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1 June 2011

Heterogeneity of Socail Classes and Job Accessibility: Implications of Transports Policies in Bogota*

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June 1, 2011

Abstract

Transport in Bogotá (Colombia) has been the subject of several papers, but no one has treated the impact of the transport network on the disposition of employment in the city.

Improvement of a public transport system such as the *Transmilenio* is supposed to be beneficial to everyone in the city. However, it might be that only a portion of the inhabitants benefit from this improvement. The aim of this paper is to demonstrate that improvements in public transport are not necessarily synonymous with benefits to every social class, especially when talking about a city with a great deal of heterogeneity in its social composition. To shed light on the relation between transport accessibility and social classes within the different zones in Bogotá, the definition of the *effective size of a labor market* in a city will be necessary. We will support this with a study of the existing literature about the effective size of a labor market. The results will give us enough tools to know whether or not an enhancement of the public transport system will have a direct effect on the type of jobs or social classes there are in the different zones of Bogotá. Can enhancements of public transport determine the level of social inclusion within a city like Bogotá?

JEL Codes: J44, J68, R23, R40, R41

Keywords: Accessibility; Effective Size of Labor Market; Urban Public Transport; Social Classes; *Transmilenio*.

*This paper was presented at the 51st ERSA congress in an ordinary session. Barcelona september 2011.

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1 INTRODUCTION

Over the last twenty years, the question of urban transport policies has been a 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 owners of private cars, the increase of the population and hence the increase in the density in cities, along with a multiplicity of other reasons, has produced a rise in the commuting time and travel distance, and are at the origin of the "sprawl" of cities (Glaeser 2003).

The capital of Colombia, Bogotá, is no exception. In the last three decades, it suffered a big increase in its density and its territory. Since this big expansion of population and area and in addition to the absence of an effective urban transport system and appropriate regulatory policies, Bogotá had fallen into a mobility chaos by the end of the 1990s.

Thenceforth, the city was managed by mayors who attached prime importance to the problems of mobility and accessibility. 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 recognized as one of the most successful BRT systems in the world.

The first phase of the system began operations in December 2000, counting 42 km of exclusive lanes for articulated buses. Seven years later (2007), the whole of the two first phases of *Transmilenio* were in operation. They counted 84 km of exclusive corridors for 1080 articulated buses, 114 stations with off-board fare collection, and seven terminals connected with an inter-urban transport system. The third phase is planned to be finished in May 2012 and it will count 36.3 km more new corridors. In its entirety, the *Transmilenio* is expected to have 388 km of exclusive corridors covering 80% of the daily transit trips in the city.

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

Nevertheless, even if gains in travel time and speed continue to be important factors to take into consideration for transport policies, characteristics of a public transport system (PTS), such as affordability, accessibility, and impact on employment and hence, on the productivity of the city, have had more relevance in the last twenty years.

Literature regarding the accessibility of urban transport systems is vast. Some researchers on accessibility have focused their studies on "time accessibility" or "gravity accessibility" (Hansen 1959, Wilson 1970, Wachs 1973 and Koenig 1974). This branch of theory focuses on the reduction of travel time and commuting costs, including both the direct and indirect costs such as the cost in terms of time, the cost of the trip, etc. This suggests that the less the travel time is, the less the global cost is and the better the accessibility is. Thus, the productivity of the inhabitants will be higher. Theorists and policy makers ahve developed two kinds of solutions: increase the speed of the trips, or reduce the travelling distances involved.

To increase the speed, some authors and policy makers (see Barr 2000, Cervero 1997, Cervero 2002a,c) have suggested the construction or extension of ways and highways and hence the use of cars can be looked upon as a solution (Glaeser 2004, Sheickman and Glaeser 99, Anas 99, Fujita 2001)[1], so that commuting times and commuting costs will be lessened. But what researchers have observed is the tradeoff between speed and distance and between work and home. In fact, with such improvements in the infrastructure, individuals realized the possibility of living further away 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 when living in zones of the city which lack public transportation is to have a private car.

Nonetheless, the limited space and budget of cities to improve infrastructural networks, and the exponential increase in the use of cars, reveals the limitations of this kind of strategy. Traffic jams and hence the increase in commuting times and the loss in productivity shows that this kind of policy was not one of the better ones to solve the problems of accessibility and mobility.

For these reasons, another way to reduce commuting times is, according to several researchers (Duranton and Puga 2003, Glaeser 2001?) the "densification" of some city zones. As a result of such a "densification", there can occur learning and matching effects (Puga-Duranton 2003) which will translate into economies of agglomeration and reductions in the distance between houses and jobs.

