

Checking the Validity of the ITE Trip Generation Models for Brazilian Shopping Centers

Editor's Note: The research contained in this article was conducted prior to the printing of ITE's Trip Generation, 8th Edition (December 2008).

INTRODUCTION

Shopping centers, when well located, can stimulate the adoption of policies for managing trip demand to promote a more sustainable mobility pattern, strengthen the area by attracting other nearby construction, and make available activities and services not existing before, thus developing and enhancing the value of the region where they are located. The concentration of activities in these facilities also tends to provide comparative and competitive gains, fruits of economies of scale, which can favor the developers and managers of shopping centers and their shopkeeper clients.

However, when shopping centers are poorly designed or are built in unsuitable places, they can overload public infrastructure and cause social dysfunctions, particularly evident in the deterioration of traditional high street shopping districts, along with undesirable changes in land use, environmental degradation, and problems of circulation and parking, with resulting traffic congestion and accidents (Portugal, 2006). Because of this duality, it is important to study the size, design, and location of shopping centers before starting construction so as to maximize their positive effects and minimize the negative ones. The overall objective is to provide for their profitability while at the same time ensuring they contribute to the social interest. There is concern in nearly all countries with these questions, and impact studies generally are required to obtain construction permits. The

importance of these studies is even greater in countries such as Brazil, because of the

rapid and disordered growth of cities and the lack of adequate urban planning processes. Indeed, shopping centers have been spreading at a feverish pace in Brazil, evidenced by the growing number of applications filed with municipal authorities

to build or expand malls. Consequently, in the past 20 years the number of members of the Brazilian Association of Shopping Centers (ABRASCE) has grown more than tenfold (from 34 in 1986 to 346 in 2007). In the past six years this growth has been roughly 50 percent and shows no signs of letting up (www.abrasce.com.br, on August 10, 2007).

Largely as a result of this trend, there was an advance in legislation on the matter with the enactment in 2001 of Federal Law 10,257, which provides national parameters for neighborhood impact studies for large development projects (Oliveira, 2001).

In these studies, analysis of trip generation is one of the main facets that must be addressed. In Brazil there is no entity such as the Institute of Transportation Engineers (ITE) that systematically updates the trip generation rates and models. These rates and models are normally derived from academic studies, but the impact studies often use the trip generation characteristics from ITE instead. However, this has potential drawbacks, considering the urban and socioeconomic differences between Brazil and North America and the characteristics of the shopping centers and their location. These differences justify the development of models compatible with specific local realities. Studies indicate that in Brazil a significant portion of trips to shopping centers are by public transportation or on foot. In a survey of 15 shopping centers, an average 40 percent of users rode buses and 8 percent came on foot. This is very different from the pattern in the United States, where the use of private cars predominates (Portugal & Goldner, 2003).

In this context, it is common for works such as those of Goldner (1996), Rosa (2003), and Cárdenas (2003) to consider the initial hypothesis that the estimates generated by the equations suggested by ITE are too high when applied to Brazil.

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Table 1. Characteristics of the sample.

Shopping Center	Gross Leasable Area (m ²)	Total Constructed Area (m ²)	Friday Volume	Saturday Volume	Parking Spaces	Offices	Supermarket	Cinema
A	71,623.00	127,000.00	22,000	23,000	5,093	No	No	Yes
B	65,103.00	200,528.00	13,000	16,000	4,500	Yes	Yes	Yes
C	58,000.00	81,000.00	14,000	18,000	2,700	Yes	No	Yes
D	52,000.00	90,000.00	8,000	9,000	2,600	Yes	No	Yes
E	49,222.00	135,000.00	6,934	8,472	1,651	Yes	No	Yes
F	35,000.00	77,531.00	6,500	7,800	2,000	No	Yes	Yes
G	31,000.00	75,000.00	3,200	4,200	1,200	No	No	Yes
H	30,598.00	72,330.00	3,100	4,200	1,150	No	No	Yes
I	26,450.32	93,200.00	5,000	6,000	1,500	No	No	Yes
J	21,837.53	73,068.00	3,255	3,821	1,100	Yes	No	Yes
K	20,035.59	55,000.00	1,730	2,050	716	No	No	Yes
L	15,600.00	57,714.00	2,600	2,600	613	No	No	Yes
M	15,000.00	60,000.00	1,000	1,500	1,000	No	No	Yes
N	13,536.35	47,000.00	1,980	2,508	740	No	No	Yes
O	12,503.75	41,670.00	2,000	2,500	790	No	No	Yes
P	6,844.10	19,253.00	1,736	1,890	347	No	No	Yes
Mean	32,772.10	81,580.875	6,002	7,096	1,731.3			
Standard Deviation	20,379.44	43,131.03	5,613	6,285	1,376.3			
Coefficient of Variation	62.19%	52.87%	94%	89%	79.50%			

