Transport networks’ accessibility and jobs’ accessibility: the significance of this correlation on the configuration of labor market in Bogotá?

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Very Preliminary Version (without empiric section)

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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. This research has two different aims which are directly interrelated. The definition of the effective size of labor market in the city is necessary to sheds light on the relation of transport accessibility and type of jobs or social classes within different zones in Bogotá. We will support the first part of our study on the existing literature about the effective size of labor market. Under the specification of a conceptual model, we want to demonstrate the significant correlation (even causality) between accessibility and type of jobs in Bogotá. In order to capture the possible endogeneity among transport’ accessibility and type of jobs in Bogotá we will use a structural equation modeling. Results will give us enough tools to know if transport network’ accessibility, jobs’ accessibility and type of jobs (or social classes) are large interrelated or not in the city of Bogotá.

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

Keywords: Accessibility; Effective size of labor market; Conceptual model; Urban public transport; structural equation modeling.

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1 INTRODUCTION

1.1 Characteristics of Bogotá

Bogotá is the most important city in Colombia and the largest one from the point of view of population and area. Urban area counts more than 34,000 hectares\(^1\) and has more than 7 million of inhabitants. Despite that, it can be considered as a compact city with a density around 205 persons per hectare (230 inhabitants per hectares adapting from Suarez, 2005). Since 90’s, the city adopted the French decentralization following the Parisian model\(^2\); it counts 20 sub city urban areas or districts called “Localidades” (19 urban and one rural). Each urban area has a “local” mayor which is supposed to be and to know more clearly different needs of each area. He is suppose also to administrate and make more realistic development plans to each district. In spite of this organization, extension of “Localidades” still to be very large which was the main reason for the council of the city, in 1999, to reorganize the city in smallest zones of planning which would be part of each 20 districts. Now, the city is divided in twenty “Localidades” and in 112 “Zones of Planning” (UPZ\(^3\)).

Production of those 112 zones represents approximately 30% of Colombia’s GDP. Despite this importance on national economy, Bogotá has a typical characteristic of cities from developing countries: uncontrollable growth of the urban area, high density, income and social segregation traduced on social problems and big problems of mobility.

Six socio-economic strata\(^4\) denote different social and economic groups in the city. About 80% of inhabitants live in strata 1, 2 and 3 representing the low income population of Bogotá. Middles class is represented by people who live in stratum 4; it represents less than 14% of population. High class is represented by people living in strata 5 and 6; they are 6% of population.

Therefore, urban structure and social organization in the city suffer big disparities. Rich and poor neighborhoods are clearly delimited. Basic services are not provided in the same proportion and public services are not the exception. Clean water, electricity and even paved streets and urban transport system are not equally offered everywhere. As a consequence of these big disparities and

\(^1\) DAPD for 2002. Department of Planning of Bogotá. 38.000 If we take in consideration preservation areas in urban zones
\(^2\) Jaime Castro Castro was elected from 1991-1993
\(^3\) In Spanish: “Unidades de Planeamiento Zonal-UPZ”
\(^4\) Urban areas are split into six socioeconomic strata. A stratum denotes the socioeconomic level of people who live in those areas. Stratum 1 is the lowest socioeconomic level and stratum 6 the highest. The strata are used to target public service subsidies and other social programs (see Medina et al., 2007)
tending to solve them, last mayors\(^5\) concluded in their administrations that development of urban transport systems and accessibility’ improvement in the city (among other public policies), represent relevant tools to reduce disparities.

### 1.2 Evolution of Transportation Policies

Before 1960’s, provision of public transport was leaded by public administration. Buses, taxis and lines of tramway composed the urban transport system of the city with the tramway as the “spinal column”. Nevertheless, because of a huge public debt of Bogotá and due to different factors\(^6\), tramway closed and public administration decide to privatize public transport system. Since this decade, management of public transport is in charge of private entrepreneurships. Public transport system of the city is composed by private entrepreneurships assembled in about 60 private enterprises assuring the provision of the service in the city. Public administration do not have a participation on utilities; it has the role of regulator and determines the different lines of buses which are needed in some zones of the city and after a call for tender, it assigns those lines to “winner” enterprises. It was the expansion of public transport system and thereby the spread of the city that took next 30 years.

