.8%). Another characteristic of the research was to show that the majority of the trips (65%) were direct trips (drop-in), 30% were diverted trips and only 5% were new trips to the surveyed establishment. The authors conclude that establishments with bigger area than the one surveyed may present different values for the trip types because factors like the localization of the commercial center, the image and the name recognition of the enterprise and the type of goods sold may influence the attracted trips.

For the Brazilian case, Goldner (1994) widely studied the modal split for trips to shopping centers using aggregated and disaggregated approaches. For the aggregated approach, a sample of 14 establishments resulted, on average, in 52.3% of trips by automobile, 37.0% by bus, 7.4% pedestrian and 3.6% by other modals, including the train, subway, motorcycles and bicycles. For the disaggregated approach there were utilized stated and revealed preference techniques and binomial and multinomial logit type models were calibrated to samples of 200 questionnaires applied to users of central and suburban shopping centers. The results indicated, for central and suburban shopping respectively, 64.2% and 42.6% for trips by automobile, 31.6% and 47.2% by bus, 3.7% and 6.2% pedestrian, 0.5% and 1.0% by motorcycle and 0.0% and 3.0% of trips by the taxi mode.

Still in Brazil, researches by Portugal and Goldner (1991, 1992 and 2003), Goldner and Portugal (1993), Ary (2002), Rose (2003), Andrade (2005) and Amâncio (2005) discuss the process of trip generation to TGH. In some of these studies trip generation models were developed showing that pedestrian and bus trips are significant.

Portugal and Goldner (1991) researched a significant sample of shopping centers members of the *Associação Brasileira de Shopping Centers* (ABRASCE) and developed models to estimate of the number of trips by automobile attracted by establishments, which made possible to determine the necessities of street space and the integration between the establishments and the urban area occupied by them.

Portugal and Goldner (1992) also analyzed the specific case of one shopping center in Rio de Janeiro, RJ, having a big supermarket as the main store and they found that 60% of the trips to the establishment were by the transit mode. This is due to many bus routes connecting all the neighborhoods in area of influence of the shopping, together with the modal integration, like to train and subway.

Portugal and Goldner (2003) also report many studies that deal with the trip generation to TGH, mainly to shopping centers.

Ary (2002) researched six shopping centers in Fortaleza, CE and characterized the trip demand establishments in relation to the generation, distribution and modal split. The author also observed that the attracted demand is related to factors as localization and socioeconomic matters of the influential area of the TGH.

Rosa (2003) derived socioeconomic variables that could be used in the estimate of trips to shopping centers of the southeastern of Brazil. The author also proposed a graphical to determine the volume of vehicles attracted to establishments using values of the monthly average income in the surroundings of the study area and the gross leaseable area of the establishments.

Amâncio (2005) studied the relationship between the urban form and the pedestrian trips and concluded that the characteristics of the urban form influence the behavior of people when choosing the pedestrian mode to accomplish for their trips.

This paper shows the results from survey (Soares de Andrade, 2005) that characterized the trip demand to a shopping center regarding the mode choice, distance and travel time to the establishment.

3. THE CENTER SHOPPING STUDY CASE

The Center Shopping is located in Uberlândia, MG, a medium-sized city, near to the Central Business District (CBD) area and it has a 79,000m² of constructed area and 31,000m² of gross floor area. The shopping has 2,500 parking spaces, where 900 are indoors, 205 stores, mainly from the clothing sector, accessories and services, together with a hotel building with 153 apartments and a convention center. The food court has 700 spaces. It is estimated that the number of shopping employees is around 2,400 persons. It has a contiguous supermarket, installed in an area of 30,000m², which has a parking lot that people use to have access to the shopping (Figure 1).



Figure 1: Aerial view of the Center Shopping

In 2004 a survey was undertaken with a random sample of 300 users of the Center Shopping, who answered a questionnaire with 26 questions about the characteristics of the trip and providing socioeconomic data of the traveler. The survey was carried out in 29 and 30 of October and 5, 6 and 11 of November, Fridays and Saturdays. The main questions asked were about the trip frequency, day and time, transport mode utilized, travel time, origin and destination, trip purpose and socioeconomic data, like education level and monthly wage rate. 298 out of the 300 questionnaires were used totalizing 52% of female and 48% of male users. The survey characterized the trips to the Center Shopping relating the origin and destination, the travel time to the shopping, the purpose, the modal chosen and the bus routes and services used.