The proximity between houses and work places is highly suitable, because the nearer inhabitants are to their jobs, the less time they will expend in commuting, and as a consequence, they will be more efficient. In addition, it will have some other positive effects, such as a reduction of the use of cars and, in turn, a reduction of traffic jams, smog, and all kinds of negative externalities.

[1] Those studies talk about the "Sprawl process" of cities begun decades ago, and show how policies have encouraged car use.

Bringing inhabitants and their jobs closer together seems to be the better solution but this zoning would also have as a consequence a cost increase[2] in formal housing, and thus such undesirable effects as the restriction of inhabitants from moving to those zones (in parallel with such other unwanted consequences as squatting) (Duranton 2008). So, people should be pushed to live near their jobs but even if a geographical densification is suitable it is not 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 use,is to mix a densification and a reduction of commuting time with an improvement in the public transport system. Enhancement of the accessibility on the part of a bigger proportion of inhabitants, by the use of an "efficient" public transport system, and not, as before, by increasing incentives to car use, seems to be useful. Jobs and houses are getting closer, which is supposed to lead to higher productivity and less commuting costs. Apparently, policy makers and researchers have found the recipe for enhancing everybody's accessibility to cities, or at least, this is what theory and some empirical studies say.

Urban mobility usually depends on public transportation. Most people use a PTS to travel within the city from home to work. The statistics gathered by city planning departments confirm that it is often more advantageous to take a bus (BRT) or the metro than it is to use a private car. The encouragement of the use of private cars is rapidly decreasing as a result of the enhancement of the PTSs.

2 Research question

The accessibility of inhabitants was a relative success of the transport policies implemented in Bogotá. After the construction of the *Transmilenio*, the travel times between work and home decreased in the city. With improvements in PTS travel time had decreased to an important extent: people's jobs are closer to their homes.

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 the Labor Market" (ESLM), which is the average number of jobs reachable in a specific interval of time, will be higher with the enhancement of the PTS: probability of finding a job can rise with this kind of policy. But the question for this kind of policy is not only to get people closer to jobs but also to get people closer to the type of jobs they are trained to do. There is not the same interest in connecting a working-class neighbourhood to a zone of the city specialized in financial services, for example.

[2] Sometimes artificially

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

As Wenglenski has illustrated in the case of Paris, (Wenglenski 2006) the probability of reaching jobs is not the same for every worker's profile. In effect, people belonging to the highest class (executives, managers) seem to receive more benefits from Parisian PTS policies than people who belong to the lowest class (unskilled workers).

This paper gives us different tools to know if enhancements of a Public Transport System or the transport policies of Bogotá give people belonging to a specific social class the same level of possibilities of reaching a job of their skills as to other classes. The aim of this research is to know if people belonging to different social classes in Bogotá are taking advantage to the same extent of the improvements in accessibility provided by the *Transmilenio*. If this is not the case, we will try to find out how transport policies could alter this conclusion.

3 Research methodology

To take up the subject and to analyze the research question, we must, firstly, estimate the Effective Size of the Labor Market in Bogotá, as recommended by Prud'homme and Lee (1999). After having the ESLM of the city of Bogotá for some intervals of time, we will suggest an approach to the question of the accessibility of each social class[3] to different zones of the city.

3.1 The "Effective Size of the Labor Market" (ESLM) approach

To estimate the effective size of the labor market in Bogotá, we follow the methodology suggested by Prud'homme and Lee (1999). This theory is based on the assertion that the labor market is a function of the travel times and zones where employees live and work. The goal of this approach is to know how many

[3] There will be three social classes for the purposes of this study: lowest, medium, and highest

jobs are reachable by workers in a specific time from their homes to their jobs. The commuting time intervals we used are from 10 minutes to 120 minutes.

To provide some of the background for this approach, we will merely describe it as the authors did in their paper[4].

The database we have takes into account 824 different tracts of Bogotá which, in turn, make part of 112 "Zones of planning" (UPZ)[5]. This gives us $n = 112$ zones of study.

E_{k_i} will represent the number of employees with the kth type of job located in zone i, so $\sum_i E_{k_i} = E$ will denote the total employees in the city. J_{k_i} represents the number of jobs of type k placed on zone i, and $\sum_i J_{k_i} = J$, the total jobs in zone i. Finally, T_{ij} is the average time needed to reach zone j from zone i.

For each i, the ESLM for workers of zone i will be

$$Li(t) = \sum J_{k_i}$$

in order to have $T_{ij} \leq t$, the commuting time to reach j from i (T_{ij}) will have to be less than or equal to t: this is the temporal constraint.

For the city, the ESLM will be

$$L(t) = \frac{\sum L_i(t) * E_i}{E} = \frac{\sum_{i=1}^{n} \sum_j J_j * E_i}{E}.$$

This represents the weighted average of the effective labor size of all zones, weighted with respect to the number of employees who live in the city.

