

Using Land Value Capture to Fund Rail Transit Extensions  
in Mexico City and Santiago de Chile

by

Alvaro Covarrubias

Ingeniero Civil de Industrias  
Pontificia Universidad Católica de Chile, 1999

Submitted to the Department of Urban Studies and Planning in  
Partial Fulfillment of the Requirements for the Degrees of

Master in City Planning  
and  
Master of Science in Transportation

at the  
Massachusetts Institute of Technology  
June 2004

© 2004 Massachusetts Institute of Technology  
All rights reserved

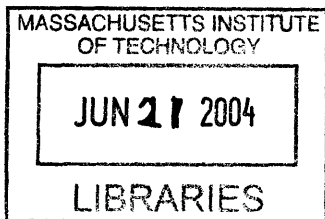
Signature of Author.....  
.....  
Department of Urban Studies and Planning  
May 17, 2004

Certified by.....  
.....  
Professor Ralph A. Gakenheimer  
Department of Urban Studies and Planning  
Thesis Supervisor

Certified by.....  
.....  
Professor Joseph M. Sussman  
JR East Professor  
Department of Civil and Environmental Engineering  
and Engineering Systems  
Thesis Supervisor

Accepted by.....  
.....  
Professor Dennis M. Frenchman  
Chair, MCP Committee  
Department of Urban Studies and Planning

Accepted by.....  
.....  
Professor Nigel H. M. Wilson  
Chair, MST Committee  
Department of Civil and Environmental Engineering



ROTCH

Using Land Value Capture to Fund Rail Transit Extensions  
in Mexico City and Santiago de Chile

by

Alvaro Covarrubias

Submitted to the Department of Urban Studies and  
Planning on May 17, 2004 in Partial Fulfillment of the  
Requirements for the Degrees of Master in City Planning  
and Master of Science in Transportation

ABSTRACT

The effects of rail rapid transit on land uses and land values are discussed. Rail transit can enhance accessibility, and can raise the demand for locating in areas around stations, increasing land value, and in some cases fostering redevelopment at higher densities. The attraction that the areas around stations produce depends on the number of trips generated for unit of land for different types of land-uses. A series of studies on the effect of rail transit on land values are reviewed.

Using data from censuses and origin-destinations surveys, the effects of metro lines on land-uses during the 1990's in Mexico City and Santiago de Chile are determined. Results show that in Mexico City neither zones located next to the new lines, nor zones located next to the lines built before 1990 had a higher growth of population, income per capita or employment, as compared to other zones with similar densities and incomes per capita. In the case of Santiago, whereas the areas located next to the newly built line had similar changes to other zones, the areas located next to the two lines built before the 1990's had a significantly higher growth in number of households and average income per capita than other areas, especially in high-income districts. These results are explained by the lower attractiveness of the metro for middle and high-income people in Mexico City as compared to Santiago de Chile, which is proven by specifying relations between ridership and GDP for both cities, using multiple regression models.

The potential of land value capture as a mechanism for funding rail transit in both cities is discussed, based on the experience of other rail transit systems around the world, and on the characteristics of both metros. In both cases a land value capture system is proposed for new lines. Some guidelines for the implementation of land value capture mechanisms are provided.

Thesis Supervisor: Ralph A. Gakenheimer  
Title: Professor of Urban Planning

## **Acknowledgments**

I would like to acknowledge financial support from the Integrated Program on Urban, Regional and Global Air Pollution with funds provided by the Fideicomiso Ambiental del Valle de México and the MIT/AGS. Additionally, I would like to thank the directors of the Program, Luisa and Mario Molina.

For this thesis I used some of the results from previous research I did on value capture, as part of a research program funded by Tren Urbano and the Chicago Transit Authority.

I would like to thank several people for the information they provided me. Some of them are Rafael Núñez, José Flores and Silvia Estrada from STC in Mexico; Pedro Sabatini and Roland Zamora from Metro in Santiago; María Teresa Atrián from Seduvi in Mexico; Henry Malbrán, Alan Thomas and Esteban Godoy from Sectra in Santiago; Bernardo Navarro from UAM in Mexico; Leonardo Martínez from Sigea in Mexico; Oscar Figueroa and Rodrigo Garrido from PUC in Chile; Pablo Trivelli from Universidad de Chile; Christopher Zegras and Francisco Gallego from MIT.

Several of my colleagues in the Integrated Program on Urban, Regional and Global Air Pollution provided valuable comments and suggestions. Particularly, I would like to thank Julia Gamas, Carmen Pastor, Cristian Guevara, Anjali Mahendra, Bernardo Ortiz and Alejandro Bracamontes.

My thesis Supervisor, Ralph Gakenheimer, as well as two other readers, Joseph Sussman and Mikel Murga, gave me important feed-back and advise. Two other faculty members, Ken Kruckemeyer and Fred Salvucci, gave me useful suggestions in the early stages of research.

Finally, I would like to thank my family and friends for their support and encouragement.