The present article tests this hypothesis—at an exploratory level—by examining the statistical behavior of the vehicle volume attracted by shopping centers in the city of Rio de Janeiro and comparing this volume with the estimates using ITE rates and equations (2003).

Therefore, we hope this article will help give policymakers, entrepreneurs, and civil society a better technical foundation to predict and deal with the traffic impacts of shopping centers.

OBTAINING THE DATA

The most precise method of obtaining the daily flow of cars would have been by detailed counting carried out during representative periods at each shopping center studied. However, in Brazil this is not a usual practice. Shopping center administrators are reluctant to provide detailed traffic flow information because they regard this as proprietary. There are also no data available from government sources in this respect. Therefore, we decided to gather aggregate data through questionnaires sent to contacts working in the shopping center administrations. We were able to assuage their fears to a certain

extent in this respect after some personal meetings, and we managed to obtain their limited cooperation. We believe the aggregate data obtained are reliable, as shown by the data consistency test in item 3. Besides the daily car volume and characteristics of the parking facilities, these questionnaires asked for other variables to enable classifying the malls as to size and activities offered, times of operation, and peak days. The reference months were October and November. Like most countries, Brazil has special days spaced out through the year to encourage retail sales. The most important, the Christmas season, only gets underway in December, so we felt these two months were representative for this type of study.

There are 19 shopping centers in the city of Rio de Janeiro affiliated with the Brazilian Association of Shopping Centers (ABRASCE) that have their own parking facilities (lots or structures). After repeated contacts by Internet, telephone, and in person, we managed to obtain responses from the managements of 16 of these centers, or 84.2 percent of them.

To maintain the anonymity of the centers, each is identified by a letter. Table 1

contains some information on each center, organized in decreasing size, measured by gross leasable area (GLA).

It can be seen that the sizes of Brazilian shopping centers are a good deal smaller than the large centers found in the United States. While the largest one in the sample in Rio de Janeiro has a bit over 71,000 square meters, centers in the United States often have twice this area.

We obtained the demographic data from the censuses conducted by the Brazilian Institute of Geography and Statistics (IBGE) and those on car ownership from the Rio de Janeiro City Traffic Engineering Company (CET-RIO, the municipal traffic control authority).

ANALYSIS OF THE DATA

To identify the level of consistency of the data obtained from shopping center managers, we compared the number of parking spaces against an estimate of the number necessary at peak use to see if these figures were close. To calculate the need for spaces, we multiplied the volume on Saturday (the most popular day) by the peak hour percentage (11.81 percent) and by the average time of stay (1.96 hours)

Table 2. Data consistency test.

Shopping Center	Saturday Volume	Average Stay (h)	Peak Factor	Spaces Necessary	Spaces Existing	% Error
A	23,000	1.96	11.81%	5,324	5,093	+4.53%
B	16,000	1.96	11.81%	3,704	4,500	-17.69%
C	18,000	1.96	11.81%	4,167	2,700	+154.32%
D	9,000	1.96	11.81%	2,083	2,600	-19.88%
E	8,472	1.96	11.81%	1,961	1,651	+18.78%
F	7,800	1.96	11.81%	1,806	2,000	-9.70%
G	4,200	1.96	11.81%	972	1,200	-19.00%
H	4,200	1.96	11.81%	972	1,150	-15.48%
I	6,000	1.96	11.81%	1,389	1,500	-7.40%
J	3,821	1.96	11.81%	884	1,100	-19.64%
K	2,050	1.96	11.81%	475	716	-33.66%
L	2,600	1.96	11.81%	602	613	-1.79%
M	1,500	1.96	11.81%	347	1,000	-65.30%
N	2,508	1.96	11.81%	581	740	-21.49%
O	2,500	1.96	11.81%	579	790	-26.70%
P	1,890	1.96	11.81%	437	347	+25.94%

obtained in the study by Andrade (2005). As shown in Table 2, the response on the volumes attracted appears to be relatively consistent. Of the 16 shopping centers, there was an error of more than 30 percent in absolute value in only three (C, K and M). This does not mean that these are wrong. Instead, it might be that the average stay and peak factor in these cases are different than those indicated by the bibliographical review.

