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CARPOOLING: A SUSTAINABLE CHOICE IN DEVELOPING CITIES?

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ABSTRACT

Carpooling is seen as a positive strategy towards sustainable mobility in developed cities. However with a modal share where public transport is usually predominant, impacts may be different in developing cities . The present work aims to determine the factors that influence the decision making process of choosing a travel mode as a reaction to the inclusion of a new mode, in this case carpooling. This is done by evaluating individual costs and benefits of a modal shift and the type of users that benefit from it. An analysis of global costs and benefits is also done to determine the pertinence of this kind of systems in a developing city context.

Keywords: Carpooling, revealed preferences, developing cities,

INTRODUCTION: CARPOOLING AS AN ALTERNATIVE MODE

Developing countries like Colombia are in a situation where increase in the number of cars is likely to be more pronounced because of the economic growth. According to Acevedo et al (2009), in Bogotá, the number of trips made by car may grow in 80% in the next ten years, in a "do nothing" scenario. The increased traffic may result in a more congested city which also leads to increased travel times, pollution, traffic accidents and a deteriorated road infrastructure. In this situation, a policy aimed to promote an efficient car use is necessary.

Carpooling systems aroused as an alternative solution to mitigate the growing congestion problems and the negative externalities associated with the private car use by improving its occupation rate. Historically, the interest in carpooling is related to fuel shortage or crisis (Huang, Yang, & Bell, 2000). Carpooling first appeared in United States as a strategy to reduce fuel consumption during the Second World War. In order to increase the automobile occupation rate, publicity campaigns were implemented to promote shared trips to work

between workmates having a close origin. In this system, the number of carpoolers is limited because of the high dependency between passengers and drivers and the reduced time and route flexibility associated with it (Correia & Viegas, 2011). Another scheme, household carpooling, involves trips made within households. This scheme has been proven to be inefficient due to the increasing motorization rate of households and the decreasing flexibility of schedules and destinations (Morency, 2007).

Dynamic carpooling appeared as a consequence of the development of communication technologies and as a response to the limited flexibility of the traditional systems. This scheme allows the arrangement of single trips in a short time period. In spite of being a more flexible system than the traditional, in most cases, it has demonstrated limited results mainly because of the difficulty to match near-term travels and the impossibility to generate stable trip arrangements in the long term (Correia & Viegas, 2011). This scheme has been used mainly in large organizations and has the advantage of having a common destination and a more homogenous schedule distribution.

High occupancy educational centers represent a major potential due to their particular characteristics. As it has been found in some specific scenarios that younger persons with lower income are associated with a higher preference for carpooling (Correia, e Silva, & Viegas, 2010), students may be more susceptible to participate. Also the number of trips that is attracted to this kind of institutions is relevant since the number of carpooling travels has a quadratic relationship with the number of travels held (Dailey, Loseff, & Meyers, 1997).

In year 2010, a dynamic carpooling system was implemented in Universidad de los Andes. Its main purpose was to provide an alternative sustainable mode which could provide improved travel conditions to University students, faculty and staff. The present work aims to determine the effects of the implementation of a carpooling system in the transportation behavior of Universidad de los Andes community. This is done by evaluating the costs and benefits associated with the modal shift in order to determine if individual responses result in a socially adequate outcome. For this purpose, the response of people to a new transportation mode is analyzed with internet web based surveys implemented before and after the existence of the carpooling system. General attitudes and perceptions regarding transportation modes are evaluated as travel costs and revealed choices made in the last travel as well as declared preferences and attitudes. Valuation of parameters is differentiated between users and non-users before and after the carpooling system implementation. A difference between valuations of travel characteristics is expected between users and non-users as a response to the arousal of the new mode.

CONTEXT: MOBILITY IN THE UNIVERSITY AND THE CARPOOLING SYSTEM VIAJE

Universidad de los Andes is located in the central zone of Bogotá, the capital of Colombia. In year 2010, approximately 16,000 trips were generated each day to and from the University, 56% of them were made in public transport: 28% in traditional collective system and the

remaining 28% in Transmilenio, the local BRT system. According to the planning direction of the University, in that year the number of students, faculty and employees was of 13,700. The university´s population has shown a regular growth of around 3% every year. For the first semester of 2010, there were 15,700 daily trips to the University (Cruz Rodríguez, 2009). An important characteristic of the trips made to and from the University, is the distribution along the day. In year 2009, nearly 40% of the attracted trips arrived between 6:30 and 7:00 a.m., while nearly 20% of generated trips departed between 4:45 and 5:00 p.m.

