HETEROGENEITY OF SOCIAL CLASSES AND JOB ACCESSIBILITY: IMPLICATIONS OF TRANSPORT POLICIES IN BOGOTA

WORK IN PROGRESS

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Abstract

Several researches have been done about transport in Bogotá (Colombia) but no one has treated the impact of the transport network on the configuration of employment in the city. Improvement of public transport system like Transmilenio supposes to be beneficial to every people in the city. However, a part of inhabitants could benefit of the improvement. The aim of this research is to demonstrate that improvements of public transport are not necessary synonymous of benefits to every social classes moreover if we talk about a city with a big heterogeneity of social classes. The definition of the effective size of labor market in the city is necessary to sheds light on the relation of transport accessibility and social classes within different zones in Bogotá. We will support our study on the existing literature about the effective size of labor market. Results will give us enough tools to know if enhancement of public transport system has a direct effect on type of jobs or social classes of different zones of Bogotá. Can enhancements of public transports determine the level social inclusion of a city like Bogota?

JEL Codes: R 12, R23, R40, J68, J44
Keywords: Accessibility; Effective size of labor market; urban public transport; Social classes

I. Introduction

Throughout last twenty years the question of urban transport policies makes part of the core of socio-economic debates on developing and developed countries. In fact, the lack of regulation of public and private urban transport, the increasing number of private cars' owners, the increasing of population and hence the raise of density on cities traduced on a rising of commuting time and travel distance among a multiplicity of other reasons, are on the origin of the "sprawl" of cities (Glaeser E., 2003).

The capital of Colombia, Bogotá, is not the exception. In the last three decades, it suffered a big increase of its density and its territory[1]. Since this big expansion of population and area and in addition to the absence of an effective urban transport system and appropriate regulation policies, Bogota fell into a mobility chaos at the end of nineties.

Thenceforth, the city was managed by mayors who gave a main importance to mobility and accessibility problems. Actually, the core of their plan of government was the planning and the implementation of a suitable transportation system for the city. Between 1998 and 2000, public managers decided to plan and to construct a Bus Rapid Transit System (BRT) called Transmilenio which was rapidly recognize as one of the most successful BRT system in the world.

First phase of the system began operations on December 2000 counting 42 km of exclusive lanes for articulated buses. Seven years later (2007), whole of the two first phases of Transmilenio were in operation. They count 84 km of exclusive corridors for 1080 articulated buses, 114 stations with an off-board fare collection and seven terminals connected with inter-urban transport system. Third phase is planned to be finished in may 2012 and it will count 36,3 km more of new corridors and entirely Transmilenio system is expected to have 388 km of exclusive corridors covering 80% of the daily transit trips in the city.

Several studies [2] explain the different reasons to consider Transmilenio as the most successful BRT system in the world. Indeed, gains of commuting time were remarkable passing from 1h30 to 30 minutes (66% of gain of time) in addition to the increasing of the average speed of travels of public buses. While the average speed of Transmilenio is 25 km/h (similar than a metro system average speed), average speed of public service buses is 15 km/h.

Nevertheless, even if gains of travel time and speed continue to be important factors to take in consideration on transport policies, characteristics such affordability to public transport

[1] Se supone que tengo datos que demuestran la progresión
[2] Acá cito algunos trabajos de Transmilenio que muestren todos sus beneficios

system (PTS), accessibility to and of PTS and their impact on employment and hence, on productivity of the city, have been having more relevance on last twenty years.

Literature regarding accessibility "to" and "of" urban transport system is very vast. Some of researchers on accessibility focused their studies on "time accessibility" or "gravity accessibility" (Hansen 59, Wilson 70, Wachs 73 and Koenig 74). This branch of theory focuses on the reduction of travel time and commuting costs (involving direct and indirect cost as cost of time, cost of trip, etc). It suggests that the less the travel time is, the less global cost is and the better the accessibility is. Thus, the productivity of inhabitants will be higher. Theorists and policy makers evoked two kinds of solutions: increase the speed of trips or reduce the distance of travels.

To increase the speed, some authors and policy makers (see Bar,r 2000; Cervero, 1997; Cervero, 2002 a,c) construction or extension of ways and highways and hence, the use of cars can be look upon as solutions (Glaeser 2004, Sheickman and Glaeser 99, Anas 99, Fujita 2001)[3], so commuting time and commuting cost will be slighter. But, what researchers observed the tradeoff between speed and distance between houses and jobs. In fact, with those improvements of infrastructure, individuals realized the possibility of living more far from their jobs in order to live in bigger houses and thus, take the same time to go from their houses to their jobs. In other words, they "give up" commuting time per distance in order to have more space or amenities in their living zone. But, the only way to have the same commuting time living in zones of the city with no presence of public transports is to have private cars.

Nonetheless, the limited space and budget of cities to improve infrastructure networks in addition to the exponential use of cars reveal limitations of this kind of strategy. Traffic jams and hence increasing of commuting time and loose of productivity show that this kind of policies was not the better ones to solve accessibility and mobility problems.

For these reasons, according to several researchers (Duranton – Puga 2003, Glaeser, 2001?), the other way to reduce commuting time that people expend on each trip is the "densification" of some zones of cities. As results of "densification", we can observe learning and matching effects (Puga-Duranton, 2003) which will be traduced on economies of agglomeration and reductions of the distance between houses and jobs.