To obtain a more accurate answer to our research question, the estimation of the ESLM was performed for the population belonging to each social class. To realize whether 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 the ESLM undertaken in this paper took into account three scenarios, depending on possible connections between UPZ where TM skirt or pass within those zones, and UPZ that do not have any connection to TM. As a result, we have three possible scenarios:

[4] We use the same expressions as the authors.

[5] UPZ is the acronym, which we will use, for the Spanish *Unidades de Planeamiento Zonal*.

- Travel from a UPZ with direct connection to TM to another UPZ with direct connection to TM;
- Travel 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 also made a distinction in the ESLM with respect to the kind of transportation used by the inhabitants. We calculated the fraction of jobs accessible to inhabitants belonging to a social class with respect to the kind of transport system used (public or private). The results brought some interesting information to light.

3.2 Social class and grouping of zones

Bogotá is a very big city, composed of 20 subcity urban areas[6] divided in turn into 112 planning zones. The density in Bogotá is approximately 230 people/ha[7], (one of the densest cities in South America) and the social class heterogeneity is sometimes really appreciable. The city is divided into six socioeconomic strata: from stratum 1, the lowest socioeconomic level, to stratum 6, the highest level. Stratas 3 and 4 often represent the middle class.

As we said above, Bogotá is organized into six socio-economic strata. The analysis we have undertaken took in consideration three types of social classes, which will be made up out of these six socio-economic strata.

Actually, we grouped these strata into what we call three "social classes" composed as follows:

- Strata 1–2: Lowest Social Class
- Strata 3–4: Middle Social Class
- Strata 5–6: Highest Social Class

On the other hand, to make easier the analysis of travels, I suggest a grouping of some zones. I take into consideration the most important "employment centers" of the city. I suggest those "subcenters" because of the number of

[6] The urban area as a whole is composed of 19 subcity urban areas and one rural one. The urban areas amount to 35,000 hectares (three times the size of Paris).

[7] Adapted from Suarez (2005).

people working in these zones and also because of the dynamism we perceive in some zones of the city. I defined three different subcenters which are, in turn, composed of a number of UPZ:

- One of those centers is the zone known as "The Center"[8] 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 subcenter, "Center", is composed of 12 UPZ of the city .
- The second subcenter, "Center-North"[9], includes five UPZ and is defined as a financial subcenter which is 8 km from the historical center. It is these zones which have the highest buildings, belonging to several bank companies.
- The third subcenter, "North"[10], includes six UPZ and is defined as the commercial subcenter, and is located 14 km from "center" and six kilometers from "Center-North". This zone has been, for almost ten years now, a new center wherein internationals and also financial companies have their headquarters[11].
- The rest of the UPZ (84) are called "rest" in our analysis but, even if in this analysis it is considered as a subcenter, it does not represent it.

In this classification, we have made sure that every subcenter is almost served by the same kind of public services, especially by public transport systems. We paid particular attention each subcenter's being served by *Transmilenio* in similar proportions.

4 Analysis of the data

Even if we notice that our analysis is made with data from the matrix of transport of the city of Bogotá, we have to take into account that the information

[8] Subcenter "center" is composed of 12 UPZ: Britalia, Sosiego, Ciudad Jardín, Santa Isabel, Restrepo, Sagrado Corazón, La Macarena, Las Nieves, La Candelaria, Las Cruces, Lourdes, and Teusaquillo.

[9] Subcenter "center-north" is composed of 5 UPZ: Pardo Rubio, Chicó Lago, Los Alcazares, Chapinero, Galerias

[10] Subcenter « north » is composed of 6 UPZ : Usaquén, Country Club, Santa Bárbara, La Alhambra, Los Andes

El Refugio

[11] Analysis of the number of employees of each subcenter as well as the time spent by people commuting from and to these subcenters can be found in appendix 1.

given by this data is not complete. We make the hypothesis that the informal labor market has the same behaviour and characteristics as the formal labor market. Therefore, we can suppose that our results concerning the effective size of the labor market can be very close to reality, which can also be contested, but our objective was mainly the analysis between social classes.

4.1 Database

Bogotá 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 is comprehensible, there is no truthful data for the underemployment market but, even if such data is not available, this does not really challenge our results due to our focus on social classes and the formal labor market in the city.

To understand the characteristics of the trips, the public administration decided to make the most detailed mobility survey ever made in the city[12]. The database used for our study was obtained from this survey. It has information about several variables regarding the mobility of the inhabitants: distance of trips, commuting time, social classes of users, type of job of users, and starting and destination points within each of the 112 zones of the city.