The origin and destination of trips also tends to concentrate in certain zones of the city. With information of a survey made to a representative sample of students, faculty members and employees (N=756), Figure 1 was constructed. As can be seen, most of the trip destinations are located in the east north zone where the darker back color indicates a higher concentration of trips. It can also be seen that the modal share varies among zones of the city where some transportation modes seem to be more convenient. For example, as is expected, in the surroundings of the University (which is denoted by its logo) trips made by foot represent a bigger proportion. In a similar way, the trips made by taxi are concentrated in a relatively close zone. Spatial distribution of the trips made by car (as a driver) is particularly interesting for the present study. Since most of the car owners live in the north-eastern zone of the city relatively near the University, they may not serve as drivers of the passengers that live farther.

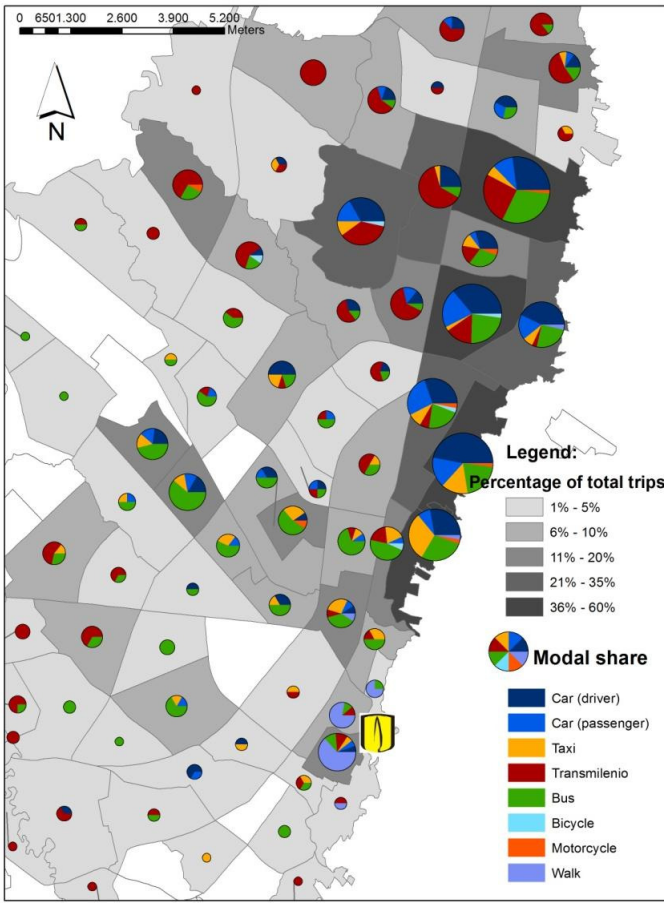

Figure 1. Spatial distribution and modal sharing of University sample

As a consequence of the increasing congestion problems of Bogotá, travel times of the trips to and from the University have increased in 14% between year 2010 and 2011. However, there is not a significant modal shift between these two periods for University members. There are important differences in travel times according to each mode. Public transport users are the ones that spend more time in transportation, spending almost 40% more time than private transport users.

In an attempt to improve the mobility to the University members and to promote the efficient use of the automobile, the idea to design and implement a carpooling website arose. The main objective of the website was to generate an alternative choice that could transport the University members in a safer and faster way while having a more efficient use of the private car. The carpooling website would be only available to members of the University. Figure 2 describes the way the carpooling system works.