In 1990’s, as consequence of this sprawl and big lack of planning policies for a long time, Bogotá suffered big problems with mobility and transportation system. The continuous reduction of accessibility, the sever congestion in some main roads of the city in addition to long travel times and poor road network conditions, became the most relevant evils of the city.

From more than one decade, the administration of Bogotá has been displaying a great necessity of some urban transport policies to improve urban mobility of citizens. It’s because last four mayors (since 1993) focused their public policies to get a better transport network in the city looking for greater levels of accessibility for inhabitants. Thereby, suggestion of original public policies took place. Cultural policies encouraging people to use bicycle (Cervero, 2005) or “Car-Free” day\(^7\), and other kind of policies like traffic restriction, had their “circumstantial” success (A. Mahendra 2007). Even so, construction of big infrastructure projects like Transmilenio was also took in consideration to solve mobility and accessibility problems of the city.

In fact, Transmilenio is the highest capacity Bus Rapid Transit (BRT) system in the world, using bus-ways (84 kms), stations (114) and terminals (7)

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\(^5\)Since the administration of Antanas Mockus on 1995-97. He was re-elected for another period of three years between 2001-2003. Between 1998-2001 it was Enrique Penalosa the mayor of the city and between 2004-2008 it was Luis Eduardo Garzon.

\(^6\)Budget crisis and “Bogotazo” 1948 among several others

\(^7\)Bogotá officials have held car-free days on the first Thursday of February since 2000. Nobody, in exception of public transport vehicles, can use their cars.
connected with inter-urban transport system. It is adapted for articulated buses (1080 buses) with capacity to carry 60-120 passengers. Today, the system moves about 41,000 passengers per hour per direction so, 1,5 millions of passengers per day at a mean-speed of 27 km/h. The main plan proposed by Public Administration is to construct more than 300 km of Transmilenio in eight separate phases in a period between two or three decades. Today, those 84km which are already in function, correspond to phases one and two. Third phase is planned to be finished in 2012 and it will be composed by 36.3 km of new corridors.

Even if these policies are helpful to get a better mobility in the city from last ten years, gains are generally thwarted because of the constant demographic and geographic growth.

1.3 Present of public transportation system of Bogotá; ordinary public transport system and Transmilenio and new perspectives of evolution

As we said previously, since 1960’s until now, public transport system in Bogotá is provided by about 60 private companies. They generally have unsafe, shape and old buses with 20 or 25 seats. Companies get the permission of public administration to manage those routes. Generally, buses belong to smalls and independents transporters which have to affiliate their cars to these companies. Transporters have to pay for the attachment to a company so they have to ensure a minimum production per day or per month, to pay this affiliation and after that, they could have some benefits. In 2004, a study revealed that in Bogota there was an average of 17,000 buses per month assuring their services.

Transporters compete between them to get the more passengers they can, pushing them to drive in a dangerous style without respect neither road rules nor limit speeds. There is no formal planning of these routes, no time schedules and buses can stop to pick up or drop passengers wherever they want (even at the middle of the street). Those are the main reasons to have what is called “The War of Cent” between public buses on “bogotanians” streets. At the end of 1990’s, Bogotá was swamped in a transit chaos with a huge disorganized public transport system in sum of an “unavoidable” increase of Vehicle Park.

Being aware this big need of the city, at the end of 1990’s, major of Bogotá decides to improved and innovate infrastructure of public transport system by

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8www.transmilenio.com
9Worsened by the conflict refugees which arrive everyday to the city
11Enrique Penalosa was elected for a period of three years the period 1998-2001
the construction of the Transmilenio which is the most efficient BRT system even seen in Bogotá.

As we noted earlier, the Transmilenio system is one of the most popular and successful Bus Rapid Transit (BRT) system on the world. After its implementation, mobility in corridors where it works has been changed radically. Travel time decrease in 66% (from 1h30 hour to 30 min) and hence, accessibility also increase in a considerable level connecting the north and the south of the city on about 50 min per trip.