The 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 in the city, it still was a survey. The study was completed by the transport matrix of the city which gives us the time estimation of every trip within the city. In fact, the matrix of transport of Bogotá has information about the commuting time between every zones of the city (every possible itinerary between one UPZ and another).

In addition to this information[13] we judged that we had to take into consideration some of the socio-economic data pertaining to the various zones in order to have better results. In 2007, the administration made another survey in the city[14] with the aim of having some information about the quality of life of "Bogotanians". This survey takes into account socio-economic data such as the socioeconomic level of the inhabitants of each UPZ, the number of unemployed

[12] Mobility Survey 2005 or "Plan Maestro de Movilidad 2005: Encuesta de Movilidad 2005", in Spanish. Secretaria de Movilidad del Distrito.

[13] The Mobility Survey 2005 and Transport Matrix of Bogotá.

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

people in each zone, the number of cars by households, and other variables. It is very interesting to include these variables in our study analysis especially if we are looking to have a greater socio-economic framework of UPZ.

With this data, we will be able to make a more refined analysis to answer our research question.

The variables taken in consideration were organized by UPZ of origin and UPZ of destination. The poll of 2005 had the following information for each variable:

- Reason of the trip (8 reasons): return to home, work, study, business, shopping, personal business, change of bus, and other.
- Type of vehicle or type of transport used from destination to origin (11 types): foot, bicycle, motorcycle, private car as driver, private car as passenger, taxi, *Transmilenio*, bus of *Transmilenio*, bus, micro bus, other.
- Principal Activity of the person: study, job, house job, retired, independent, searching for job, cannot work, other.
- Type of job of people for which their principal activity is to work: worker or employee, housework employee, independent worker, manager or owner, household worker without salary, other.
- Socio-economic stratum: 1 – people belonging to lowest socio-economic stratum, 6 – people belonging to the highest one.
- Calculated time: walking time to the nearest station plus waiting time inside the station plus time inside the vehicle.

Besides the type of work, Table 1 presents us some descriptive statistics resulting from the poll. Among those people for whome their reason for the trip is to work, we can observe that commuting times differ between people with different kinds of jobs. As expected, managers and owners are those who take less time to commute, to wait, and to walk to the nearest station where they take the vehicle. In contrast, we see that employees, unskilled workers, and housework employees are those who take more time to reach their destinations.

Table 1: Descriptive statistics according to the type of job of those people for whom their reason for 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	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/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 w 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's calculations from "Encuesta de Movilidad 2005"

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[15]. This matrix includes information about all possible itineraries "from" and "to" every 112[16] zones of the city. This matrix is divided into 824 zones of transport of Bogotá. This gives us a matrix with 678,976 itineraries, which in turn make part of the whole UPZ, so we will bin the data of the transport matrix into the 112 UPZ in order to have just 12,432 itineraries.

The transport matrix also has information about the time spent in stations waiting for public buses or even the time people spent walking from home or work to the nearest station, as well as the socio-economic classification of the users.

[15] This information was obtained from the Secretaria de Movilidad del Distrito and University of Los Andes (Bogotá).

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

According to the socio-economic class of the people whose reason for the trip is to work, we observe that people from the lowest socio-economic (strata 1 and 2) take more time to walk to the next station than do people of the other socio-economic stratum (table 2).

Table 2: Descriptive statistics according to the socio-economic class of people whose reason for the trip is to work

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's calculation from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogotá

Actually, people of the highest socio-economic strata take less time (14.4%) to commute within the city (tables 2 and 3)[17]. Equally, those differences are also revealed between the medium and the lowest classes (9.85%). But the highest differences are observed in walking time to the nearest station or waiting for the vehicle. These differences are substantial, even if they are not really significant compared to the total commuting time. For example, we see that people of the lowest socio-economic strata take 40.92% more time to reach the nearest station than do people of the highest strata. Concerning waiting time, people of the lowest class spent 68.92% more time waiting than did people of the highest class, and 46.20% more than people of the medium class. The same differences between people of the highest class and the medium class are also important but not so much so (Annex 1).

In Bogotá, more than 3.2 million travels have work as their cause. More than half of all trips (59.9%) are made on public transportation and 41.1% of all trips are by private vehicles (table 3). Among the three subcenters, the "Center" is the one who has more trips than the other two (10.5% of the total trips of the city. 6.3% and 3.2 % for "Center-North" and "North", respectively). We

[17] Three kinds of times are included: walking time, waiting time, and time inside the vehicle.

observe that two-thirds of the trips in the "Center "and "North" are made in private vehicles. On the other hand, almost half of the trips in "Center-North" are in public vehicles. This suggests that the modal choice can be heterogeneous across subcenters and UPZ of the city.