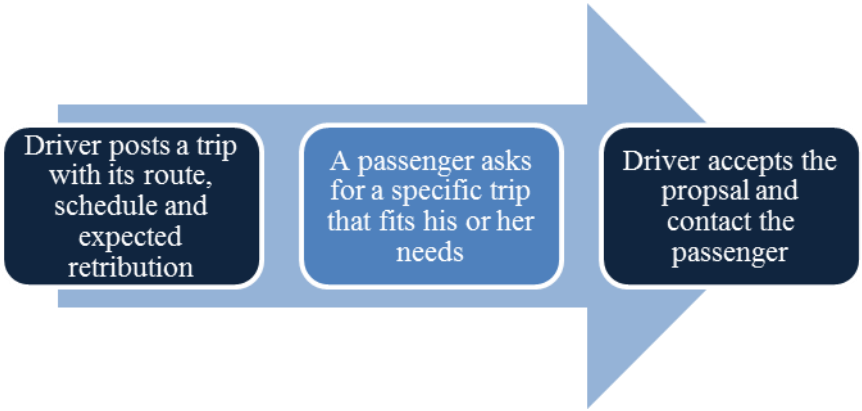

Figure 2. Carpooling website operation scheme

In October of 2010 the website was lunched and some students, faculty members and employees began to use website VIAJE. For the first two months of year 2011, the number of users is still limited and account for less than 1% of the total generated and attracted trips. In average there were 50.6 trips each day during the first two months of 2011. In the following sections, travel behavior will be examined in order to determine the reasons of the limited success that had the website during its first months.

INFORMATION

In order to determine the impact of the new system in mobility choices, three surveys were applied. The first one (N=756) was held before the carpooling website and contains information of individual socio-economic characteristics, information of the last trip made from and to the university (including travel time and origin/destination) and attitudes and perceptions regarding general transportation aspects and carpooling systems. For the specific case of car users, there is information of occupation rate and general monetary cost. Occupation rate was also inquired for taxi users. After the implementation of the system, two additional surveys were held, one was directed to a general representative sample of the University population (N=276) and the other one was directed specifically to carpooling users

(N=361). These surveys were designed to be comparable with the first one so they have similar questions. Schedule and general monetary costs were included as well as specific fuel and parking facility costs for car users.

FINDINGS

Before the implementation of the website, preferences and the willingness to use a carpooling system were analyzed. Most of the people showed interest in using a potential carpooling website; nearly all inquired persons (92%) said that they would use a carpooling web site to plan their daily trips. In order to have a better idea of the number of persons that would really participate in the system and the price they would effectively pay or demand, an experiment was done. Among the other survey questions, a part of the survey was destined to simulate a market. Individuals were inquired about the disposition to use the system and the price they would pay for a ride if they were passengers or the price they would ask for if they were drivers. This experiment was repeated later and a question about the number of seats each driver would offer was included. The results can be seen in Figure 3.