Proximity between houses and work places is strongly suitable because, the nearer inhabitants are to their jobs, the less time they will expend in transports and by consequence they will be more efficient. In addition, it will have some other positives effects like a reduction of the use of cars and hence, a reduction of traffic jams, reductions of smog and all kind of negative externalities.

[3] Those studies talk about the "Sprawl process" of cities since decades ago and show how policies encouraged the car use.

Bringing closer inhabitants and their jobs seems to be the better solution but this zoning have also as consequence a cost increasing[4] of formal housing, thus, a non desirable effect as the restriction of inhabitants to move to those zones (in parallel of an unwanted consequences as squatting), (Duranton 2008). So, people should be push to live near their jobs but even if a geographical densification is suitable it is not at a hundred per cent affordable because of high costs (Brueckner and Selod, 2008).

For those reasons, policy makers and researchers think that the better solution to deal with, is to mix densification and reduction of commuting time with an improvement of public transport system. Enhancement of accessibility to a bigger proportion of inhabitants by the use of an "efficient" public transport system and not like before, by the incentive of the use of car, seems to be useful. Jobs and houses are getting closer which supposes to have a higher productivity and less commuting costs. Apparently, policy makers and researchers found the recipe to enhance accessibility to everybody in cities, or at less, this is what theory and some empirical studies say.

Urban mobility depends more frequently on public transport system. Most people use PTS to travel within the city from their houses to their jobs. Statistics of planning department of cities confirm that is often more advantageous to take bus (BRT) or metro in spite of private car. The encouragement of the use of private cars is rapidly decreasing as the result of the enhancement of PTS.

II. Research question

Accessibility of inhabitants was a relative success of transport policies in Bogotá. As we say beyond, after the construction of Transmilenio, time of travels between houses and jobs decreased in the city. With improvements of PTS travel time had decrease in an important degree, thus people are closer to their jobs from their houses.

In addition, they also have more opportunities to reach more jobs. In fact, following some researchers (Prud'homme and Lee, 1999), the "Effective Size of Labour Market" (ESLM), which is the average number of jobs reachable in a specific interval of time, will be higher with the enhancement of PTS; probability to find a job can rise with this kind of policies. But the question of this kind of policies is not only to get closer people to jobs but also to get people closer to the type of jobs they are trained to do. It does not have the same interest to connect a neighbourhood of working-class to a zone of the city specialized in financial services for example.

Some studies about Paris show that, even in this city, some transport policies were more useful for managers than for workers. Indeed, managers have a higher range of jobs to

[4] Sometimes artificially

access than workers, even if both live in the same zone (Selod et alii, 2004; Wenglenski 2005, 2006). Thus, the effective size of labor market of managers is bigger than the one of workers which could be clearly a flaw of favoritism or exclusion of public policies. This fact has as consequence a division and a possible segregation that can entail a reduction of social interactions which should be avoidable from the economic and social point of view. (Glaeser and Scheinkman, 1999; Brueckner, 2003).

As Wenglenski had illustrated with the Parisian case, (Wenglenski, 2006) probability to reach jobs is not the same to every workers' profile. In effect, people belonging highest class (executives, managers) seem to receive more benefits from Parisian PTS policies than people who belong to lowest class (unskilled workers).

It is interesting to wonder if people belonging to different social classes in Bogotá, are taking advantage in the same proportion of the improvement of accessibility provided by Transmilenio. This paper gives us different tools to know if PTS policies of Bogotá are giving to people who belong to a specific social class, the same level of possibilities to reach a job of their skills. If is not the case, we tend to know how transport policies could have an influence on this statement.

III. Research methodology

To take up the subject and to analyse the research question, we must, in a first time, estimate the Effective Size of Labour Market in Bogotá as Prud'homme and Lee (1999) recommend. After having the *ESLM* of the city of Bogotá for some intervals of time, we will suggest an approach of the accessibility of each social class[5] on different zones of the city.

Effective Size of Labor Market (ESLM) approach:

To estimate the effective size of labor market in Bogotá we follow the methodology suggested by Prud'homme and Lee (1999). This theory is based on the assertion that labor market is in function of travel time and zones where employees live and work. The goal of this approach is to know how many jobs are reachable by workers in a specific time from their houses to their jobs. Commuting time intervals we used are 10 minutes to 120 minutes.

To have a background of this approach, we will merely describe it as authors did on their article[6].

The data base we have, take into account 824 different tracts of Bogotá which at their turn, make part of 112 "Zones of planning (UPZ)[7]. It give us n=112 zones of study.

[5] Social classes in this study will be 3: Lowest, medium and highest.
[6] We take same expressions than the authors.

E_{k_i} Number of employees with *k* type of job located in zone *i* so $\sum_i E_{k_i} = E$ will denote the total of employees in the city. J_{kj} number of *k* type of jobs placed on zone *j* so $\sum_j J_{k_j} = J$ is the total of jobs in zone *j*. Finally, T_{ij} is the average time to reach zone *j* from zone *i*, so $i = j = 112$.

For a given zone *i* the ESLM for workers of zone *i* will be:

$$\boxed{L_i(t) = \sum J_{k_j}}$$

for such that $T_{ij} \leq t$ the commuting time to reach *j* from *i* (T_{ij}) have to be equal or less than *t*, the temporal constraint.