Table 3: Number of trips with "work" as their reason, by subcenter

Sub-center	Number of trips		By type of transport mode			
	Total	%	PT	%	CO	%
Center	337,970	10.5%	131,155	38.8%	206,815	61.2%
Center-North	204,382	6.3%	109,375	53.5%	95,007	46.5%
North	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's calculations from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogotá

The attraction and generation of trips (Table 4) from and to subcenters displays the differences between them. In fact, we see that 6.8% of the total trips attracted to Bogotá (trips to a subcenter) correspond to "Center", 5.7% are to "Center-North", and 1.8% to "North". But what is also interesting to see is that these subcenters generate more trips than they attract. In effect, "Center" generates 15.9% of the trips generated in Bogotá, which is 57.7% more than the trips that it attracts. "North" generates 5.2% of the trips generated in the city (90.7% more trips than it attracts). In contrast, "Center-North" attracted more trips than it generates, and the majority of trips attracted are by private vehicles (84%). Most of the trips attracted and generated from and to "Center" are made by public transportation (two-thirds of the trips) but one-third of the trips attracted to "North" are made by public transportation which suggests that the rest are made in private vehicles. This lets us suggest that two-thirds of the people working and living in "center" use public transportation. In contrast, 84% of the people who work in "Center-North"use private transportation and 96.7% of the trips of people who live and do not work in "Center-North", use public transportation to reach their jobs. Finally, two-thirds of the trips attracted by "North", (people who work in "North") use their cars to go to their jobs; two-thirds of the 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 than they generate (85% attracted vs. 71.5% generated) and more than four-fifths of the trips are made by public transportation.

Table 4: Distribution of number of trips generated and attracted by transportation by subcenter

	Zone	Total	%	PT	%	CO	%
Trips atracted	Center	131,155	6.8%	96,705	73.7%	34,451	26.3%
	Center-North	109,375	5.7%	17,488	16.0%	91,887	84.0%
	North	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%
	Center-North	95,007	7.3%	91,887	96.7%	3,121	3.3%
	North	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's calculations from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogotá

Concerning the distance traveled by people between their homes and their jobs, we observe that people living or working in "Center" travel lesser distances than people living or working in another subcenter (Annex 2). We can suggest that there is a greater willingness to be closer to "Center". This can confirm that the fact of being closer to the zone considered as "the center" of the city, where the historical and the administrative center is located, may be more advantageous for workers. In contrast, we can observe that the distances people have to travel to "North" are longer than the others. In fact, this could be related to the fact that 84% and 63% of the trips attracted by "Center-North" and "North" are made in private vehicles, which allows people to travel longer distances. In contrast, most of the trips generated in every zone are made by public transportation.

Data from the planning office of the city hall and from the Chamber of Commerce of Bogotá shows us that "Center" attracts 12.6% of the formal jobs of the city and contains 14.5% of the workforce. "Center-North" and "North" have 17% and 8.3% of the formal jobs, respectively, and 13.3% and 8.9% of the workforce of the city (Annex 3). The rest of the zones ("rest") have similar portions of the formal jobs and workforce.

Having information about all the kinds of jobs in each subcenter may be the most desirable, but because of the lack of accurate information we opted to make an analysis with respect to social classes in order to have a better estimation of the influence of transport policies in Bogotá on the effective size of the labor market.

As we have said before, every subcenter has a direct connection with the *Transmilenio* (TM), but each subcenter is composed of several UPZ. Each UPZ makes part of a subcenter but might not have direct access to TM.

The level of concentration of jobs and workforce in UPZ with direct access to TM is as follows: (Annexes 4–5)

- 10.6% of the formal jobs are directly connected to TM and make part of "Center". Only 2% of the formal jobs of the city, which represents 15.9% of the formal jobs of "center" subcenter", do not have a direct connection to TM.

- 16.4% of the formal jobs are directly connected to TM and make part of "Center-North". No more than 0.6% of the formal jobs of the city, which represents 3.4% of the formal jobs of "zone 72" subcenter", do not have a direct connection to TM.

- 5.5% of the formal jobs are directly connected to TM and are part of "North". But 2.8% of the formal jobs of the city, which represents 34.2% of the formal jobs of "center" subcenter", do not have a direct connection to TM.

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

Unfortunately, we do not have detailed data of the number of kinds of jobs and underemployment in each UPZ and this does not allow us to make a complete study of the effective size of the labor market in Bogotá. Our results can be criticized, but we believe 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 as the formal employment market.

5 RESULTS

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

As Table 10 shows, people commuting by public transportation and living in a low-income UPZ with a direct connection to TM, have access to 22.93% of the jobs in the city. Besides, when a UPZ has a direct access to TM, people who belong to strata 3 and 4 (medium class) have access to 28.98% of the jobs in the city (26.4% more than people of the lowest class) in the same length of time. Finally, when people commute by public transportation and live in a UPZ of the highest class, where a TM passes through or surrounds them, they can reach 29.83% of the jobs of the city in thirty minutes (2.93% more than people of the middle class and 30% more than people of the lowest class).