This thesis is dedicated to my wife Carolina

## Table of Contents

ABSTRACT .....	2
Acknowledgments.....	3
Table of Contents .....	4
List of Tables .....	7
List of Figures .....	10
Executive Summary .....	12
1 Motivation and Content .....	16
2 Introduction.....	18
3 Transportation Infrastructure and Land Values .....	22
3.1 Transportation infrastructure and accessibility.....	22
3.2 Accessibility and land values.....	24
3.3 Land values and optimal floor-area-ratio.....	26
3.4 Other conditions necessary for land values to increase .....	33
3.5 Who is benefited and who is affected by the construction of rail transit lines?.....	35
3.6 Land values, location decisions and city structure.....	38
3.6.1 Macro Level .....	38
3.6.2 Micro Level.....	44
4 Literature Review: The Effect of Rail Transit Construction on Land Values .....	46
4.1 General considerations.....	46
4.2 Studies on commercial properties.....	48
4.3 Studies on residential properties .....	49
4.4 Why have the studies shown different results?.....	52
4.4.1 Different methodologies to measure land value changes .....	52
4.4.2 Different technologies/annoyance to local residents .....	53
4.4.3 Different appeal to the public .....	54
4.4.4 Different opportunities for redevelopment around stations.....	55
4.4.5 Different conditions of the real estate market.....	56
4.4.6 Provision of pedestrian facilities.....	58

4.4.7	Accessibility that transit provides.....	58
4.4.8	Local externalities.....	60
4.4.9	Effects of Rail transit on crimes.....	60
4.4.10	Unbalance between transit value proposition and land values .....	61
5	Mexico City and the Metro .....	62
5.1	Urban development in Mexico City.....	62
5.2	Public transportation and the metro .....	69
5.2.1	History of public transportation .....	69
5.2.2	Metro and its ridership.....	76
5.3	Effects of the metro on the city.....	77
5.3.1	Commented review of existing literature.....	77
5.3.2	An analysis of the effects of the metro lines 8, A and B on land uses.....	82
6	Santiago and the Metro .....	107
6.1	Urban development in Santiago.....	107
6.2	Public transportation and the metro .....	114
6.2.1	History of public transportation .....	114
6.2.2	Metro and its ridership.....	120
6.3	Effects of the metro on the city.....	122
6.3.1	Commented review of existing literature.....	122
6.3.2	An analysis of the effects of the metro on land uses.....	128
7	Reasons to Explain the Different Impacts in Both Cities .....	139
7.1	Differences in the intensity of use .....	139
7.2	Different average income of riders in both cities.....	144
7.2.1	An analysis of ridership in Mexico City.....	145
7.2.2	An analysis of ridership in Santiago de Chile.....	152
7.2.3	Conclusions from the analyses.....	159
8	Using Land Value Capture to Fund Transit Investment .....	161
8.1	Distortions generated by property taxes .....	161
8.2	The case for land value capture .....	163
8.3	Land value capture in the US.....	165
8.4	Land value capture in Europe .....	168

8.5	Land value capture in Asia .....	170
8.6	Land value capture in Latin America.....	171
9	Proposals .....	174
9.1	What to do.....	174
9.1.1	Using tax increment financing .....	174
9.1.2	Direct negotiations .....	177
9.1.3	Special benefits assessment .....	178
9.1.4	Differentiated pricing, capturing of consumer's surplus .....	179
9.2	Proposal for Santiago.....	180
9.3	Proposal for Mexico.....	183
	Conclusions.....	186
	References.....	192
	Appendix 1.....	201
	Appendix 2.....	202
	Appendix 3.....	206
	Appendix 4.....	209
	Appendix 5.....	211

## List of Tables

Table 1: Trip intensity per unit of floor area in the US .....	39
Table 2: Trip intensity per unit of ground area .....	40
Table 3: Variation in urbanized area and population, 1970-1987 .....	65
Table 4: Population and density in the MCMA .....	78
Table 5: Correlation of Density and Distance to Zócalo with Average Income per Capita for AGEBs in the MCMA.....	90
Table 6: Number of the 77 selected AGEBs in each of the twelve categories .....	91
Table 7: Comparison of changes in population and average income per capita of AGEBs with high income, low density and high distance to the city center, sorted by accessibility to metro .....	92
Table 8: Comparison of changes in employment for AGEBs with high income, low density and high distance to the city center, sorted by accessibility to metro .....	93
Table 9: Comparison of changes in population and average income per capita of AGEBs with low income, low density, low distance to the city center, sorted by accessibility to metro .....	94
Table 10: Comparison of changes in employment for AGEBs with low income, low density, low distance to the city center, sorted by accessibility to metro .....	95
Table 11: Comparison of changes in population and average income per capita of AGEBs with low income, low density, high distance to the city center, sorted by accessibility to metro .....	96
Table 12: Comparison of changes in employment for AGEBs with low income, low density, high distance to the city center, sorted by accessibility to metro .....	97
Table 13: Comparison of changes in population and average income per capita of AGEBs with low income, medium density, low distance to the city center, sorted by accessibility to metro .....	98
Table 14: Comparison of changes in employment for AGEBs with low income, medium density, low distance to the city center, sorted by accessibility to metro .....	99