We sought to find a statistical correlation between the volume of vehicles attracted and the characteristics of the shopping centers and their neighborhoods. For the centers, the characteristics considered were the total constructed area, gross leasable area, and number of parking spaces. In the case of parking spaces, the centers with more spaces may be encouraging more trips by private cars to the detriment of more socially productive means, such as public transport and walking. For the neighborhoods where the centers are located, the variables studied were average monthly income of the head of household, number of vehicles owned by neighborhood residents, population, and rate of vehicle ownership. We found no statistical correlation between the number of vehicles attracted and these variables. There were some other variables we initially considered pertinent to check for correlations, such as supply of public transportation and distance from the nearest competing shopping center, but it was not possible to obtain these data.

Figures 1 and 2 show the dispersion graphs and trend line of the relation of gross leasable area and traffic volume on Friday and Saturday. The trend lines of these graphs are determined by Equations 1 and 2, presented below each graph. We divided the GLA by 10,000 because otherwise the exponents of the equations would have been very small.

$$Vv = 1091e^{0.4063X} \quad \text{Equation 1}$$

$$R^2 = 0.89$$

Where:

Vv = Vehicle volume attracted on Friday
 X = GLA (m²) / 10,000

$$Vv = 1347.1e^{0.4X} \quad \text{Equation 2}$$

$$R^2 = 0.92$$

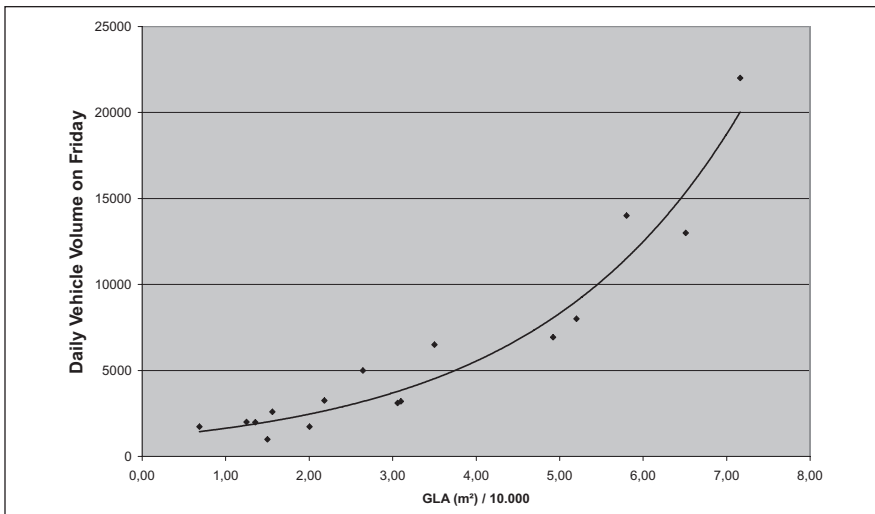


Figure 1. Correlation of the GLA with the volume attracted on Friday.