With an interval of time of thirty minutes, we find that when people use public transportation to reach their jobs from a UPZ where there is a presence

of TM with direction to a UPZ where TM passes, the richest people have access to 30% more jobs than people with the lowest income of the city. Such differences are bigger when people would like to reach their jobs in 20 minutes. In fact, while rich people have access to 11.3% of the jobs in twenty minutes of travel, poor people have such access to only 0.8%. The disparity decreases when the commuting time increases. When the commuting time is sixty minutes, the difference between the number of jobs reachable in this time between rich people and people of low income is only 17.5%.

We find the same characteristics when the trips are made in private cars.

Table 5: Effective size of labor market for people travelling in public vehicles when neither UPZ has a direct connection to TM

Effective Size of Labor Market							
Type of transport	Time of Travel (minutes	10	20	30	40	50	60
PUBLIC	Lowest Class	0.00%	0.80%	22.93%	43.28%	58.63%	71.42%
	Medium Class	0.00%	9.49%	28.98%	46.05%	63.44%	79.00%
	Highest Class	0.00%	11.31%	29.83%	49.25%	68.20%	83.82%
PRIVATE	Lowest Class	4.61%	29.20%	53.58%	75.88%	89.98%	96.54%
	Medium Class	9.30%	30.71%	56.19%	77.97%	91.56%	97.16%
	Highest Class	9.93%	32.03%	57.17%	79.41%	92.03%	97.63%

Source: Author's calculations

In fact, when the trips are made in private cars between two UPZ with direct TM, the people belonging to the lowest classes have access to 29.20% of the jobs of the city in twenty minutes, while the number of such jobs of people belonging to the middle (high) class is 30.71% (32.03%) (Table 12). This difference in the accessibility between the high class and the low class when the trip is made in a private car is 9.7%. When the commuting time increases, this difference decreases.

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

The commuting times between UPZ were taken from the transport matrix of Bogotá but we thought that these proportions are higher than they are perceived by the inhabitants. We thought the results might change concerning the number of jobs in each UPZ. In fact, we have to remember that not all jobs were considered in that study. We are focusing only on the formal labor market and we are not taking into account the informal labor market, which represents almost 50% of the employment of the city. But even if we do not have those

data, the goal of the paper still has been achieved: the differences between the benefits of the social classes from the enhancement of transport policies such as the *Transmilenio* have been exposed.

5.2 Travels from a UPZ without any connection to TM to another UPZ without any connection to TM.

As expected, the accessibility to jobs for people living and working in a UPZ which the TM does not traverse and does not even skirt the boundaries, is fewer for commuting times going from thirty minutes to sixty minutes (Table 13). The differences between social classes in the number of reachable jobs are also less important than in the previous section. (22.38% more jobs are accessible to people of the highest classes than are reachable by people of the lowest social level for a commuting time of thirty minutes and using public transportation).

Table 6: Effective size of labor market for people travelling in public vehicles when neither UPZ has a direct connection to TM

		Effective Size of Labor Market					
Type of transport	Time of Travel (minutes	10	20	30	40	50	60
PUBLIC	Lowest Class	0.00%	0.80%	22.93%	43.28%	58.63%	71.42%
	Medium Class	0.00%	9.49%	28.98%	46.05%	63.44%	79.00%
	Highest Class	0.00%	11.31%	29.83%	49.25%	68.20%	83.82%
PRIVATE	Lowest Class	4.61%	29.20%	53.58%	75.88%	89.98%	96.54%
	Medium Class	9.30%	30.71%	56.19%	77.97%	91.56%	97.16%
	Highest Class	9.93%	32.03%	57.17%	79.41%	92.03%	97.63%

Source: Author's calculations

It is interesting to see the magnitude of the differences in labor market size between people living in a UPZ with TM and those who live in zones without TM and who commute by public transportation to reach their jobs. In fact, for intervals of commuting time between ten and twenty minutes, we observe differences but they are not very significant (Table 14). Nevertheless, the differences in labor market size can be seen for trips of thirty, forty, and fifty minutes. In fact, "rich people" have access to 18.07% fewer jobs than people living and working in zones with TM when they travel thirty minutes, 31.92% less when they travel forty minutes, and 25.72% less when they take fifty minutes to reach their jobs.

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

Even if people do not travel in TM, the zones that benefit from its presence have bigger labor markets. The differences for the lowest and medium classes are similar.