Table 15: Comparison of changes in population and average income per capita of AGEBs with low income, medium density, high distance to the city center, sorted by accessibility to metro .....	100
Table 16: Comparison of changes in employment for AGEBs with low income, medium density, high distance to the city center, sorted by accessibility to metro .....	101
Table 17: Comparison of changes in population and average income per capita of AGEBs with low income, high density, low distance to the city center, sorted by accessibility to metro .....	102
Table 18: Comparison of changes in employment for AGEBs with low income, high density, low distance to the city center, sorted by accessibility to metro .....	103
Table 19: Change in Employment in AGEBs in the DF in Mexico City, sorted by delegación .....	105
Table 20: Population in Santiago de Chile .....	108
Table 21: Value of land in different areas of Santiago (constant CHP of 1980 / m <sup>2</sup> ) ....	124
Table 22: Upper and Lower limits of average income per capita and population density for zone groups in Santiago de Chile .....	130
Table 23: Number of zones in each of the eight categories.....	131
Table 24: Comparison of changes in population and average income per capita of zones of group A in Santiago .....	132
Table 25: Comparison of changes in population and average income per capita of zones of group C in Santiago .....	133
Table 26: Comparison of changes in population and average income per capita of zones of group E in Santiago .....	134
Table 27: Comparison of changes in population and average income per capita of zones of group G in Santiago.....	135
Table 28: Upper and Lower limits of average income per capita and population density for zone groups in Santiago de Chile .....	137
Table 29: Change in income per capita and population density for X and Z-zones in Santiago.....	137
Table 30: Passengers per station in selected subways around the world in 1998.....	142
Table 31: Results of regression with Model 1 for Mexico City .....	148

Table 32: Results of regression with Model 2 for Mexico City .....	149
Table 33: Results of regression with Model 3 for Mexico City .....	149
Table 34: Results of regression with Model 4 for Mexico City .....	150
Table 35: Results of regression with Model 5 for Mexico City .....	150
Table 36: Results of regression with Model 6 for Mexico City .....	151
Table 37: Results of regression with Model 1 for Santiago de Chile .....	154
Table 38: Results of regression with Model 2 for Santiago de Chile .....	155
Table 39: Results of regression with Model 3 for Santiago de Chile .....	156
Table 40: Results of regression with Model 3 for Santiago de Chile .....	157
Table 41: Results of regression with Model 6 for Santiago de Chile .....	158
Table 42: Ridership, GDP, average fare, average fare/GDP per capita and number of stations in Mexico City .....	202
Table 43: Ridership, GDP, average fare, average fare/GDP per capita and number of stations in Santiago .....	203
Table 44: Income per capita, distance to city center, Urban Area for municipalities in the Santiago Metropolitan Area .....	206
Table 45: Income per capita, distance to city center, Urban Area for municipalities in the Santiago Metropolitan Area .....	207
Table 46: Hypothetical stations in a new metro line in Santiago .....	211
Table 47: Average value of land sold in the fourth quarter of 2002 in selected municipalities of the Santiago metropolitan area.....	212
Table 48: Total area around stations subject to special charge, and generated revenue.	213

## List of Figures

Figure 1: Average travel time of journeys to work for households with different income in the US .....	27
Figure 2: Average travel time of the journey to work of groups of households with different income in the US .....	28
Figure 3: Cost and price per unit of housing.....	30
Figure 4: Profits per unit of land.....	31
Figure 5: Shift in demand after new rail station opens .....	32
Figure 6: Profits per unit of land, before and after a rise in demand .....	32
Figure 7: Residents in the Mexico City Metropolitan Area.....	63
Figure 8: Density for concentric rings in Mexico City .....	66
Figure 9: Density of commercial and service jobs in districts of the MCMA .....	68
Figure 10: Map of Mexico City's Metro.....	75
Figure 11: Number of passengers in the different lines in Mexico City 1969-2003 .....	76
Figure 12: Histogram of Average Income per Capita in 1990 of 83 selected AGEBS .....	85
Figure 13: Summation of variances of average income per capita of two groups of AGEBS .....	86
Figure 14: Histogram of Residents per Block in 1990 for 82 selected AGEBS .....	87
Figure 15: Summation of variances of residents per block of two groups of AGEBS.....	88
Figure 16: Histogram of Distance to Zócalo for selected 78 AGEBS.....	89
Figure 17: Summation of variances of distance to Zócalo of two groups of AGEBS .....	90
Figure 18: Density for concentric rings in Santiago .....	112
Figure 19: Density for concentric rings in Santiago, excluding Zona Oriente .....	113
Figure 20: Original Metro Plan in Santiago.....	115
Figure 21: Bus and Metro Fares 1978-1991 .....	117
Figure 22: Map of current lines and lines being constructed in Santiago.....	119
Figure 23: Number of passengers per line in Santiago .....	120
Figure 24: Income per capita and population density of zones located next to lines 1 and 2 in Santiago, Chile.....	136