As a result of this reorganization of public transport network where public administration participates as manager and as inspector, a change of social and urban structure took place in Bogotá. Rich and poor neighborhoods are now connected directly by Transmilenio with direct consequences on social and urban configuration like in 60’s.

Due to the continuing sprawl of the city, public administration is thinking to develop more infrastructure projects like more lines of Transmilenio and/or the first line of metro in Bogotá. In fact, Bogotá belong to those big cities in South – America who does not have yet a subway network.

In that way, mobility became, to policy makers, one of the most important subjects in the city, without clearing importance to social and educational problems of course. Actually, this was the main topic in last campaign to the city hall and the winner was the candidate who proposed the construction of the first line of metro in the city which is very controversial from several points of view.

The two focal points of the discussion about the construction of the metro and/or more corridors of Transmilenio are principally the social and financial question. There are several studies supporting this project but the are some others against the metro and supporting the improvement of Transmilenio because of their low costs and so, its better accessibility to poor neighborhoods in the city.

Actually, since more than three decades, several cost-benefit analyses were presented to public administration. Many surveys and reports about social and economic impacts of those projects have been analyzed. Positive consequences of the construction of a metro line or the expansion of Transmilenio were always evaluated. Studies about this question were presented several times to the city, but no one could convince city council to give “green light” to the project.

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12 Before Transmilenio, this same trip take around 2.5 hours at less. The route is of at least, 20 kilometers

13 Samuel Moreno was elected in 2008 for a period of four years.

14 Lastly, two studies on transport in Bogota, one by the Japanese agency of technical cooperation (JICA) and another by the consortium Ingetec S.A., Bechtel y Systra, were completed in 1997
It became a “political question” and without this political consensus, the project has not been able to start up.

Therefore, searching to understand trips’ behavior of inhabitants and because of the extremely increasing congestion in the streets of the city, public administration decided to make the most detailed poll ever made in the city\(^\text{15}\). Table 1 show us the information we have access with this poll. It took in consideration several variables regarding mobility of inhabitants like travels’ time, distance of trips, starting and destination points, social provenance, kind of job among other variables within each 112 zones of the city\(^\text{16}\).

Tables 1 and 2 show us variables which are taken in consideration in that study. Table 2 point up descriptive statistics of that poll.

Table 1: Variables taken in consideration in the poll 2005

<table>
<thead>
<tr>
<th>UPZ of origin</th>
<th>UPZ of destination</th>
<th>Reason of the trip</th>
<th>Type of vehicle or transport used to travel from O-D</th>
<th>Principal activity of the person</th>
<th>Type of job of the person which principal activity is to work</th>
<th>Socio-economic class</th>
<th>Calculated time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Return to the house</td>
<td>Foot</td>
<td>Study</td>
<td>Worker or employee</td>
<td>1</td>
<td>Time of walk to reach the station</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Go to work</td>
<td>Bike</td>
<td>Job</td>
<td>Housework employee</td>
<td>2</td>
<td>Time of walk into the station</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Study</td>
<td>Bicycle</td>
<td>3</td>
<td>Independent worker</td>
<td>3</td>
<td>Time into the vehicle</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Business</td>
<td>Private car as driver</td>
<td>4</td>
<td>Manager or owner</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Shopping</td>
<td>Private car as passenger</td>
<td>5</td>
<td>Household worker without salary</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Personal business</td>
<td>Taxi</td>
<td>6</td>
<td>Independent</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Change of bus</td>
<td>Motorcycle</td>
<td>7</td>
<td>Search job</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Other</td>
<td>House job</td>
<td>8</td>
<td>Other</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Independent worker</td>
<td>9</td>
<td>Other</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Manager or owner</td>
<td>10</td>
<td>Manager or owner</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Job</td>
<td>11</td>
<td>Manager or owner</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Retired</td>
<td>12</td>
<td>Manager or owner</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Home worker</td>
<td>13</td>
<td>Manager or owner</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Independent worker</td>
<td>14</td>
<td>Manager or owner</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Manager or owner</td>
<td>15</td>
<td>Manager or owner</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Other</td>
<td>16</td>
<td>Manager or owner</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>112</td>
<td>112</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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. Even if the sample is not negligible (84,000 interviewed), it still has been just a poll which has to be complemented with other information like the transport matrix. Actually, it does not have every kind of possible trips into the city which can be found on the transport matrix of the city. Nevertheless, results of this poll revealed interesting information about commuting behavior and accessibility in the city.