5.3 Travels from UPZ with a direct connection to TM to another UPZ without any connection to TM, and reciprocally

Regarding the effective size of the labor market for people traveling from a UPZ with a direct connection to TM to another UPZ without a connection, we can observe in Table 15 that people commuting in travelling vehicles take twice as much time than if they live and work in a UPZ 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 is a difference that tends to disappear; nevertheless, this difference still can be important.

Concerning the comparison between social classes, we observe varying differences in the sizes of the labor markets: 22.16% more reachable jobs for rich people than for poor people who take thirty minutes to go to their jobs. When the trips take forty and fifty minutes, the size of the labor market is 12.07% bigger, respectively, 10.15% bigger, for people belonging to high classes, respectively, for people living in low social level classes.

Table 7: Effective size of labor market for people travelling in public vehicles when neither UPZ UPZ has a direct connection to TM

Effective Size of Labor Market							
Type of transport	Time of Travel (minutes	10	20	30	40	50	60
PUBLIC-3-1	Lowest Class	0.00%	0.30%	9.88%	23.98%	42.34%	57.13%
	Medium Class	0.00%	1.80%	11.85%	25.79%	45.20%	61.98%
	Highest Class	0.00%	2.17%	12.07%	26.89%	46.64%	65.67%
PUBLIC-3-2	Lowest Class	0.00%	0.36%	14.39%	36.29%	57.31%	72.93%
	Medium Class	0.00%	3.43%	18.74%	38.61%	59.64%	75.91%
	Highest Class	0.00%	4.23%	19.68%	40.81%	61.75%	77.79%
PRIVATE-3-1	Lowest Class	0.84%	11.48%	25.92%	48.28%	67.49%	81.83%
	Medium Class	1.90%	11.61%	27.10%	50.14%	69.81%	82.94%
	Highest Class	1.87%	11.47%	27.84%	51.74%	71.61%	84.71%
PRIVATE-3-2	Lowest Class	2.61%	17.12%	38.09%	61.68%	78.01%	90.24%
	Medium Class	4.80%	17.22%	40.09%	63.46%	79.80%	91.89%
	Highest Class	4.75%	17.44%	39.56%	64.00%	81.38%	93.21%

Source: Author's calculations

Furthermore, we might think that the proportions and differences observed on the ESLM for people travelling from UPZ with TM to another UPZ without

any connection to TM and the ESLM for people travelling from a UPZ without a direct connection to a UPZ with a direct connection to TM will be the same. Instead, with surprise, we notice that there is a non negligible difference of the ESLM, depending on whether it is a zone from which the individuals are leaving that has TM into their "boundaries" and zones where they are arriving and has no TM to their boundaries. In fact, if we compare the results from Table 17 with those from Table 15, we see that individuals who take public transportation to leave a UPZ without a direct connection to TM to reach their jobs in a UPZ with TM have 48.7% more jobs which are reachable in an interval of time of twenty minutes. The disparities of the ESLM still are significant for intervals of thirty, forty, and fifty minutes, with, respectively, 38.66%, 34.10% and 24.46% more reachable jobs.

Regarding the 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% more reachable jobs for people with higher incomes, but for the intervals of forty or fifty minutes, the differences are not higher than 13%, which is not insignificant but it is not very important.

With respect to trips made in private cars, we see the same kind of differences between social classes, and especially in the case of individuals leaving a UPZ with TM to another one that does not. Actually, Table 18 gives us almost similar information as the preceding table.

6 Conclusions and public policy implications

Even if we notice that our analysis is made with data from the matrix of transport of the city of Bogotá, we have to take into account that the information given by that data is not complete. We make the hypothesis that the informal labor market has the same behavior and characteristics as the formal labor market. Therefore, we can suppose that our results concerning the effective size of the labor market can be very close to reality, something which could be contested, but our objective was mainly an analysis of differences between social classes, which was done.

The object of this paper was to evaluate the enhancements of the public transport system in Bogotá (the presence of the *Transmilenio* in some zones of the city) and the influence it might have on the accessibility to employment of the inhabitants with respect to their socio-economic status. Our results tend to contribute to the comprehension of some disparities of the accessibility to the labor market between social classes in the city.

With this research, we have confirmed the existence of a significant correlation between the presence of the *Transmilenio* in a specific zone of the city and the effective size of the labor market of the population living or working in that zone. People who live in zones served by the *Transmilenio* have, at least between 18% and 30% higher probability of finding a job than do people who do not live in zones served by the *Transmilenio*. The improvements in public transportation like the *Transmilenio* seem to have had a positive and important impact on accessibility to the labor market.

Besides, when we focus on the comparison of the Effective Size of Labor Market (ESLM), we find that people in the city with less income are those who have less accessibility to the labor market even if they live in the same zone of the city as people with the highest incomes. Their probability of finding a job is, on average, 20% lower than that of those of the upper classes.