Figure 25: number of passengers per year ..... 140

Figure 26: Passengers per station in Mexico City and Santiago..... 141

Figure 27: Intensity of use per line for Mexico City and Santiago de Chile in 2003 ..... 143

Figure 28: Ridership, GDP, average fare (adjusted for inflation) and number of stations in Mexico City’s metro ..... 146

Figure 29: Ridership, GDP, average fare and number of stations in Santiago’s metro.. 152

Figure 30: Percentage of Increasing Land Value Captured by TIF for Chile..... 176

Figure 31: Diagram of the effect of rail transit on real estate markets, and the potential for value capture ..... 186

## **Executive Summary**

After 150 years building railroads and highways, transportation planners are starting to realize what has been obvious for private investors from the first day: transportation infrastructure opens land for development. Assuming that after the construction of large pieces of transportation infrastructure land uses will remain unchanged, is nothing more than a naïve and myopic approach. The opening of rapid transit systems or highways induces transformations of land uses, and an increase in travel demand. In most cases, the benefits that justify the investment in highway projects do not remain in time: in few years average speeds return to their original level, and average trip lengths increase. In many cases, the only permanent benefits are the increases of accessibility and of land values.

In the 19<sup>th</sup> and 20<sup>th</sup> centuries, many private firms used value capture as a funding source for transportation infrastructure. In recent decades, the construction of roads and transit has become a task of governments, but they have largely failed to recover the benefits of their investment in this area. This passive attitude of governments has created perverse incentives for private companies, which have been allowed to capture these benefits through land speculation. Speculation reduces the availability of land for development, promoting sprawl. The failure to get an adequate return on the invested funds produces a shortage of transportation infrastructure, damaging the economy.

The lack of value capturing has reduced governments' accountability for the projects they implement. A century ago, if a streetcar line did not generate increases in land values or profits from its operation, the developer would go bankrupt. Nowadays, even if a highway does not generate land value increases, other external benefits, or profits from tolls or other sources, it can still be justified by the vague concept of being "good for the economy". This is nothing else than wasting taxpayers' money.

International experience shows that there are several ways in which transit agencies can maximize land values around stations. Some of them are to provide high quality

pedestrian facilities, assemble land for redevelopment, relax zoning constraints, remove local externalities, and solve the problems generated by the imperfections of the real estate market (e.g. speculation). Nevertheless, land value maximization should not be the only objective of transit agencies. They should also foster the creation of mix-uses around stations, which make transit a more attractive option by allowing people to make linked-trips, generating traffic all along the day, and producing a balance of flows in both directions of rail lines. At the network level, it is necessary to have a balance between generated and attracted trips, and to maximize the use of land around stations for traffic-intensive uses. These actions require metropolitan coordination, which is far from perfect in cities like Santiago de Chile and Mexico City.

Transit agencies, local governments and private developers have used several mechanisms to capture land value increases generated by rail transit. The most common approach in the US has been joint development, which has captured only a minor part of land value increases, but has been relatively successful in increasing the number of riders, and hence, fare-box revenue. Several other alternatives, such as tax increment finance, direct negotiations and special benefit assessment are usually more effective than joint development to collect revenue, and have been used in Europe and Asia to fund transit. In these regions private companies and governments have funded commuter lines through land development. In other cases, property owners have been asked to help fund new rail transit lines. The British government has recently announced that it will use this kind of mechanism to fund a significant portion of Crossrail, the new line being planned for London. In Latin America, there is very limited experience with these mechanisms for funding transit systems, Sao Paulo being the city with the most successful experience, through a program of joint development of shopping centers and bus terminal around rail transit stations.

Land value capture has also been used to fund other transportation infrastructure. Highways usually use mechanisms such as direct charges to users, and the creation and rental of retail space next to highway (e.g. for gasoline stations).

A reform of the property tax systems, including a tax levied exclusively on land at a higher rate than today, and based on the most intensive potential use of the land, would create an efficient mechanism to capture land value increases. It would also have several additional benefits, such as lowering monitoring costs and evasion (as there are no tax-havens for land), reducing speculation and sprawl, and facilitating the access to land of low-income people. The revenue from such a tax would allow governments to reduce other taxes, or increase spending.

Rail transit systems can maximize their impact on land values and land uses by providing an attractive value proposition for people that can afford living next to the stations and that would like to live there. Alignments along high-income areas only have a positive impact on land values if rapid transit's value proposition is attractive to those people. Conversely, fares that are too high may have a null effect on land uses and land values in low-income areas.

Sometimes local governments may need to provide incentives for the location of firms and families around transit stations. People have many alternative areas to locate in, some of which have prices that do not account for the external cost generated by locating there. This is the case of the suburbs. Providing subsidies for the construction of rail transit is only acceptable as a second best option, when charging vehicles for the congestion, pollution, accident and infrastructure costs they produce is not feasible. Still in those cases, to create an efficient allocation of resources, the amount of subsidy to transit investment should be limited to the value of the external costs produced by cars. Even in these cases, using land value capture to fund transit investment would not hamper the objective of attracting residents and firms to the area, and in fact it can help create the necessary infrastructure to make the area attractive.