For the city ESLM will be:

$$\boxed{L(t) = \frac{\sum L_i(t) * E_i}{E} = \frac{\sum_1^n \sum_j J_{k_j} * E_i}{E}}$$

It represents the weighted average of the effective labour size of all zones with respect to the number of employees who live in the city.

IV. Analysis of data

Bogotá is a very big city composed by 20 sub city urban areas[8] divided at their turn in 112 planning zones[9]. Density in Bogotá is approximately 230 people/ha[10], (one of the densest city in South America) and heterogeneity of social classes is sometimes really appreciable. The city is divided into six socioeconomic strata from stratum one, the lowest socioeconomic level, to stratum six, the highest level. Strata 3 and 4 often represent middle class.

Data Base

To understand trips' behavior, public administration decided to make the most detailed mobility survey ever made in the city[11]. The data base used for our study was obtained from this survey. It has information about several variables regarding mobility of inhabitants: distance of trips, commuting time, social classes of users, type of job of users and starting and destination points within each 112 zones of the city, can be found in this poll.

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[7] See page 1 subsection 1.1 of this paper.
[8] 19 urban and one rural
[9] *UPZ* in Spanish *Unidades de Planeamiento Zonal* we will use *UPZ* denomination herein.
[10] Adapting from Suarez,2005.
[11] Mobility Survey 2005 or "Plan Maestro de Movilidad 2005: Encuesta de Movilidad 2005", in Spanish. Secretaria de Movilidad del Distrito.

Results from this survey were really satisfactory to the city. More than 84.000 persons were asked about their travels or about the time they took to go to their destinations.

Nevertheless, even if this last study is the most detailed mobility survey ever made before in the city, it still been a survey. The study is completed by the transport matrix of the city which gives us the time estimation of every travel within the city. In effect, the matrix of transport of Bogotá has information about commuting time between every zones of the city (every possible itinerary between UPZ).

In addition to this information[12] we consider that we have to take in consideration some socio-economic data of zones in order to have better results. In 2007 the administration made another survey in the city[13] with the aim to have some information about the quality of life of "bogotanians". This survey takes into account some socio-economic data like socioeconomic level of inhabitants of each UPZ, number of unemployment people on each zone, number of cars by households among other variables. It is very interesting to consider these variables in our study analysis especially if we are looking to have a greater socio-economic framework of UPZ.

After having those data we will be able to make a finer analysis to answer to our research question.

Tables 1 and 2 show us variables which are taken in consideration in that study.

Table 1: Variables taken in consideration in the poll 2005

UPZ of origine	UPZ of destination	Reason of the trip	Type of vehicle or transport used to travel from O-D	Principal activity of the person	Type of job of the persone which principal activity is to work	Socio-economic class	Calculated time
1	1	1. Return to the house	1. Foot	1. Study	1. Worker or employee	1	1. Time of walk to reach the station
2	2	2.Work	2. Bycicle	2. Job	2. Housework employee	2	2. Time of wait into the station
.	.	3.Study	3. Motorcycle	3. House' job	3. Independent worker	3	3. Time into the vehicle
.	.	4.Business	4. Private car as driver	4. Retired	4. Manager or owner	4	
.	.	5.Shopping	5. Private car as passenger	5. Person of Independent	5. Household worker without salary	5	
.	.	6.Personal business	6. Taxi	6. Searching job	6. Other	6	
.	.	7.Change of bus	7. Transmilenio	7. Cannot work			
.	.	8.Other	8. Bus (transmilenio)	8. Other			
.	.		9. Bus				
.	.		10. Microbus				
112	112		11. Other				

Source: Encuesta de Movilidad 2005

As we can see in table 1, this survey took in consideration many of variables like the reason of the trip, the type vehicle used to commute, the principal activity of people, the socio-economic class or the principal activity of the person interviewed among many others. Table 2 point up descriptive statistics of the poll.

[12] Mobility Survey 2005 and Transport Matrix of Bogotá.

[13] Encuesta de Calidad de Vida para Bogotá (ECV) 2007. Secretaria de Planeación del Distrito de Bogotá. "*Survey of quality of life for Bogotá"*

Table 2: Descriptive statistics according to the type of job of the people which the reason of the trip is to work

Type of job	Time	Mean	Maximum	Minimum	Standar deviation
Worker of employee	Time of walk	4,37	55	0	4,86
	Time of wait	6,99	105	0	7,64
	Time into the vehicle	58,23	1010	1	39,98
Housework employee (cleaning, driver,…)	Time of walk	4,78	62	0	4,865
	Time of wait	7,88	80	0	7,64
	Time into the vehicle	62,31	600	1	39,98
Independent worker	Time of walk	3,36	123	0	4,86
	Time of wait	5,51	93	0	7,64
	Time into the vehicle	52,93	910	1	39,98
Manager or owner	Time of walk	1,63	70	0	4,86
	Time of wait	2,28	90	0	7,64
	Time into the vehicle	40,97	240	5	39,98
Household worker without salary	Time of walk	2,81	10	0	4,86
	Time of wait	3,5	20	0	7,64
	Time into the vehicle	46,31	120	10	39,98
Other	Time of walk	3,01	95	0	4,86
	Time of wait	4,69	91	0	7,64
	Time into the vehicle	45,98	900	1	39,98

Source: Author calculus from "Encuesta de Movilidad 2005"

Among people which the reason of the trip is to work, we can observe that commuting times differ between people with different kinds of job. As expected, managers and owners are those who take less time to commute, to wait and to walk to the next station where they take the vehicle. In opposition, we see that unskilled workers, employees and housework employees are those who take more time to reach their destinations.