\(^{15}\)Mobility Survey 2005 or “Encuesta de Movilidad 2005”, in Spanish.

\(^{16}\)Bogota has 112 UPZ, so a person has 111 possibilities of destinations if he is in one of those 112 UPZ. 12432 is the result of 112x111
Table 2: Descriptive statistics according to the type of job of the person which principal activity is to work

<table>
<thead>
<tr>
<th>Type of job</th>
<th>Time</th>
<th>Mean</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker of employee</td>
<td>Time of walk</td>
<td>4.37</td>
<td>55</td>
<td>0</td>
<td>4.86</td>
</tr>
<tr>
<td></td>
<td>Time of wait</td>
<td>6.99</td>
<td>105</td>
<td>0</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>Time into the</td>
<td>58.23</td>
<td>1010</td>
<td>1</td>
<td>39.98</td>
</tr>
<tr>
<td></td>
<td>vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housework employee (cleaning, driver, ...)</td>
<td>Time of walk</td>
<td>4.78</td>
<td>62</td>
<td>0</td>
<td>4.86</td>
</tr>
<tr>
<td></td>
<td>Time of wait</td>
<td>7.88</td>
<td>80</td>
<td>0</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>Time into the</td>
<td>62.31</td>
<td>600</td>
<td>1</td>
<td>39.98</td>
</tr>
<tr>
<td></td>
<td>vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent worker</td>
<td>Time of walk</td>
<td>3.36</td>
<td>123</td>
<td>0</td>
<td>4.86</td>
</tr>
<tr>
<td></td>
<td>Time of wait</td>
<td>5.51</td>
<td>93</td>
<td>0</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>Time into the</td>
<td>52.93</td>
<td>910</td>
<td>1</td>
<td>39.98</td>
</tr>
<tr>
<td></td>
<td>vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manager or owner</td>
<td>Time of walk</td>
<td>1.63</td>
<td>70</td>
<td>0</td>
<td>4.86</td>
</tr>
<tr>
<td></td>
<td>Time of wait</td>
<td>2.28</td>
<td>90</td>
<td>0</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>Time into the</td>
<td>40.97</td>
<td>240</td>
<td>5</td>
<td>39.98</td>
</tr>
<tr>
<td></td>
<td>vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household worker without salary</td>
<td>Time of walk</td>
<td>2.81</td>
<td>10</td>
<td>0</td>
<td>4.86</td>
</tr>
<tr>
<td></td>
<td>Time of wait</td>
<td>3.5</td>
<td>20</td>
<td>0</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>Time into the</td>
<td>46.31</td>
<td>120</td>
<td>10</td>
<td>39.98</td>
</tr>
<tr>
<td></td>
<td>vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Time of walk</td>
<td>3.01</td>
<td>95</td>
<td>0</td>
<td>4.86</td>
</tr>
<tr>
<td></td>
<td>Time of wait</td>
<td>4.69</td>
<td>91</td>
<td>0</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>Time into the</td>
<td>45.98</td>
<td>900</td>
<td>1</td>
<td>39.98</td>
</tr>
<tr>
<td></td>
<td>vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Results of the author from “Encuesta de Movilidad 2005”

In effect, among people which principal activity is to work, we can observe that commuting times differ between people with different kinds of job. As is 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 workers, employees and housework employees are those who take more time to reach their destinations.

(We will analyze further data on next sections of this paper)

1.4 Research question

As we highlighted earlier, several surveys and studies focus about the circumstances of transport networks in Bogotá and some possible policies from administration to improve them. Last one was the Mobility Survey 2005 that
gives us quite good information of commuting behavior of “bogotanians”. In spite of these studies, no one treats the impact of the transport network on the configuration of employment productivity in the city from a scientific point of view. The purpose of this paper is to analyze the relationship between transport systems, hence the relation between the level of accessibility\textsuperscript{17} of all zones in Bogotá with respect to the “employment landscape” of the city. Having those estimations, we expect to have the degree of accessibility\textsuperscript{18} to (and of) labor market in Bogotá which will include social parameters like the type of jobs or the social class of transport system users. Thereby, we will obtain the “effective size of the Labor Market” (Prud’homme and Lee, 1999; Wenglenski, 2004) of Bogotá.