Rapid transit investment is not only desirable for its own sake, but also for its capacity to shape land uses and city form. Cities served by transit can have more interaction among people. Moreover, transit can increase accessibility and labor efficiency. These benefits are not fully captured by fare revenue but transferred to consumer's surplus and land

values. Finally, by reducing the number of cars in the streets, transit provides external benefits, such as reducing pollution, congestion and accident costs.

I propose the usage of value capture mechanisms to fund future rail transit extensions in Mexico City and Santiago de Chile. Among the possible methods of value capture, I suggest the implementation of a scheme of different fares for distinct segments of the market; special-benefit assessment, and special negotiations with property owners. I also suggest implementing a plan for reducing the barriers for redevelopment around the exiting and future lines, specifically to avoid zoning constraints, limitation for people to sell the homes they bought with governments' support, fragmentation or lack of legality in the ownership of the land, and speculation.

New lines would generate network economies for the overall transit system, and force a more intense use of urban land. This intensification of land uses would ultimately benefit transit systems by creating a larger base of origin and destinations along the alignments, and therefore increasing ridership.

Implementing value capture to fund rail transit would have several benefits for Mexico City and Santiago. The cost/benefit analysis of new extensions would be scrutinized in more detail; the governments would be able to reduce the expenses in new projects, and focus on transferring funds for the poor; the funds would create a stable and long-term funding source, less dependent on political cycles than under the current funding system; maybe some extensions of the metro network that would be profitable to built from a social point of view, would not need to be postponed.

## **1 Motivation and Content**

The purpose of this thesis is to study how the construction of rail transit affects land values and land uses, to review the impacts of different rail transit systems around the world on land values and land uses, to determine the result that mechanisms of land value capture have had in different cities around the world, and to explore the potential of these mechanisms in Mexico City and Santiago de Chile.

Chapter 2 is an introduction to the problem of mobility in cities around the world.

Chapter 3 gives an overview of the relation of transit and cities, explaining how the accessibility provided by transit is capitalized into land values. It also discusses the relation of rail transit and land values, and their impact on density. Then, it discusses some of the conditions required for land values to increase, and the income-distribution effects of these increases. Finally, it analyzes the way rail transit shapes cities at the macro and micro levels.

Chapter 4 discusses the effect that rail transit systems have had on land values in different cities in the developed world. Several hedonic price studies of urban real estate of cities in the US and Europe are described. Some of the reasons explaining the contradictory results obtained in these studies are discussed.

Chapters 5 and 6 focus on Mexico City and Santiago de Chile, respectively. These Chapters review the history of the construction of their metros, and they discuss how they have affected land values and land uses. The Chapters discuss the applicability of the principles discussed in Chapter 3 for the context of the developed world to the context of these two metropolitan areas.

In Chapter 7, different hypotheses to explain the different impact of the metros in Mexico City and Santiago de Chile are tested.

Chapter 8 discusses the imperfection created by most property taxes, and makes the case for using land value capture to fund rail transit construction. This Chapter also describes different mechanisms that have been used to capture land value increases generated by rail transit projects, in the US, Europe, Asia and Latin America, by a wide array of entities, including transit agencies, local governments, and private companies.

Finally, Chapter 9 discusses the advantages and disadvantages of different mechanisms for value-capture in the context of Mexico City and Santiago de Chile, and proposes approaches to implement these mechanisms in the two cities.

## 2 Introduction

In many cities around the world, residents are expressing an increasing concern for road congestion. Economic growth and the relative reduction of the cost of buying and operating private vehicles with respect to income, have spurred a fast growth of motorization rates. The problem is not exclusive to cities in developed countries. In fact, in recent years, motorization rates have grown the fastest in some developing countries<sup>1</sup>. The growth of motorization has driven the increase in congestion, and the decrease of the modal share of transit. Congestion alters daily life dramatically, and this is why it has become a topic of interest not only for transportation experts, but also for policy makers.

Adapting cities to the demand of infrastructure for vehicles has become a difficult task, especially in cities that were shaped before the car-era. The high densities of pre-car cities make the widening of roads and the construction of highway extremely expensive. Meanwhile, some of the cities that have been designed to accommodate the automobile and have low transit shares, have suffered a rise in the demand for road space, which has caused severe congestion<sup>2</sup>. Very few cities around the world have been able to avoid congestion. Some of them are cities with very low income and low motorization, and others are cities with tight control on car usage such as Singapore<sup>3</sup>.

Due to the high cost of providing more road space in urban areas, governments are looking for alternative solutions to congestion. Many cities have tried to improve transit systems to make them an attractive option to automobiles. Other cities have tried to raise the direct cost of using cars. Whereas the provision of transit usually enhance people's mobility, making private transportation more expensive generally does the opposite,

---

<sup>1</sup> Gakenheimer (2002) states that in recent years some developing countries such as China, Mexico and Korea, have had motorization growth above 10% a year.