Even if the sample is not negligible (84.000 interviewed) it has to be completed. To do that, we use the Transport Matrix of Bogotá[14]. This matrix encloses information about all possible itineraries "from" and "to" every 112[15] zones of the city. This matrix is divided in 824 zones of transport of Bogota. It gives us a matrix with 678976 itineraries which at their turn make part of whole UPZ so, we will resume data of the transport matrix in 112 UPZ in order to have just 12432 itineraries.

The transport matrix have also information about the time they stay on stations waiting for public buses or even the time people spent walking from their houses or jobs to the nearest station and the socio-economic classification of users.

[14] Secretaria de Movilidad del Distrito and University of Los Andes (Bogota) we obtained this information.

[15] To ensure homogeneity of data between UPZ and because we do not have the entirely socio economic information of 112 UPZ, we have to exclude 5 UPZ from the analysis. This paper will take into account data from 107 UPZ.

According to socio-economic class of people that the reason of the trip is to work, we observe that people who represent the lowest socio-economic (stratum 1 and 2), take more time to walk to the next station in comparison to people of other socio-economic strata (table 3)[16].

Table 3: Descriptive statistics according to the socio-economic class of people which the reason of the trip is to work

		Total			
Socio-Economic Class	**Time**	**Mean**	**Maximum**	**Minimum**	**Standar Deviation**
Lowest level (stratus 1-2)	Time of walk	16,46	52,62	7,71	5,77
	Time of wait	2,5	8,05	1,73	0,7
	Time into the vehicle	42,94	63,98	28,59	8,89
Medium level (stratus 3-4)	Time of walk	13,02	41,12	7,1	3,96
	Time of wait	1,71	6,25	1,18	0,5
	Time into the vehicle	41,62	62,74	27,94	8,53
Highest level (stratus 5-6)	Time of walk	11,68	36,23	6,87	3,32
	Time of wait	1,48	2,47	1,08	0,23
	Time into the vehicle	40,95	62,61	27,64	8,32

Source: Author calculus from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogota

Actually, people of highest socio-economic strata take less time (14.4%) and even fewer, to commute within the city (table 3 and 4)[17]. Equally, those differences are also revealed between medium and lowest class (9.85%). But highest differences are showed on time spent to walk to the next station or to wait the vehicle. Differences, even if they are not really significant in the total of the commuting time, are substantial between them. For example we see that people of lowest socio-economic strata take 40.92% more of time to reach the nearest station than people of highest strata. Concerning the time to wait the vehicle, people of lowest class spent 68.92% more of time than people of highest class and 46.20% more than people of medium class. Differences of time between people of highest class and medium class are also important but not so highly (table 4).

Table 4: Differences of times between socio-economic classes

Time	Hi-low	Med-low	Hi-Med
Walk	40,92%	26,42%	11,47%
Wait	68,92%	46,20%	15,54%
Into	4,86%	3,17%	1,64%
Total	14,40%	9,85%	4,14%

Source: Author calculus from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogota

[16] Graph of this table is on annex 1

[17] Three kinds of times comprise: Time of walk, Time of wait and Time into the vehicle.

V. Results

To make easier the analysis of travels, I suggest in this paper a grouping of some zones. I take in consideration the most important "employment centers" of the city. I suggest those "sub-centers" because of the number of people working on and around these zones and also according to the zones with greater dynamism we perceive in the city. I defined three different sub-centers which are, at their turn, composed by a number of UPZ. One of those centers is the zone known as "The Center" of the city which is not the geographical center but the historical and the administrative center of the city with the majority of national and regional bureau. This sub- center, "Center", is composed by 12 UPZ of the city[18]. The second sub-center, "zone 72"[19], encloses five UPZ and is defined as the financial sub center which is at 8 kilometers from the historical center. The third sub-center, "zone 116"[20], encloses six UPZ and is defined as the commercial sub-center which is located at 14 kilometers from "center" and at six kilometers from "zone 72". The rest of UPZ (84) are called "rest" in our analysis.

Every sub-center is served by the same kind of public services, specially, by public transport systems. We give a particular attention to the fact that each sub-center is served by Transmilenio in similar proportions.

In Bogotá, more than 3,2 millions of travels have as cause to work. More than half of all trips (59,9%) are by public transport and 41,1% of trips are by private vehicles. Among the three sub-centers, the "center" is the one who group more trips than the other two ones (10.5% of the total of trips of the city. 6.3% and 3.2 % for "zone 72" and "zone 116" respectively). We observe that 2/3 parts of trips in "center "and "zone 116" are by private vehicles. On the other hand, almost half of trips in "zone 72" are done in public vehicles. It less us that modal choice can be heterogenic among sub-centers and UPZ of the city.