With those results, we will understand the degree of correlation between accessibility to public transports and accessibility to jobs with respect to type of jobs and/or social class of labor force. Finally, using the Structural Equation Modeling technique, we will explore if between these variables we can suppose if it exists a causal relationship. Does accessibility or just travel time determine social class or type of job of people or are social classes or type of jobs, determinants of accessibility in Bogotá?

2 Urban structure, accessibility and effective size of labor market: selected literature review

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.

Between several methods to reduce “commuting time”, 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 Barr 2000, Cervero 2001) find as an answer, the construction or the extension of ways and highways. By the other side, to reduce time that people expend on each trip, some theorists suggest that densification of some zones of cities would be suitable (Duranton – Puga 2003). This “densification” can promote economies of agglomeration and the reduction of the distance between houses.

\textsuperscript{17}In our study, accessibility is defined as the number of activities accessible in a given range of travel time or distance according to the capability and affordability to reach public transport system and type of jobs of people.

\textsuperscript{18}Accessibility as we define on footnote 17
and jobs is reached. Actually, proximity between houses and work places is strongly suitable because, the more inhabitants are near with respect to their jobs, the less time they will expend in transports and by consequence the more efficient they will be.

However, a period of “Sprawl” took place in 70’s and 80’s\(^{19}\) and many cities thought that increasing of speed should be the answer. In effect, the number of cities where cars and car’ users were the spot of public policies (Glaeser 2004, Sheickman and Glaeser 99, Anas 99, Fujita 2001)\(^{20}\) is larger during this period. Development of several projects of public infrastructure like the construction of big avenues or highways which promote the use of car had, as principal consequence, a spread of the population and jobs in all cities (Brueckner 2002, Fujita 99, Anas 91, Zenou 2003, Cervero 01, 03). Though, at the end of 90’s, this solution seems not to be the best one as we can see now if we take in consideration the cost of pollution, the level of congestion and their costs and the waste of time traduced in a decreasing of productivity of residents who have a car. Consequently, bringing closer inhabitants and their jobs seems to be the better solution but this zoning have also as consequence a cost increasing\(^{21}\) of formal housing, hence, 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 this reason, even densification is not completely done a reduction of distance took place and fulfills this need by another way. Actually, the majority of public policies are focused to the reduction of commuting time between origins and destinations points to get closer houses and job places but not only with the improvement or the construction of more ways and highways but with the enhancement of the possibilities of inhabitants to travel between different places in cities. It can be traduced by an improvement of public transport system, accessible to the entirely population and not as excluding as policies who encouraged use of cars, thereby, it is upgrading of the infrastructure and transport policies tend to reach gains in time (Hammadou and Jayet, 2002).

These kind of policies look for an increasing of “disposable time”\(^{22}\) of employees that can boost their productivity and can provide an estimation of what Prud’homme and Lee (1999) denoted the “effective size of labor market” which is the average number of jobs reachable to workers in t minutes or less; size of the city, distance between homes and jobs (degree of sprawl) and average speed

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\(^{19}\)Even before this period and more precisely in USA and developing countries and Bogotá was not the exception.

\(^{20}\)Those studies talk about the “Sprawl process” of cities since decades ago and show how policies encouraged the car use.

\(^{21}\)Sometimes artificially.

\(^{22}\)Free of commuting time to be less tired and be more productive.
to take work places$^{23}$ from homes, defined the “effective size of labor market”. Those characteristics can explain the efficiency of cities and the difference of efficiency between cities.

Labor productivity is measured as the capacity of employees to produce as much as they can in a given time. Therefore, the larger is the “disposable time” to employee, the higher his output will be and by consequence, we can observe a bigger probability to have an increasing in productivity of the city (Cervero, 2001). Decreasing the time that employees spend in travels between homes and jobs, will have as consequence a gain on the productivity. But, “what is stake is not, as the car driver believes, the speed of journeys, but diversity, quality and density of opportunities allowed by urban areas” (Crozet, 2009).