The modal split to the Center Shopping and results from an origin-destination survey carried out for the entire Uberlândia urban area (PMU, 2002) are shown in Table 1.

Table 1: Comparison of the modal split between the trips to the Center Shopping and the results from an origin-destination survey.

Mode	<i>Center Shopping</i>	Total	Origin-destination survey	Total
Automobile	Motorist = 49% Passenger = 15%	64%	Motorist = 15% Passenger = 13%	28%
Bus	1 vehicle = 8% 2 or more veh. = 14%	22%	Regular bus = 33% Small bus = 2%	35%
Pedestrian		7%		27%
Motorcycle		4%		5%
Bicycle		2%		4%
Other	Taxi	1%	Tucks	1%
Total		100%		100%

It is observed for the trips to the shopping that the automobile mode prevails (64%), but with a significant amount for the bus mode (22%). It is also observed that the pedestrian trips make up to 7% and the results from origin-destination survey are also significant (27%).

The main trip purpose to the Center Shopping was according to the survey with the users: 50% for leisure, purchases = 22%, services = 19%, work = 7% and education = 2%.

The survey also showed the average travel time by automobile to the Center Shopping with intervals from zero to 5min, from 5 to 10min and with more than 10min trip. The survey for travel trip time was carried out in 22 of October and 26 of November of 2004, Fridays, where the surveyor drove an automobile following the speed limit of the main routes to the shopping.

Socioeconomic data from the users to the shopping are shown in Table 2.

Table 2: Socioeconomic data from de users to the *Center Shopping*

	Education level	Wage rate: Minimum Wage (MW)	
Elementary school	15%	2.5 to 5.0 MW	24%
High school	40%	5.0 to 8.0 MW	22%
Undergraduate student	12%	8.0 to 12.0 MW	20%

Undergraduation	28%	12.0 to 18.0 MW	12%
Graduation	5%	Other classes	22%
Total	100%		100%

Comparing to the aggregate approach of Portugal and Goldner (2003) for 14 shopping centers one can conclude that the survey with the users of the Center Shopping showed that the modal split resembles the average values found by the authors only for the pedestrian mode, as it is shown in Table 3.

Table 3: Comparison of the modal split between the trips to the Center Shopping and ones surveyed by Portugal and Goldner (2003)

Mode	Center Shopping	Portugal and Goldner (2003)
Automobile	64%	52.3%
Bus	22%	37.0%
Pedestrian	7%	7.4%
Motorcycle	4%	
Bicycle	2%	3.6%
Others	Taxi = 1%	

It was developed, for the Center Shopping, an annual trip generation equation by automobile according to the construction area and the amount of services and miscellaneous goods sold by the establishment, as shown in Equation 1:

$$Y = 234,033.12 + 15.24X_1 + 44,098.30X_9 \quad (1)$$

Where:

- Y** = automobile annual trips;
- X₁** = construction area;
- X₉** = services and miscellaneous goods;

Test t = 2.71

F = 20.04

R² = 0.88

4. QUALITATIVE MATRIX OF IMPACTS

This study also shows a qualitative matrix that correlates the characteristics of the establishment (Center Shopping) with attributed values to different impacts identified and caused by the shopping in its surrounding and in the city as a whole. There were identified: environmental factors, spatial, social, economics and impacts of traffic and transportation, like the ones suggested by DENATRAN (2001).

4.1 Environmental Factors

Environmental factors were: the ground impermeability, degradation of the quality of the stream water, occupation of the subsoil, vibration in the surroundings of the establishment, noise, air and visual pollution, increase of temperature, and reduction of vegetation.

4.2 Spatial Factors

Spatial factors were: changes in the land use, population density, occupation of urban streets, and changes in the geometry of streets.

4.3 Social Factors

Social factors were: access to services, travel time and travel cost, relocation of population, risk of traffic accidents, transit services availability, and installation of institutions and public equipments.

4.4 Economic Factors

Economic factors were: job and income availability, real estate valuation, increase of tax collection, increase of travel time and travel cost, increase of costs with infrastructure, and change in the standard of edifications.

4.5 Traffic and Transportation Factors

Transit and transport factors were traffic impacts, such as: excess capacity of the surrounding streets, increase in the attraction and production of trips, increase of traffic conflicts, traffic accidents, travel routes, changes in the street flows and right of way, as well as changes in urban mobility and accessibility and in the relation between streets and land use.