Table 5 - Number of trips with "work" as the reason of the travels by sub-center

Zone of the city	Number of trips		By type of transport mode			
	Total	%	PT	%	CO	%
Center	337 970	10,5%	131 155	38,8%	206 815	61,2%
72	204 382	6,3%	109 375	53,5%	95 007	46,5%
116	102 401	3,2%	35 220	34,4%	67 180	65,6%
Rest	2 586 547	80,0%	1 658 627	64,1%	927 921	35,9%
Bogota	3 231 300	100,0%	1 934 377	59,9%	1 296 923	40,1%

Source: Author calculus from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogota

[18] Sub-center "center" is composed by 12 UPZ : Britalia, Sosiego, Ciudad Jardín, Santa Isabel, Restrepo, Sagrado Corazón, La Macarena, Las Nieves, La Candelaria, Las Cruces, Lourdes, Teusaquillo

[19] Sub center "center-north" is composed by 5 UPZ: Pardo Rubio, Chicó Lago, Los Alcazares, Chapinero, Galerias

[20] Sub-center « north » is composed by 6 UPZ : Usaquén, Country Club, Santa Bárbara, La Alhambra, Los Andes El Refugio

The attraction and the generation of trips from and to sub-centers display us differences between them. In effect, we see that 6.8% of the total trips attracted in Bogotá (trips to a sub-center) corresponds to "center", 5.7% corresponds to "zone 72" and 1.8% to "zone 116". But what is also interesting to see is that these sub-centers generate more trips than they attract. In effect, "center" generates 15.9% of trip generated in Bogotá which represents 57.7% more of trips that it attracts. "Zone 116" generates 5.2% of trips generated in the city (90.7% more of trip than it attracts). In contrast, "Zone 72" attracted more trips than it generates as well as the majority of trips attracted are by private vehicles (84%). Most of trips attracted and generated from and to "center" are made in public transport system, (2/3 parts of trips) but a third part of trips attracted to "zone 116" are made in public transportation which suppose that the rest is made in private vehicles. It lets us suggest that 2/3 of people working and living in "center" use public transportation. In opposition, 84% of people who work in "zone 72", use private transportation and 96.7% of trips of people who live and do not work in "zone 72", use public transportation to reach their jobs. Finally, 2/3 parts of trips attracted by "zone 116", (people who work in "zone 116") use their cars to go to their jobs; 2/3 parts of people living in that zone but working in another one, use public transportation to get to their jobs.

The rest of the zones of the city represented by "Rest" attract more trips that they generate (85% attracted – 71.5% generated) and more than 4/5 parts of trips are made in public transportation.

Table 6: Distribution of number of trips generated and attracted by transportation by sub-center

	Zone	Total	%	PT	%	CO	%
Trips atracted	Center	131 155	6,8%	96 705	73,7%	34 451	26,3%
	72	109 375	5,7%	17 488	16,0%	91 887	84,0%
	116	35 220	1,8%	12 909	36,7%	22 311	63,3%
	Rest	1 658 627	85,7%	1 318 957	79,5%	339 670	20,5%
Trips generated	Center	206 815	15,9%	161 763	78,2%	45 052	21,8%
	72	95 007	7,3%	91 887	96,7%	3 121	3,3%
	116	67 180	5,2%	42 048	62,6%	25 132	37,4%
	Rest	927 921	71,5%	733 540	79,1%	194 381	20,9%

Source: Author calculus from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogota

Concerning the distance traveled by people between their homes and their jobs, we observe that, people living or working in "center" travel fewer distances than people living or working at another sub-center (table 7). We can suggest that there is a bigger willingness to be closer to "center". It can confirm that be closer the zone considered as "the center" of the city where is located the historical and the administrative center, may be more advantageous for workers. In opposition, we can observe that the distances people must travel to go to "Zone 116" are longer than other. In fact, it can be related to the fact that 84% and 63% of trips attracted by "zone 72" and "zone 116" are made in private vehicles which allow people to travel longer distances. In opposition, most of trips generated on every zone are made in public transports.

Table 7: Mean distance of trips by sub-center

Sub-center	Mean Distance of trips (km)	Standar Deviation (km)
Center	7,7	5,5
72	8,8	5,6
116	10,7	6,5
Rest	8,7	6,2

Source: Author calculus from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogota

As it was suggest by some theorist (Wenglenski, 2006; Crozet, 2009), most of the trips of executive managers or managerial staff of a city are made in private vehicles. We can suppose that these results can give us a sign of jobs and type of employees on each zone.

Having information of all kind of jobs placed on each sub-center may be the most desirable but because of lack of accurate information we opted to do an analysis with respect to social classes in order to have a better estimation of the influence of transport policies in Bogota on effective size of labor market.

Employment framework and analysis of the effective size of labor market

Bogota is a city where a third part of the population has a formal job. Two parts of the population in age to work is underemployment or unemployment. As comprehensible, there are not truthful data of underemployment market. But, even if those data are not available, it does not challenge our results focusing our approach on social classes and formal labor market in the city.

Data from planning office of the city hall and from chamber of commerce of Bogotá show us that "center" attracts 12.6% of formal jobs of the city and contain 14.5% of the workforce. "Zone 72" and "zone 116" have 17% and 8.3% of formal jobs respectively and 13.3% and 8.9% of workforce of the city.