This last sentence from Yves Crozet$^{24}$ (2009) can be interpreted as the need of the city and transport system to be more inclusive. Actually, it is not enough to reduce the time travel. The improvement of transport system should be useful to everybody, which means that it should pass in as much zones of the city as it can. It has to be unrelated of the social classes of population who live in theses zones but they have to take in consideration the kind of jobs of people and the characteristics of zones that the system is connecting. Thereby, if for example transport system join zone a with zone b, it could not have incidence in productivity because maybe zone a is a residential zone of bankers employees and zone b is a zone of factories. This is also one of our goals with this paper; to establish if in Bogotá, urban transport system has been efficiently introduced.

As stated above, transport system has to be more inclusive which means that public policies have to avoid flaws of exclusion of zones and social classes. 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 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).

$^{23}$It take place in a « working-day »  
$^{24}$Professor University of Lyon. Institute of Transport Economics - LET
3 Methodology and data: How to proceed?

3.1 Effective Size of Labor Market (ESLM) approach and econometrics tools: Structural Equation Modeling (SEM)

As we argued earlier, first of all we will tend to estimate the effective size of labor market in Bogotá. To do that, we will 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. To have a background of this approach, we will merely describe it as authors did on their paper.25

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)”. It give us \( n = 112 \) zones of study.

\( E_{k,i} \) will represent the 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. \( J_{k,i} \) represents the number of \( k \) types of jobs placed on zone \( i \) and \( \sum_{i} J_{k,i} = J \) the total of jobs in zone \( i \). Finally, \( T_{i,j} \) 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:

\[
L_{i}(t) = \sum J_{k,i}
\]

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

For the city ESLM will be.

\[
L(t) = \frac{\sum L_{i}(t) \cdot E_{i}}{E} = \frac{\sum_{i=1}^{n} \sum_{j} J_{j} \cdot E_{i}}{E}
\]

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.

25 We take same expressions than the authors
26 See page 1 subsection 1.1 of this paper
Having those results we will be able to better understand the correlation between ESLM and type of jobs or social classes. (Results will be presented in maps using GIS programs).

The estimation of the correlation between accessibility to public transports, accessibility to jobs and type of jobs will be based on the use of a Structural Equation Modeling (SEM). A regression analysis through an OLS or Probit is also suitable to contrast results from two different techniques. This diversity of analysis of the correlation will give us different kind of methods which can help us to comprehend this relationship. We assume that reader is familiar with concepts about OLS and Probit model. With respect to SEM we rather will give a barely description of how it works \(^{27}\).

SEM is a very powerful multivariate analysis technique that can be applicable to the construction and the estimation of causal modeling. Those models suppose the existence of causal relationships among variables and test the causal models with a linear equation system. Causal models can involve either manifest variables, latent variables or both.

To put into practice this approach, is advisable that researchers use a path diagram to establish inter-relation between some variables (fig. 1). The goal will be to test the structural relation models whether the variances and covariance fit this model. In order to better understand the test of causal model between social classes and accessibility to and for a specific zone in a city, figure 1 illustrates the conceptual model from the perspective of the aggregate data available to us.

\(^{27}\)To a better background about SEM, reader is advised to consult Principles and Practice of Structural Equation Modelling, Rex Kline
We expect to have more information about the employment and unemployment in the city. This is just a brief example of the conceptual structural equation model. It is not the last one version.

Narrows represent relationships and direct effects between variables. A single one represent direct effect from one variable to another one and reciprocal narrows represent possible interactions (causal relationship) between two endogenous variables.