<sup>2</sup> According to TTI (2002), between 1982 and 2000 Los Angeles was the US city with the largest growth in annual delay per peak road traveler. Other car-oriented cities, such as Dallas, Denver, Orlando and Atlanta are also among the 10 cities with the highest increases.

<sup>3</sup> Gakenheimer (2002).

unless transit service is provided<sup>4</sup>. Therefore, raising the cost of using cars should be a complement of transit improvements, and its objective should be to produce an increase in the modal share of transit.

It is expensive to provide high-quality transit service in areas with low densities. Transit is a cost-effective option only in densely built environments. Convincing people to accept an increase of the cost of using cars is not an easy task, because of the notion that people have the right to use their cars wherever and whenever they want and free of charge, is very entrenched in modern societies. Moreover, in cities where car ownership is not affordable for everybody, as it is the case in Mexico City and Santiago, driving a car is a symbol of social status.

By 1995 both Mexico City and Santiago de Chile, had fewer cars per capita than comparable cities in Latin America. Whereas in Mexico City there were 200 private vehicles per 1000 inhabitants in 1995, its two most similar cities in terms of population in Latin America, Sao Paulo and Buenos Aires, had 301 and 264 per 1000 inhabitants respectively. Santiago, with 83 private vehicles per inhabitant, also lagged behind Caracas (139) and Bogotá (89), two cities in the region with almost the same population<sup>5</sup>.

In addition to the benefits to their users, transit systems usually provide external benefits. Compared to other modes such as private automobiles, transit usually produces less congestion and less pollution per passenger, particularly as buses and trains have many passengers per vehicle. In many cases, rail transit also produces an increase of the value of real estate around stations, which is in part a measure of its passengers' consumer surplus. If governments were capable of capturing part of these external benefits, they could build more rail transit and increase social welfare.

---

<sup>4</sup> The exception is when, just by charging a congestion toll, the carrying capacity of the road network is increased. This happens when the initial density of vehicles on the roads is more than the density that maximizes flows.

<sup>5</sup> All figures from UITP (2001). DICTUC (2003) reports that in 2001 the motorization rate in Santiago had grown to 148 vehicles per 1000 inhabitants.

The high investment cost of rail transit is the main barrier to their construction. Rail transit usually provides a high quality service, at least along the corridors it serves. In spite of its popularity among city dwellers all over the world, rail transit is usually discarded as an option, because of its high investment cost. With few exceptions, rail transit systems are not able to pay for their operational costs, and they need government subsidies<sup>6</sup>. In this respect, they are not different from highways, with the exception that subsidies to road construction seem to be more politically acceptable<sup>7</sup>. This dependency on governments' budget makes long-term financing of transit uncertain, and heavily affected by political cycles.

In recent years, there has been an extensive debate around the comparison between rail transit and bus rapid transit (BRT)<sup>8</sup>. Heavy rail is accused of being too expensive for developing countries, inflexible, and overall less cost-effective than BRT or than other improvements of the bus systems<sup>9</sup>. Mexico City and Santiago are two cities in developing countries that have built heavy rail transit systems, but both are planning to build the first BRT lines in the next few years.

In spite of the loss in modal share of rail transit in recent decades, the governments of Chile and Mexico are planning further extensions of their capital cities' subways in the future. These reductions in share will probably continue in the near future, for the following reasons:

- The increase in income will determine a higher motorization rate
- Suburbanization is likely to continue, fueled by the availability of land on the fringes of the city and the construction of roads to serve these areas
- Many train cars are approaching the end of their operational life. Unless governments invest in fleet renewal, there will be a deterioration of their level of service

---

<sup>6</sup> Some of the few subways that cover their operational costs are Honk Kong, Singapore and Santiago de Chile.

<sup>7</sup> The proportion of roadway construction cost that was paid by car users through fuel and vehicle taxes in the US is only 56% (Moore and Thorsnes, 1994). In many other countries the situation is similar.

<sup>8</sup> For example see Kuhn (2002) and Stutsman (2002).

<sup>9</sup> See World Bank (1986).

The next Chapter reviews the effect of rail transit on accessibility, and discusses how the increases in accessibility affect the location decision of different activities.

### **3 Transportation Infrastructure and Land Values**

In this Chapter, I will discuss how rail transit and roads induce changes in the pattern of land development through an increase of accessibility. I will also describe other factors that affect land values. Then, I will identify the groups that may benefit from these increases of land values, and those who may be affected. Finally, I will describe how rail transit shapes cities, at a macro level (the entire city), and at a micro level (the neighborhood).