Table 8: Workforce and number of jobs by sub-center

Sub-center	Number formal jobs	%	Workforce	%
Center	188082	12,6%	437795	14,5%
72	253916	17,0%	403891	13,3%
116	124851	8,3%	269424	8,9%
Rest	930888	62,2%	1914483	63,3%
Total	1497737	100,0%	3025593	100,0%

Source: Author calculus from Secretaria de Planeación del Distrito de Bogotá. "*Survey of quality of life for Bogotá 2007*"

The rest of zones ("rest") have similar part of formal jobs and workforce .

As we have said before, every sub-center has direct connection with Transmilenio (TM) but each sub-center is composed by several UPZ. Each UPZ, make part of sub-centers but does not have direct access to TM.

Tables 9 and 10 shows the level of concentration of jobs and workforce on UPZ with direct access to TM:

- 10.6% of formal jobs are directly connected to TM and make part of "center". Only 2% of formal jobs of the city which represents 15.9% of formal jobs of "center" sub-center", do not have direct connection to TM.
- 16.4% of formal jobs are directly connected to TM and make part of "zone 72". No more than 0.6% of formal jobs of the city which represents 3.4% of formal jobs of "zone 72" sub-center", do not have direct connection to TM.
- 5.5% of formal jobs are directly connected to TM and make part of "zone 116". But 2.8% of formal jobs of the city which represents 34.2% of formal jobs of "center" sub-center", do not have direct connection to TM.

Table 9: Jobs and direct access to TM by sub-center

Sub-center	Number of jobs in UPZ with direct acces to TM	%	Number of jobs in UPZ without direct acces to TM	%
Center	158 186	10,6%	29 896	2,0%
72	245 209	16,4%	8 707	0,6%
116	82 192	5,5%	42 659	2,8%
Rest	595 440	39,8%	335 448	22,4%
Total	1 081 027	72,2%	416 710	27,8%

Source: Author calculus from Secretaria de Planeación del Distrito de Bogotá. "*Survey of quality of life for Bogotá 2007*"

Table 10: Workforce and direct access to TM by sub-center

Sub-center	Workforce in UPZ with direct acces to TM	%	Workforce in UPZ without direct acces to TM	%
Center	333 938	11,0%	103 857	3,4%
72	388 438	12,8%	15 453	0,5%
116	179 433	5,9%	89 991	3,0%
Rest	1 427 149	47,2%	487 333	16,1%
Total	2 328 958	77,0%	696 635	23,0%

Source: Author calculus from Secretaria de Planeación del Distrito de Bogotá. "*Survey of quality of life for Bogotá 2007*"

Likewise the concentration of jobs, the level of concentration of workforce on UPZ with and without direct access to TM is rather identical. It gives us a framework of employment in Bogotá.

Unfortunately, we do not have detailed data of the number of kinds of jobs and underemployment on each UPZ and it do not allow us to make a complete study of the effective size of labor market in Bogotá. Results can be minimized but we suppose that our approach will reflect the reality of the labor market in the city. We will suppose that, even if we do not have data for underemployment it has the same behavior than the formal employment market.

To obtain a more accurate answer to our research question, the estimation of the effective size of labor market (*ESLM*) was performed for population belonging to each social-class. To

realize if improvements of PTS represent an advantage in terms of *ESLM,* we took into account the direct access of each UPZ to TM.

The analysis of *ESLM* undertaken on this paper took into account three scenarios depending to possible connections between UPZs where TM skirt or pass within those zones, and UPZ that do not have any connection to TM. As result, we have three possible scenarios:

- Travel from a UPZ with direct connection to TM to another UPZ with direct connection to TM.
- Travels from a UPZ without any connection to TM to another UPZ without any connection to TM.
- Travels from UPZ with direct connection to TM to another UPZ without any connection to TM and reciprocally.

Besides those possible combinations of connections between UPZ, we had also made a distinction of *ESLM* with respect to the kind of transportation used by inhabitants. We calculate the fraction of jobs accessible to inhabitants belonging to a social class with respect to the kind of transport system used (public or private). Results revealed interesting information.

a- Travel from a UPZ with direct connection to TM to another UPZ with direct connection to TM.

As table 11 shows, people commuting on public transports and living in a low-income UPZ with direct connection to TM, have access to 22.93% of jobs of the city. Besides, when UPZ have direct access to TM, people who belong to strata 3 and 4 (medium class) have access 28.98% of jobs of the city (26.4% more than people of lowest class) in the same gap of time. Finally, when people commute on public transports and live in UPZs of highest class where TM passes through or surrounds them, they can reach 29.83% of jobs of the city in thirty minutes (2.93% more than people of middle class and 30% more than people of lowest class).

With an interval of time of thirty minutes we denote that, when people use public transports to reach their jobs from UPZ where there is a presence of TM with direction to a UPZ where TM pass, richest people have accessibility to 30% more of jobs than people with lowest income of the city. Differences are bigger when people would like to reach their jobs in 20 minutes. In effects, while rich people have access to 11.3% of jobs in twenty minutes of travel, poor people have access to 0.8% of jobs. Disparity decrease when commuting time increase. When commuting time is sixty minutes, the difference between the number of jobs reachable in this time between rich people and people of low income ranges 17.5%.