After analyzing all the factors above it was developed a qualitative matrix that characterized those factors in relation to indicators like the time of occurrence (implementation, operation and previous to the establishment), effect (positive and negative), materialization form (direct and indirect), degree of importance (high and medium), scale (great, medium and small), permanence of the impact (temporary and permanent), materialization (immediate and medium term), durability (short, medium and long), degree of reversibility (reversible, partially reversible and irreversible), spreading (intern to the establishment, local (surround), urban and regional) and possibility of mitigation (total, partial, none and unnecessary) (Table 4). In Table 4, the percentages for singular (only one indicator) and combined (two or more) indicators ad up to 100%.

Table 4: Qualitative Matrix in percentages

Indicator	Qualitative	Singular	Combined
Time of occurrence	I = implementation	2.0%	B and I (2.5%)
	O = operation	75.0%	B and O (10.0%)
	B = previous to the establishment	2.5%	I and O (5.0%)
Effect	P = positive	17.5%	P and N (10.0%)
	N = negative	72.5%	
Materialization form	D = direct	15.0%	D and I (17.5%)
	I = indirect	67.5%	
Degree of importance	H = high	92.5%	
	M = medium	7.5%	
Scale	G = great	65.0%	
	M = medium	32.5%	
	S = small	2.5%	
Permanence of the impact	T = temporary	15.0%	T and P (22.5)
	P = permanent	62.5%	

Materialization	I = immediate	47.5%	I and M (2.5%)
	M = medium term	50.0%	
Durability	S = short	5.0%	M and L (5.0%)
	M = medium	20.0%	
	L = long	70.0%	
Degree of reversibility	R = reversible	50.0%	R and I (5.0%)
	P = partially reversible	15.0%	
	I = irreversible	30.0%	
Spreading	I = intern to the establishment	50.0%	I, L and U (2.5%)
	L = local (surround)		I and L (12.5%)
	U = urban		L and U (10.0%)
	R = regional		
Possibility of mitigation	T = total	2.5%	
	P = partial	52.5%	
	N = none	25.0%	
	U = unnecessary	20.0%	

Table 4 shows that the impacts materialized in a medium term (50%), in a local spreading (50%), but with significant influence in all regions of the city.

Great interference was in an indirect materialization form (67%), not directly caused by the establishment, but due to the necessities of improvements and modifications that were necessary in the surrounding area together with other enterprises, due to the attractiveness and importance of its localization. However, 72.5% of the impacts were considered negative and 62.5% permanent. It is worth to say that the impacts comprise two or more qualifications, depending on the point of view, as in the indicator materialization (50%). In other words, an impact can have its principle at the beginning of the operation of the enterprise and lasts throughout its activity (see combined column in Table 4).

However, 50% of the factors present degree of reversibility and 52.5% have a partial possibility of mitigation of the impacts.

5. CONCLUSIONS

This study shows the results of a survey with the users of a shopping to center in a medium-sized city (Uberlândia, MG) in relation to the mode split and the characteristics of the travelers. It is concluded that the trips by automobile to the shopping center are significant (64%), but the bus mode also has a great percentage (22%). The pedestrian trips result 7%, similar to the figure found in the literature for other commercial centers in Brazil. It was also developed a trip generation equation by the automobile mode to the shopping based in variables as the building area and the amount of services and miscellaneous goods sold by the establishment.

The shopping analyzed in this study is the only one in its size in the city, making it of great influence in terms of impacts in its surroundings and even outside the city. The impacts caused by the traffic are significant, in particular in the urban traffic. It was also verified a close relation between the land use and the interferences in the circulation of vehicles and pedestrians.

A qualitative matrix was developed also showing the influence of the establishment in the city, mainly in the factors of the traffic and urban transportation, although there was a spreading to the spatial, social, economic and mainly environmental factors.

Unfortunately, there is no legislation for the city of Uberlândia which accomplishes to the impact analysis, neither in an environmental way nor to the generated traffic. There are no parameters of quantification and qualification of the impacts and no study process dealing with the interaction between the city's councils. The Metropolitan Policy Organizations must deal with these issues and the participation and representation of the society must be present in the decision making process and when dealing with the mitigation of impacts during the deployment of Trip Generation Hubs. This will help to improve the urban planning practice and will make life better to the citizens.

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