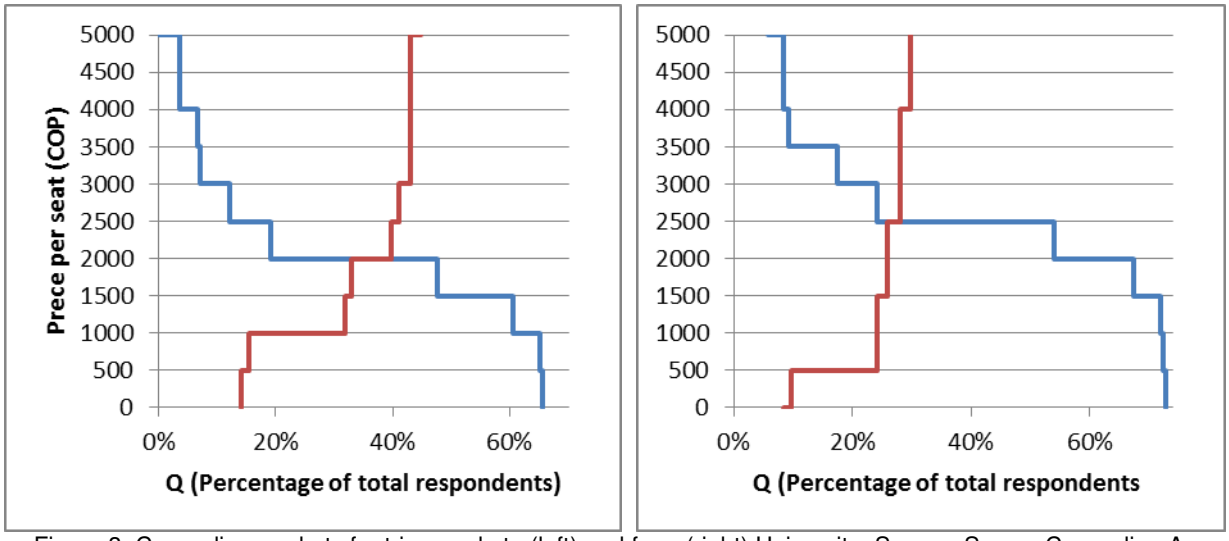

Figure 3. Carpooling markets for trips made to (left) and from (right) University. Source: Survey Carpooling A

The curves were constructed by taking into account the maximum amount of money that each passenger was disposed to spend on a trip, the minimum retribution that each car driver would expect to receive in order to offer a seat and the number of seats each driver would offer to his minimum price. The point where both curves intersect is the equilibrium and shows that the theoretical price for the trips to the University would be $2000, while in the trips from the University, the offer of trips fails as the demand raises which yield to a higher price and a lower number of trips.

In spite of the optimistic information declared by University members, as a result of the implementation of the carpooling website VIAJE, there has been a significant shift in transportation behavior only on a reduced group. Although 67% of respondents declared to know about the website, only 8% of them declared they had used it. During the first semester of year 2011, there were in average 520 visits per day. This shows that an important number

of visits were required in order to coordinate a trip. As a positive thing, the website received an average of 68 new users every month since its release day, which shows that the number of users of the system still has potential to grow. A possible explanation for the limited success of VIAJE website is that some trips may be arranged between frequent carpoolers that do not use it. In the survey made to carpoolers, almost 50% of them declared traveling with website users without arranging trips within the system.

In average, during the firsts two months of 2011, there were 72 carpoolers per day, 21 drivers and 51 passengers. The average price of the contribution was $1700 COP and cars had an average occupation of 3.0 passengers (counting the driver). This yields to an expected income of $6500 per trip for drivers. When compared to the ex-ante situation, where the low occupation rate (2.2 passengers per car) and the low retribution per passenger (200 COP), implied an insignificant income for drivers. The new retribution has made the car a lot cheaper than before, making it more competitive in terms of price compared with public transport modes. This has resulted in an increased number of drivers paying a substantially lower cost than before.

To analyze the individual benefits perceived by users, they were asked about the change in the number of days they used the car as drivers and as passengers because of the carpooling system incidence. Car users showed to be more reluctant to make any changes in the frequency they drove to the University. As 12% of them reported a decrease in the number of days they drove to the University while 8% of them increased the number of trips made by car. In the case of passengers, as was expected, an important fraction (32%) increased the number of days they used the car while 8% of them reported a reduction. Carpoolers were also inquired about the mode that they used more often before using the carpooling system. In Table 1 is shown the modal share declared for users of the website. It can be seen that most of the drivers did not made a modal shift, while most of the passengers come from the public transport. These shifts imply a small reduction in the number of cars traveling to the University and an important reduction in the number of trips made in public transport.

Table 1. Mode substituted by trips arranged in VIAJE website

	Car (driver)	Car (passenger)	Taxi	TM	Bus	Other
Drivers	46%	14%	4%	13%	19%	4%
Passengers	5%	12%	7%	30%	43%	3%

Source: Survey Carpooling C

The percentage of users that increased the use of car as passengers is substantially higher than the number of drivers that shifted to passengers. This means that most part of new passengers were pulled out from public transport. This has individual benefits in terms of travel time and comfort. However, most of the passengers (73%) declared that they have changed their schedules in order to ride a carpool, which is an additional cost that cannot be easily measured.

It can be seen that individuals that shift from almost every mode to any carpooling modality have important incentives in terms of money and time. The only exception are car users (as

passengers), who do not have incentives to make a modal shift to any carpooling scheme since in both cases it takes more time and it is more expensive.