We denote the same characteristic when travels are made in private cars.

Table 11: Effective size of labour market for people travelling in Public Transports when both UPZ have a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	0,00%	0,80%	22,93%	43,28%	58,63%	71,42%
Medium level (stratus 3-4)	0,00%	9,49%	28,98%	46,05%	63,44%	79,00%
Highest level (stratus 5-6)	0,00%	11,31%	29,83%	49,25%	68,20%	83,82%

Source: Author calculus

Table 12: Effective size of labour market for people travelling in private vehicles when both UPZ have a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	4,61%	29,20%	53,58%	75,88%	89,98%	96,54%
Medium level (stratus 3-4)	9,30%	30,71%	56,19%	77,97%	91,56%	97,16%
Highest level (stratus 5-6)	9,93%	32,03%	57,17%	79,41%	92,03%	97,63%

Source: Author calculus

In effect, when travels are made in private cars between two UPZ with direct TM, people belonging to lowest classes have access to 29.20% of jobs of the city in twenty minutes while the number of jobs of people belonging to middle class and high class is 30.71% and 32.03% respectively (table 12). Difference of accessibility between high class and low class when trip are made in private cars is 9.7%. When commuting time increase, the difference of the size of labor market between people belonging to different social classes decrease.

Our results suggest that in sixty minutes, even people of lowest social class have accessibility to almost the totality of jobs of the city when people use private cars to reach their jobs. In the other hand, when people use public transport they can reach 70% to 84% of whole jobs of the city.

Commuting times between UPZ were taken from transport matrix of Bogotá but we thought that these proportions are higher than they are perceived by inhabitants. We taught results could change concerning the number of jobs on each UPZ. In fact, we have to remember that not all jobs were considered in that study. We are focusing only on formal labor market and we are not taking into account the informal labor market which represents almost 50% of employment of the city. But, even if we do not have those data, the goal of the paper still been achieves; differences of benefits between social classes from enhancement of transport policies like Transmilenio have been exposed.

b- Travels from a UPZ without any connection to TM to another UPZ without any connection to TM.

As expected, accessibility to jobs to people living and working on UPZ where TM does not traverse and does not pass even on their boundaries, is fewer for commuting times going from thirty minutes to sixty minutes (table 13). Differences of number of jobs reachable between social classes are also less important than in the previous section. (22.38% more of jobs accessible to people of highest classes with respect to jobs reachable by people of lowest social level for a commuting time of thirty minutes and using public transports).

Table 13: Effective size of labour market for people travelling in public vehicles when both UPZ do not have a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	0,26%	2,45%	19,97%	31,26%	46,16%	64,23%
Medium level (stratus 3-4)	0,26%	8,91%	23,25%	32,78%	48,32%	68,64%
Highest level (stratus 5-6)	0,26%	11,04%	24,44%	33,53%	50,66%	70,68%

Source: Author calculus

Table 14: Effective size of labour market for people travelling in private vehicles when both UPZ do no have a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	5,62%	21,44%	31,74%	49,24%	68,17%	82,66%
Medium level (stratus 3-4)	8,53%	21,98%	32,08%	50,40%	70,57%	84,61%
Highest level (stratus 5-6)	9,75%	21,86%	32,44%	50,05%	71,56%	86,79%

Source: Author calculus

It is interesting to see the magnitude of differences of labour market size between people living in UPZ with TM and those who lives in zones without TM and who commute in public transports to reach their jobs. In effect, for intervals of commuting time between ten and twenty minutes, we observe differences but those ones are not very significant (table 14). Nevertheless, differences on labour market size can be shown for trips of thirty, forty and fifty minutes. In effect, “rich people” have access to 18.07% less of jobs of the city with respect to people living and working on zones with TM when they travel thirty minutes, 31.92% of jobs less when they travel forty minutes and 25.72% less of jobs when they take fifty minutes to reach their jobs.

Disparities of size of labour market when trips are made in private cars are also significant. For trips made in twenty minutes we observe a difference of 31.75% of jobs, 43.25% for trips made in thirty minutes, 36.97% for a travels made in forty minutes and 22.24% for a commuting time of fifty minutes.

Even if people do not make travels in TM, zones that benefit of its presence have a bigger size of labour market. Differences for lowest a medium classes are similar.

c- *Travels from UPZ with direct connection to TM to another UPZ without any connection to TM and reciprocally.*

Regarding the effective size of labor market of people traveling from UPZ with direct connection to TM to another UPZ without any connection to TM, we can observe in table 15 that people commuting in travelling vehicles take the double of the time that they take if they live and work on UPZs with TM in the area. This is true for times between ten and thirty minutes. For commuting times between forty and sixty minutes, we see that there still been a difference that tends to disappear; nevertheless, this difference still to be important.