Figure 1 shows us that commuting times determine social class and type of job but as several theorists have demonstrated, type of jobs and social class has a reciprocal interaction. Type of jobs can determine social class and vice versa. But, as shown in the figure, social class and commuting times can also have a reciprocal relation. In effect, we postulate that time that people take into the vehicle, time they take to go to the station and time they spend waiting until the vehicle (bus, metro, taxi) arrive, determine also social class and kind of jobs. So, type of jobs is also defined by generalized cost of trips which, at their turn, are defined by the fact of the tenure of a car. If we talk about car owners, we expect to have less generalized cost of trip because people could reach their jobs by car or by public transports; they have different choices. But this is not always true. Actually people can reach their jobs in less time by public transports. If the number of car owners raises a lot, the congestion will be bigger, so the time of a travel will be higher and the generalized cost of trip will be superior, so people could decide to change their commuting behaviour. This fact is also characterized by type of job; actually, depending of the type of job, people can or have to buy a car or not.
These kinds of relationships and more precisely the causality among variables is what we want to demonstrate with the SEM.

### 3.2 Data Base

As we illustrated earlier, the City Hall made a rather complete study about the mobility behavior in Bogotá with information about travels made by inhabitants. The data base used for this 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 among other information, can be found in this poll.

Results from this survey were really satisfactory to the city. It analyzed by first time, the mobility behavior of “bogotanians”. 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, not all possible trips within 112 zones of the city were taken in consideration. Actually, if we consider the 112 UPZ, we can suppose that, at least, we can have 12432 possible different travels or itineraries but this is not the case.

To complete this information we will also use the Transport Matrix of Bogotá. This matrix encloses information about all possible itineraries “from” and “to” every 112 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 all the UPZ so, we will resume data of the transport matrix in 112 UPZ in order to have just 12432 itineraries.

It is also important to know that all the information about the matrix transport of Bogotá is also available by the type of transportation. We have information about the time that people expend into their cars or into the public buses but we have also information about the time they stay on stations waiting for public buses or even the time they spend walking from their houses or jobs to the nearest station. All this kind of information is needed to improve conceptual SEM.

Finally, to complete our analysis and take into consideration social provenance and social condition of UPZ, we will use results from a census made in the city in 2007 that include information of quality of life in the city. Data like

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28 Secretaría de Movilidad del Distrito; Plan Maestro de Movilidad 2005
29 Secretaría de Movilidad del Distrito and Profesor Juan Pablo Bocarejo from University of Los Andes (Bogota) we obtained this information.
30 Encuesta de Calidad de Vida para Bogotá (ECV) 2007. Secretaría de Planeación del Distrito de Bogotá
socioeconomic level, number of unemployment people on each zone, level of education, number of cars by households among other variables can be found in this study and will be used in our analysis like control variables.

In that moment we have all the information we describe in this section but we had a problem with the interpretation of data of the transport matrix. Even if we have all data, we don’t have yet the codes from the Mobility Department of the city of Bogota to interpret those data. We hope that at the end of the November 2010 we will be able to use this information and make run our estimations.

A more detailed description of data will be available in this section. We will include as soon as possible statistic description of our data after the reception of last data we need to attac the empiric section of the paper.

4 Results/ What level of relationship between Jobs and Urban Transport System

Results we are waiting are, first of all the effective size of labor market of the city. Whit this estimation we hope we will have the map of how this market is constructed. We hope to get the configuration of this market by type of job and to show our results using the GIS method. After this mapping, we will proceed with the estimation of the causal relationship between type of job or social class of employees and accessibility index in the city of Bogota.

We think that there is a direct relationship between these variables: the more accessibility of public transport system is in a zone of the city, the best is the social class and the better are the type of jobs of inhabitants. Nevertheless, we are also waiting some contradiction with this hypothesis. Actually, it is observed (but not proved yet) that in some zones of the city where accessibility index is high, social class and types of jobs of inhabitants connected and living in these zones are not the best ones. Even so, we hope that with our methodology and data we could collect, we will be able to elucidate our research question.

5 Conclusions

We will be able to give some conclusions of our study in a couple of weeks after having our results.
6 Annexes

Annexe 1: Zonificación por UPZ

Source: Duarte Gutterman y Compañía 2005
Annexe 2: Distribution of labour force by UPZ

Annexe 3: Distribution of employment in the city of Bogotá 2005

Annexe 4: Origin of people who their reason to travel is for job

Annexe 5: Destination of people who their reason to travel is for job

7 Bibliography


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