In addition, when trips are made in private cars, the results are not dissimilar. We observe the same differences in accessibility to jobs between the high, medium, and low classes and between zones served or not by the *Transmilenio*. At the same time, however, we observe that when the trips are made in private cars, the ESLM increases by 20%, which is not a surprise but it is still more advantageous to rich people.

In general, the improvement of public transportation of Bogotá (*Transmilenio*), gave people the possibility of having a faster commute and increased the accessibility of the labor market. The buses of the *Transmilenio*, besides all the improvements of the road network, seem to have had positive effects not only on the time people spend in public transportation but also on the time spent in private cars alongside the *Transmilenio* corridors; nevertheless, the difference in the accessibility to the labor market between social classes has still been important.

Even if every social class seems to have had an increase in their accessibility to the labor market, those benefits are not equally distributed. People from higher social classes have more advantages from the public transport improvements than do people from the lowest social classes, and the "poorest" people of the city seem to have received less profit from those enhancements.

When the public administrations decided to upgrade public transit, this was always sought as a way to raise the welfare and social inclusion of the people from the lowest socio-economic level. Whereas the improvement in public transport systems such as the *Transmilenio* entails enhancements of the accessibility, this paper demonstrates that, even if it is an improvement of a public service, it does not benefit all social classes equally. The enhancement of the public transport system seems to benefit more the upper classes than the lower ones.

Our results suggest a lack in the conception of this kind of public policy; social inclusion can be stymied. Why do people belonging to the lowest social

classes not profit from the enhancements and the development of new public transportation in the same proportion as people belonging to higher social classes? Have "poor" people enough tools to enjoy those improvements in the same proportion than "rich" people? Are affordability and disposable income the causes of this difference? Those questions could complete our study and could be the subjects of further research. The subject of subsidies in public urban transport to make them more affordable might take on more importance for the conception of transport policies.

7 Annexes

Annex 1:

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's calculations from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogotá

Annex 2:

Mean distance of trips by subcenter

Sub-center	Mean Distance of trips (km)	Standar Deviation (km)
Center	7.7	5.5
Center-North	8.8	5.6
North	10.7	6.5
Rest	8.7	6.2

Source: Author's calculations from "Encuesta de Movilidad 2005" and Transport Matrix of the city of Bogotá

Annex 3:

Workforce and number of jobs by subcenter

Sub-center	Number formal jobs	%	Workforce	%
Center	188082	12.6%	437795	14.5%
Center-North	253916	17.0%	403891	13.3%
North	124851	8.3%	269424	8.9%
Rest	930888	62.2%	1914483	63.3%
Total	1497737	100.0%	3025593	100.0%

Source: Author's calculations from Secretaria de Planeación del Distrito de Bogotá. "Survey of quality of life for Bogotá 2007"

Annex 4:

Jobs and direct access to TM by subcenter

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%
Center-North	245,209	16.4%	8,707	0.6%
North	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's calculations from Secretaria de Planeación del Distrito de Bogotá. "Survey of quality of life for Bogotá 2007"

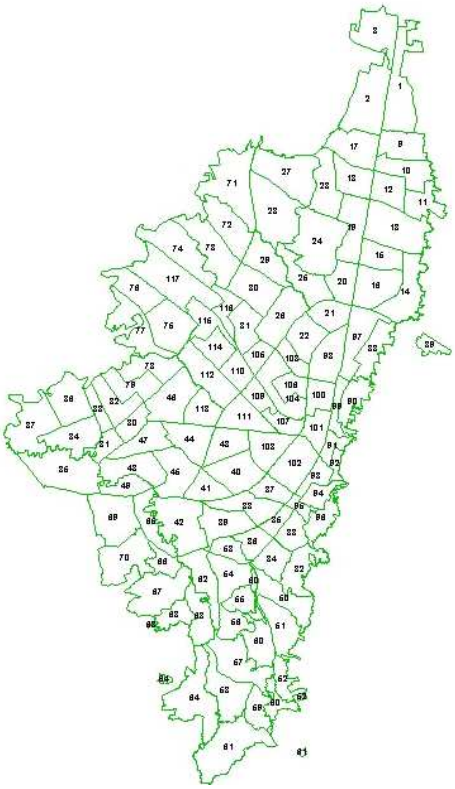
Annex 5:

Workforce and direct access to TM by subcenter

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%
Center-North	388,438	12.8%	15,453	0.5%
North	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's calculations from Secretaria de Planeación del Distrito de Bogotá. "Survey of quality of life for Bogotá 2007"

Annex 6: Zones



Source: Duarte Gutterman y Compañía 2005

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