In Table 2, there is a summary of the changes in monetary costs and travel times that an individual would perceive as a result of a modal shift to both carpooling modalities. The table was constructed by normalizing the travel times by the average distance of each mode. It can be seen that there are significant savings for car drivers and taxi users, who can save, in average, $9,600 and $7,100 COP respectively as a consequence of the modal shift to carpool passenger or $6,500 and $6,800 COP respectively as a consequence of the modal shift to carpool driver. For these users, the monetary savings are contrasted by the low savings in travel time. The small savings are attributed to the reduction in the waiting time for taxi users and the parking time for car drivers. In the other hand, the users of public transportation have an important reduction on travel time while they have a slight rise in the monetary cost. In the case of the people who originally used the car as passengers, the shift to any carpooling modality is not convenient in terms of cost and travel time. Without the carpooling scheme, these users did not pay a significant fare and had shorter travel times possibly because they were picked up in their destinations and dropped in the University.

Table 2. Monetary and time savings per trip as consequence of a modal shift to carpooling

	Shift to carpool passenger		Shift to carpool driver	
Initial mode	Time savings (min)	Monetary savings (COP)	Time savings (min)	Monetary savings (COP)
Car (driver)	6.8	550	0	6500
Car (passenger)	-4.4	-1400	-11	-1700
Taxi	2.8	7100	-2	6800
Transmilenio	16	0	8	-300
Bus	28	-300	23	-600

Source: Surveys Carpooling B & Carpooling C

In terms of general benefits, carpooling system implementation had positive net effects in travel times and monetary costs of University members. Regarding total per capita CO2 emissions, the carpooling involves a limited improvement. Results presented in Table 3, show monetary and time savings, desegregated according to transport mode used before carpooling system release. It can be seen that monetary savings come from carpoolers who used private transport before, while time savings arise as a consequence of the modal shift from public transportation. Additionally, there is a total reduction of 4% in the number of VIAJE website users that use the car as drivers. This yields to a total average reduction of one car traveling each day to the University. According to the CO2 emissions estimated in the Air Quality Management plan for Bogotá (Behrentz et al, 2010), as a consequence a reduction of 3.12Kg of CO2 per day which accounts for a reduction of 0.03% of the total CO2 emissions associated with transportation to and from the University.

Table 3.Total monetary and time savings per day as consequence of a modal shift to carpooling

	Car (driver)	Car (passenger)	Taxi	TM	Bus	TOTAL
Monetary savings (COP)	108704	-14419	30023	-4555	-14248	105505
Time Savings (min)	65	-80	-5	165	612	758
CO2 reduction (g)	444	329	1563	0	0	2313

It was intended to evaluate carpooling propensity by using a discrete choice model. However, when estimated this showed inconsistent results probably due to the impossibility to measure subjective factors that influence modal choice and the assumptions made regarding modes availability. Studies like the one from Kenyon & Lyons (2003) show the importance of the latest factor as people tend to ignore alternatives different from the one that is usually chosen.

In the surveys held, respondents were asked to score the factors that encourage the use of a carpooling system by assigning to a set of statements a score ranging between 1 and 5, where 1 stands for "not important" and 5 for "very important". Individuals declared the statements "*It contributes to improve the mobility in the city*", "*It contributes to reduce environmental impact*" and "*I have the chance to help others*" as the most important by scoring them with 4.2, 3.7 and 4.0 respectively. Results are aligned with the findings described by Walker (2011), who proved that individuals consider aspects such as environmental impacts and social influences in their modal choice. Besides, it was found that drivers who actually used the website valuated significantly more the fact that carpooling allows them to receive a monetary contribution, scoring this with 3.24, while non-users scored it with 2.46. This difference shows how monetary benefits do not encourage former drivers to share their cars, while it encourages other individuals to drive more.

To test the incidence of individual characteristics on modal choice, particularly in the use of the carpooling system, mean tests were done to evaluate statistically significant differences between users and non-users. It was found that the average age of carpoolers (21.3) was significantly higher than the one of non-users (25.2). Gender was not found to be statistically different for users and non-users. Regarding the level of income, carpoolers showed a significant lower income than other individuals. This is consistent with findings of Correia, de Abreu e Silva, & Viegas (2010). Car availability did not showed to be different between users and non-users. However, as expected, drivers that used the car have higher car availability at home. This result is consistent with the findings shown in Table 1 where it can be inferred that most of car drivers did not change their transportation mode.