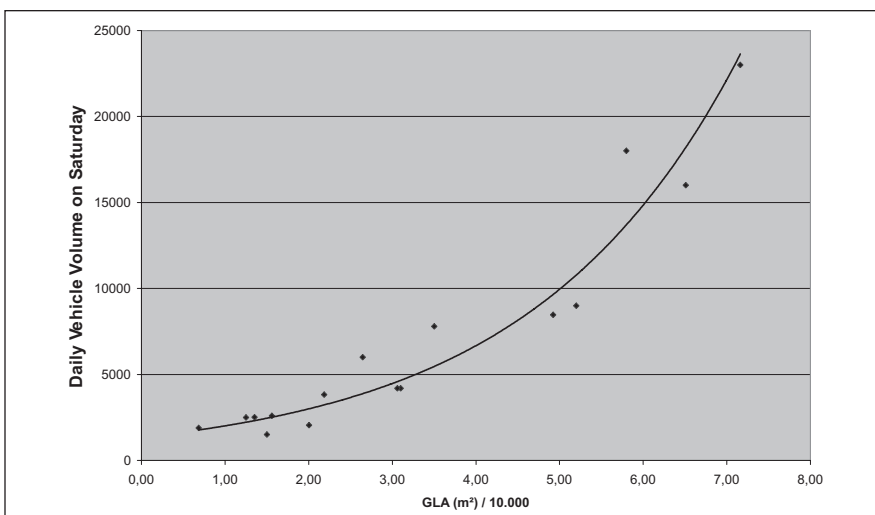


Figure 2. Correlation of the GLA with the volume attracted on Saturday.

Where:

Vv = Vehicle volume attracted on Saturday

X = GLA (m²) / 10,000

The exponential form of the curve does not correspond to what the Brazilian literature indicates (a straight line), nor does it approach the form suggested by ITE (negative exponential). However, if we seek a solution in linear form, we find an equation with a correlation index that, although lower, is satisfactory, as expressed in Equations 3 and 4. The particularity of the sample must be pointed out in this respect: Sixteen shopping centers in Rio de Janeiro with sizes ranging from 6 to 71 thousand square meters. Probably if the sample had contained larger shopping centers, the curve's shape would have changed, perhaps becoming more similar to that of the ITE model.

For Friday:

$$Vv = 0.2605 X - 2535 \quad \text{Equation 3}$$

$$R^2 = 0.84$$

For Saturday:

$$Vv = 0.2975 X - 2652.2 \quad \text{Equation 4}$$

$$R^2 = 0.87$$

Where for both equations:

Vv = Volume of vehicles

X = GLA (m²)

COMPARISON OF THE ESTIMATES USING THE ITE (2003) MODEL WITH THOSE FOUND IN THE SURVEY

Before carrying out any numerical comparison between the traffic volumes attracted by shopping centers in Brazil and the United States, it is important to point out the differences in the modal breakdown of these trips. According to Grando (1986), at the Brazilian shopping centers in that study, trips by car represented between 55 percent and 70 percent of the total visitors attracted, figures much smaller than in the United States.

For comparison, we analyzed the responses for Friday and Saturday, the days considered by the Brazilian literature (and confirmed in this study) as the busiest days. Since the conclusions were very similar, we decided here only to discuss the results for Fridays. The estimation generated based on ITE (2003) was performed by applying Equation 5 to an ordinary weekday and applying the index for Friday traffic.

Shopping Center			ITE (2003)		Trend Line	
Identification	Gross leasable Area (m ²)	Daily Friday Traffic Volume ¹	Estimate	Deviation	Estimate	Deviation
A	71,623	22,000	29.560	34.36%	20,028	-8.96%
B	65,103	13,000	27.783	113.71%	15,367	18.21%
C	58,000	14,000	25.772	84.09%	11,515	-17.75%
D	52,000	8,000	24.007	200.08%	9,024	12.80%
E	49,222	6,934	23.164	234.07%	8,061	16.25%
F	35,000	6,500	18.560	185.54%	4,523	-30.42%
G	31,000	3,200	17.152	436.00%	3,844	20.13%
H	30,598	3,100	17.006	448.60%	3,782	22.00%
I	26,450	5,000	14.572	191.45%	3,196	-36.08%
J	21,838	3,255	12.866	295.26%	2,649	-18.62%
K	20,036	1,730	12.166	603.22%	2,462	42.31%
L	15,600	2,600	10.338	297.63%	2,056	-20.92%
M	15,000	1,000	10.079	907.87%	2,007	100.70%
N	13,536	1,980	9.428	376.14%	1,891	-4.49%
O	12,504	2,000	8.954	347.68%	1,813	-9.35%
P	6,844	1,736	6.620	281.36%	1,441	-16.99%
Mean ²	32,772	6,002	16.752	314.82%	5854	24.75%
Standard Deviation ²	20,379	5,797	7.339	215.72%	5,526	22.48%
Coefficient of Variation ²	62.19%	96.58%	43.81%	68.52%	94.40%	90.84%

¹ Management supplied daily volumes
² Calculated from the absolute values.