#### **3.1 Transportation infrastructure and accessibility**

The construction of transportation infrastructure creates different effects on traffic, depending on the time frame we consider. In the short-run, new infrastructure relieves congestion. The beneficiaries of this effect are the users of the preexisting roads or transit systems. Considering this benefit, several governments around the world have allowed private companies to build new highways and charge tolls for using them. These highways provide mobility in excess of what is considered to be the minimum government's provision, which is given for free (for example the interstate highway system in the US). The provision of transportation infrastructure by the private sector has created a market for mobility. Tolls become price-signals that may lead to an optimal provision of transportation infrastructure<sup>10</sup>. The same thing happens with railroads, which in many countries are open to different users, in exchange for a toll.

In most cases, soon after the opening of new transportation infrastructure to the public, new traffic is generated. This traffic comes as a consequence of the improvement of the level of service provided, and it is equivalent to a movement along the transportation demand curve. Generated traffic comprises diverted traffic and induced traffic. Diverted traffic is a consequence of people's shift in time, route or destination as a response to the

---

<sup>10</sup> However, charging a toll that covers the investment cost of roads is not optimal if there are scale economies for the construction of roads or if the level of road investment is not optimal (Gómez-Ibáñez, 1999).

reduction of the cost of using a route. Induced traffic refers to new vehicle-miles generated as a consequence of people switching to cars from other modes, taking longer trips or making new trips<sup>11</sup>. The construction of new infrastructure benefits these new users, but at the expense of the rest of the users, who suffer an increase of their travel times.

To reduce congestion, some highways charge an extra amount of money for driving at rush hour, in addition to their flat tolls. Similarly, many rail transit systems charge more during peak-periods. This is a second level of price signaling, which allows for a more precise alignment of supply and demand in the short-run, and the optimal provision of mobility in the long-run.

Once construction for the new road begins, it is very common to see real estate developers taking advantage of the new accessibility by locating new residents, as well as commercial or service centers in close proximity to the new infrastructure. So it is not surprising to witness how new transportation infrastructure affects the location decision of firms and families. In most cases, the construction of new transportation infrastructure makes the served land more accessible. Accessibility is one of the main attributes that affect the location decision of firms and, to a lesser extent, families. This difference is due to the fact that firms usually generate more trips per unit of land than families (see section 3.6.1). The relocation of activities that occurs after the construction of transportation infrastructure is equivalent to a rise of the transportation demand curve. The subsequent increase in traffic flows, plus the traffic generated by the reduction in travel costs, is the total induced demand.

Accessibility is an abstract concept that represents "...the ease at which people can pursue the activities they desire, and business can connect with consumers, employees and goods"<sup>12</sup>. There are several ways to measure accessibility. All them add up the number of different activities around a point, weighted by a measure of how easy is to get

---

<sup>11</sup> De-Corla Souza (2000), Litman (2003).

<sup>12</sup> Walker (1998).

to those activities (shops, firms, services, housing, etc.). Studies of property values with hedonic price models have consistently proven that accessibility is one of the main attributes that determine land values, and that its effect on them is highly positive.

There is also another type of accessibility, the so-called destination accessibility, which is the proximity of out-of-home activities to each other<sup>13</sup>. An easy connection between these activities makes it easier for people to link trips, and therefore reduces travel costs.

The reductions in people's travel time, which are usually the main justification for road construction, have been proved to disappear very fast as a consequence of induced demand<sup>14</sup>. The only lasting benefits of the transportation investment are the new trips, which are marginally profitable (in fact they are not profitable at the previous average cost level)<sup>15</sup>. Only in the cases where tolls are charged, can reductions in travel time be sustained over time.

### **3.2 Accessibility and land values**

In this section I will discuss how the increase in accessibility produced by transportation infrastructure affects land values.

As I said in the previous section, the construction of transportation infrastructure raises accessibility through a reduction in travel time and travel cost. In some cases, transportation infrastructure also promotes the clustering of activities, enhancing destination accessibility. This is especially true for rail transit, which has a higher capacity to concentrate development than highways. Therefore, if all other factors that affect land values remain constant, the construction of transportation infrastructure should produce land value increases. As in most cases, property owners do not pay for the construction of transit facilities; this is an external benefit for them.

---

<sup>13</sup> Ewing (1997).

<sup>14</sup> SACTRA (1994).

<sup>15</sup> Litman (2003).

In the long run, there is an additional mechanism through which transportation infrastructure raises land values. The reduction in transportation costs or increase in productivity generated by transit can attract labor and capital to the region served by public transportation. In other words, cities that are more productive attract more economic activity<sup>16</sup>. The arrival of more labor and capital to the city generates an increase in land values not only in the area directly served by the transportation infrastructure, but also in the entire city or region. This compensates for losses in the value of the land that is not served by the new infrastructure. These losses arise because, in the short-term, the stocks of capital and labor are fixed<sup>17</sup>.

The increases in land values are in part a result of consumer's surplus. Every road user or transit passenger has a demand curve for the usage of the infrastructure. Given the fact that these demand curves are different for every user, it is impossible to charge every user a discriminatory toll that captures that user's entire consumer's surplus (it is usually illegal also). Users that benefit from the service provided by the infrastructure are willing to bid for the land served by it. The amount of money they are willing to pay for using the land is equal to the surplus they obtain from using the infrastructure<sup>18</sup>. This willingness-to-pay for the land makes values rise, regardless of whether the owners of the land use the infrastructure or not. The gains in accessibility only have an effect on land values, and not on the values of the structures built on the land<sup>19</sup>.