Table 15: Effective size of labour market for people travelling in public vehicles from UPZ with a direct connection to TM to a UPZ without a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	0,00%	0,30%	9,88%	23,98%	42,34%	57,13%
Medium level (stratus 3-4)	0,00%	1,80%	11,85%	25,79%	45,20%	61,98%
Highest level (stratus 5-6)	0,00%	2,17%	12,07%	26,89%	46,64%	65,67%

Source: Author calculus

Table 16: Effective size of labour market for people travelling in private vehicles from UPZ with a direct connection to TM to a UPZ without a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	0,84%	11,48%	25,92%	48,28%	67,49%	81,83%
Medium level (stratus 3-4)	1,90%	11,61%	27,10%	50,14%	69,81%	82,94%
Highest level (stratus 5-6)	1,87%	11,47%	27,84%	51,74%	71,61%	84,71%

Source: Author calculus

Concerning comparison between social classes, we observe differences of size of labor market that vary from 22.16% of more jobs reachable for rich people than for poor people who take thirty minutes to go to their jobs. When travels take forty and fifty minutes, the difference of the size of labor market is 12.07% and 10.15% respectively bigger for people

belonging to high classes with respect of the size of labor market of people living in low social level classes.

Furthermore, we can think that proportions and differences observed on the *ESLM* for people travelling from UPZ with existence of TM to another UPZ without any connection to TM and *ESLM* for people travelling from a UPZ without a direct connection to a UPZ with a direct connection to TM will be the same. Nonetheless, with relatively surprise we noticed that there is a not negligible difference of the *ESLM* depending if zones where individuals are going out has TM into their "boundaries" and if zones where they are arriving has not TM into their boundaries. In effect, if we compare results from table 17 with those from tables 15 we see that individuals who take public transports to leave a UPZ without a direct connection to TM to reach their jobs in a UPZ with TM, have 48.7% more of reachable jobs in an interval of time of twenty minutes. Disparities of *ESLM* still to be significant for intervals of thirty, forty and fifty minutes with 38.66%, 34.10% and 24.46% of more jobs reachable.

Table 17: Effective size of labour market for people travelling in public vehicles from a UPZ without a direct connection to TM to a UPZ with a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	0,00%	0,36%	14,39%	36,29%	57,31%	72,93%
Medium level (stratus 3-4)	0,00%	3,43%	18,74%	38,61%	59,64%	75,91%
Highest level (stratus 5-6)	0,00%	4,23%	19,68%	40,81%	61,75%	77,79%

Source: Author calculus

Table 18: Effective size of labour market for people travelling in private vehicles from a UPZ without a direct connection to TM to a UPZ with a direct connection to TM

Socio-Economic Class	Time of travel (minutes)					
	10	20	30	40	50	60
Lowest level (stratus 1-2)	2,61%	17,12%	38,09%	61,68%	78,01%	90,24%
Medium level (stratus 3-4)	4,80%	17,22%	40,09%	63,46%	79,80%	91,89%
Highest level (stratus 5-6)	4,75%	17,44%	39,56%	64,00%	81,38%	93,21%

Source: Author calculus

Regarding differences between social classes, we observe that they are not very significant. For a commuting time of thirty minutes, there is a gap of 33% of more jobs reachable for people with higher incomes but for intervals of forty or fifty minutes, differences are not higher than 13% which is not insignificant but it is not very important.

With respect of travels made in private cars, we see the same kind of differences about social classes and especially about the fact that individuals leaving a UPZ with TM to another

one that does not has. Actually, table 18 give us almost similar information as precedent table.

Conclusions and transport policy implications

Even if we notice that our analysis is made with data from the matrix of transport of the city of Bogota, we have to take into account that information gave by those data is not completed. We make the hypothesis that informal labour market has the same behaviour and characteristics than the formal labour market. Therefore, we can suppose that our results concerning the effective size of labour market can be very close to reality which can also be contest but our objective was mainly the analysis between social classes.

The aim of this paper was to contribute to the comprehension of some disparities on the size of labour market between social classes. We undertook an analysis looking for possible impacts of transport policies on the accessibility of jobs to population of each social class.

Our results suggest that there exist a big correlation between the presence of Transmilenio in a specific zone of the city and the effective size of labour market of population living or working on those zones of the city.

We demonstrate that people living in zones served by Transmilenio have at less, between 18% and 30% more probabilities to find a job than people who do not live in zone served by Transmilenio. It suggests to us that Transmilenio has a direct and an important impact on the labour market.

In the other hand, when we make a comparison of the *ESLM* between social classes, we always found that people belonging to social classes with less incomes are those who has less accessibility on labour market even if they live in the same zone of the city. Their probability to found a job is, in average, 20% lower in comparison to those of upper classes. Transmilenio give to people the possibility to have a faster transportation. Buses of Transmilenio besides all improvement of the road network which is at the side of corridors seem to have positive effects, not only on the time people spend into a public bus but also in cars that travel alongside Transmilenio. Nevertheless, it still having big disparities of accessibility between social classes. Enhancement of public transport system seems to benefit more the upper classes than the lower ones. This suggests that here is a lack in the conception of social inclusion of Transmilenio.

In addition, when trips are made in private cars, results are not dissimilar. We observe same differences of accessibility to jobs between high, medium and low classes and between zones served or not by Transmilenio. However at the same time, we observe that when trips

are made in private cars, *ESLM* increase in 20% which is not a surprise but it still been more advantageous to rich people.

Whereas improvement of public transport systems like Transmilenio entails enhancements of accessibility, this paper demonstrates that, even if it is an improvement of a public service, it does not benefit at a same proportion all social classes. An analysis of the possible reasons of this disparity of benefit of Transmilenio could be really interesting to complete our paper.

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