This index is 1.189 for centers smaller than 9,290.30 square meters (m²), 1.087 for those smaller than 27,870.91 m², and 1.154 for centers larger than that.

$$\ln(T) = 0.65 \ln(X) + 5.83 \quad \text{Equation 5}$$

Where:

T = Average vehicle volume attracted (trips)

X = 1,000 square feet of GLA

Table 3 shows three measures: the responses obtained by the survey, the application of the trend line (that is, Equation 1), and the application of the ITE estimate (that is, the result of Equation 5 times the Friday index). The figures in the "deviation" columns consider that the responses sent by the shopping center managements represent the real situation, and the difference in the estimates, both for the trend line and the ITE estimate, are presented as percentage errors.

From an analysis of the trend line, it can be seen that the figure for shopping center M behaved very differently from the statistical pattern of the study. The other results were much closer than ITE to the responses to the questionnaire. The calculated standard deviation, excluding center M, is 19.69 percent present conditions interval. Therefore, that equation can be used for trip generation estimates, at least in this specific situation.

Looking specifically at the results using the ITE equation (2003) confirms the hypothesis that the estimates generated by models calibrated for North America are well above the real results found for Rio de Janeiro. The average of the deviations was greater than 300 percent. A similar figure was found by Andrade (2005) when he compared the estimates of six trip generation models developed in Brazil and Venezuela with those of the ITE, for both Fridays and Saturdays.

Thus, applying these models in developing countries will require adjustments and new local studies. However, it is worth observing that the magnitude of the deviations for the largest shopping centers (A, B, and C) is substantially less than for the others (from 34.36 percent to 113.71 percent). Nevertheless, it was not possible to find a statistical behavior relating the GLA with the “deviation.”

CONCLUSION

The comparison of the results of this survey with the calculations according to the ITE (2003) model shows there are few similarities and many differences. The only point in common was the statistical correlation between the shopping centers’ gross leasable area and the volume of vehicles attracted by them. Peyrebrune (2001) already studied this and confirmed the ability of this variable to explain the trip generation at shopping centers, recommending that it be used in the estimation equations.

The two main differences that stand out are the shape of the curve formed by the estimation equation and the magnitude of weekday trips generated per GLA. The estimates made using the ITE (2003) equation overestimate by nearly a factor of three, on average, the figures given by the shopping center administrators. This shows the big differences between the situations in North America and Brazil, pointing to the need for local calibration when using this methodology in other countries.

Part of the difference can be explained by mode split. For U.S. shopping centers, typically close to 100 percent of trips are by personal cars. In Brazil, this number varies greatly, with the average being about 50 percent. The U.S. passenger car fleet is 10 times greater than Brazil, and the number of cars per person is also much higher (one car for every 1.2 inhabitants versus one for every 7.9 inhabitants, respectively (<http://www.anfavea.com.br/anuario2008/capitulo4.pdf>), which is reflected in the trip means pattern.

Regarding the shape, the ITE model generates a negative exponential curve, while the result of this study generated a positive one. This may result from the smaller shopping centers in Rio de Janeiro serving more local areas, enabling even more people to walk and use public

transportation than is possible with large shopping centers.

It is also worth mentioning the high correlation indexes found in Equations 1 and 2, which indicate that they can be used in estimates for situations such as those in Rio de Janeiro.

Another important observation regards the size of the shopping centers studied. Their GLA figures are between about 6,800 and 71,600 m². The use of the equations proposed here (1 to 4) to estimate the trips generated by shopping center projects much larger or smaller than this interval can generate errors. An indication of this is the fact that the results of these equations exceed the estimates made using the ITE (2003) equation. Therefore, more research is needed to find suitable models to estimate the traffic that would be created by giant shopping centers such as super-regional ones.

Finally, we stress that the difference observed in this study is natural and expected, because of the underlying differences between Brazil and North America. Nevertheless, the magnitude of this disparity can vary. This calls for new studies based on data gathered in the field. Thus, it is important to develop a system, starting from the practice followed by ITE, to gather information that permits development of trip generation models and rates in line with Brazilian reality and to periodically update them.

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