Location of individuals directly impacts the probability of carpooling. Individuals that used the website live further than individuals that use the website as passengers. This phenomena yield to a spatial concentration of users in specific areas of the city, it suggests that most of the carpoolers are located between the path of most potential drivers and the University as may be seen in Figure 4.

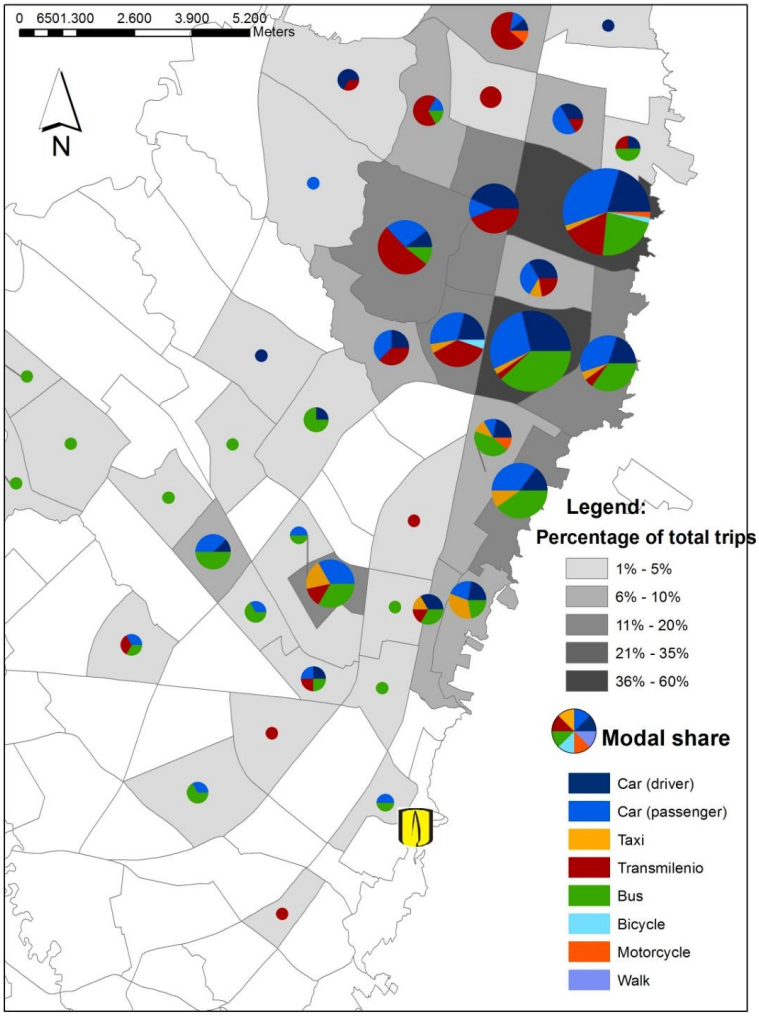

Figure 4. Carpooler's spatial distribution and modal share. *Source: Own*

CONCLUSIONS AND RECOMMENDATIONS

Carpooling systems have an important potential in high occupancy centers such as big companies and universities. It might be more efficient with a significant number of users; this will guarantee a wide offer of choices that might adapt better to individual characteristics of time and location. For this purpose, it is important to have a large number of potential users which can be reached with publicity campaigns. In part, the limited success of the system may be related to the difficulty that implies to internalize and consider a new transportation alternative as available. Additionally, people may be reluctant to share a car with strangers since this implies a privacy reduction as well as decreased flexibility of routes and schedules choices.

Socioeconomic characteristics such as income and home car availability influence the modal choice decision. Valuation parameters may vary between different populations. For this reason it is important to explore the impact of additional characteristics for other populations.

Spatial distribution of trips is a major determinant of a carpooling system usage. High income zones tend to concentrate the car trips origins and destinations. If these zones are close to the center where the system is implemented, then those car trips might not be functional for most individuals.

The carpooling scheme implemented in Universidad de los Andes has made the private transport more attractive compared to public transport. Carpool passengers might see a substantial decrease in their travel time. However, in order to use the system they might have to modify their schedule and increase the waiting time. A carpooling system is not likely to reduce the number of cars of a particular center. As a result of the congested and slow conditions that public transport users have, they are likely to pay an additional fare and make a change in their schedule to use a more comfortable, secure and reliable mode. Also, as the new option reduces the cost for drivers, those are likely to increase its use.

High occupancy employment centers have shown an increasing interest in carpooling schemes that may help reduce the need for parking space and improve the mobility conditions of their employees. The success of the carpooling implementation will depend on the transportation habits of the employees such as modal split, temporary and spatial distribution of the trips, travel costs and times as well as the willingness to use the system. This last item will depend on the publicity campaigns that are held to promote carpooling and to internalize the availability of a new mode.

REFERENCES

Acevedo, J., Bocarejo, J. P., Lleras, G. C., Echeverry, J. C., Ospina, G., & Rodríguez Valencia, Á. (2009). El Transporte como un soporte al desarrollo de Colombia: Una visión al 2040. Bogotá: Ediciones Uniandes.

Behrentz, E., Benavides, J. M., Bocarejo, J. P., Canal, M., Espinoza, M., Rodríguez, R., et al. (2010). Plan decenal de descontaminación de Bogotá (1 ed.). Bogotá: República de Colombia; Alcaldía Mayor de Bogotá: Secretaría Distrital de Ambiente (Sda).

Correia, G., & Viegas, J. (2011). Carpooling and carpool clubs: Clarifying concepts and assessing value enhancement possibilities through a Stated Preference web survey in Lisbon, Portugal. Transportation Research Part A 45 , 81-90.

Correia, G., de Abreu e Silva, J., & Viegas, J. (2010). Using latent attitudinal variables for measuring carpooling propensity. 12th WCTR. Lisbon, Portugal.

Cruz Rodríguez, M. N. (2009). Graduation Project: "Generación de Viajes por Centros Educativos en Bogotá". Bogotá D.C., Colombia: Universidad de los Andes.

Dailey, D. J., Loseff, D., & Meyers, D. (1999). Seattle smart traveler: dynamic ridematching on the World Wide Web. Transportation Research Part C 7 , 17-32.

Domencich, T. A., & McFadden, D. (1975). Urban travel demand: a behavioral analysis. Amsterdam: North-Holland Pub. Co.

Fellows, N. T., & Pitfield, D. E. (2000). An economic and operational evaluation of urban car-sharing. Transportation Research Part D 5, 1-10.

Hall, R. W., & Quresh, A. (1997). Dynamic Ride-Sharing: Theory and Practice. Journal of Transportatione Engineering Vol. 123, No 4.

Huang, H.-J., Yang, H., & Bell, M. G. (2000). The models and economics of carpools. The annals of regional science 34, 55-68.

Kenyon S., Lyons G. (2003), The value of integrated multimodal traveler information and its potential contribution to modal change, Transportation Research Part F 6

Levin, I. P. (1982). Measuring tradeoffs in carpool driving arrangement preferences. Transportation, 11, 71-85.

Morency, C. (2007). The ambivalence of ridesharing. Transportation 34, 239-254.

Oort, C. (1969). The evaluation of travelling time. Journal of Transport Economics and Policy Vol. 3, No. 3, 279-286.

Scorcia Tenjo, Y. S. (2008). Previsión de la Evolución de las Características del Parque Automotor en Bogotá. Bogotá D.C., Colombia: Universidad de los Andes.

Train, K. E. (2007). Discrete Choice Models with Simulation. New York: Cambridge University Press.

Walker, J. L., (2011), Beyond Rationality in Travel Demand Models, Access 39, 8-15.

Xin, W., Zhu, S., Wang, H., Yan, Y., & Xiong, J. (2009). Analyzing Early Market Potential and Strategies for Carpooling in China: A Case Study of Wuhan. International Conference on Management and Service Science, 2009. MASS '09, 1 - 4.