When transportation infrastructure is built, the land served by this infrastructure can be used more intensively, keeping the level of welfare of the previous users constant. The construction of transportation infrastructure raises the capacity of the land to carry urban development. This benefit is additional to the surplus of the previous consumers.

---

<sup>16</sup> Increasing the competitiveness of the city has been one of the reasons cited most often to justify rail transit investment.

<sup>17</sup> I am not aware of any study showing a long-term negative effect on land values for properties not served by rail transit.

<sup>18</sup> Moore and Thorsnes (1994).

<sup>19</sup> See Alonso (1964) and Muth (1969) for a more complete description of the capitalization of accessibility.

As land value increases are in part a measure of consumer's surplus, governments should not add all these increases as additional benefits to consumer's surplus in cost-benefit analysis. These evaluations should include, however, the rise of values resulting from the increase in carrying capacity of the land, along with the savings in travel time and travel cost of the users of the infrastructure, plus all external costs.

The subsidies that both cars and transit receive reduce the attractiveness that private investors can obtain from investing in transportation infrastructure. In some cases, governments are willing to give similar subsidies to private companies to allow them to compete against the existing infrastructure. In other cases, the high level of congestion of some roads provides an additional cost to their users, and makes private providers competitive against the existing infrastructure.

### **3.3 Land values and optimal floor-area-ratio**

In this section I will discuss how people's willingness-to-pay for locating in a certain place raises the optimal floor-area ratio (FAR) to use in its development. I will prove that after the demand for the land rises, its value is maximized only when redevelopment at a higher density is allowed.

The construction costs per unit of surface of housing, commercial and office spaces are growing functions of the floor area ratio (FAR). This relation exists because the higher the number of floors in a building, the higher that the support of the structures and foundations need to be<sup>20</sup>. Moreover, elevators are needed for buildings of more than a certain number of floors, which increases their construction cost per unit of surface. A corollary of this observation is that if land were free, the cheapest way to build a given amount of floor area would be with one-floor buildings.

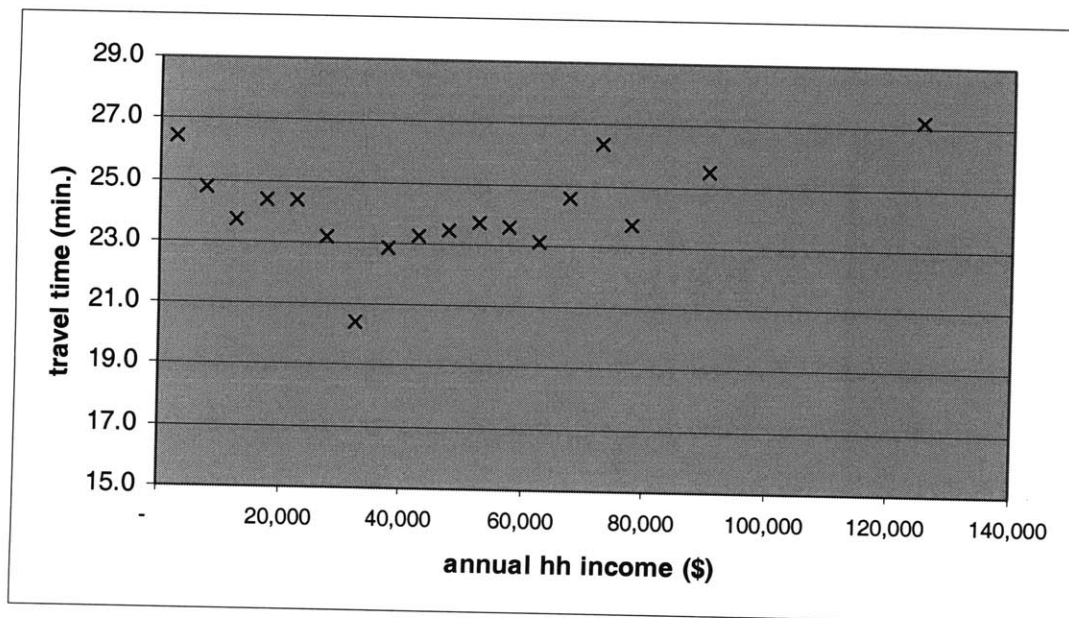
---

<sup>20</sup> DiPasquale and Wheaton (1996), page 74.

People's willingness-to-pay per unit of surface of housing is a negative function of the FAR, all else being equal<sup>21</sup>. This is especially the case in the United States, where most people express a strong preference for living in low-density areas<sup>22</sup>.

The preference for low FARs explains the paradox that in most metropolitan areas in the US, the people that value their time the most are the ones that live the farthest from the city centers, and tend to have the longest commutes. The next two graphs prove this point. The following figure shows the travel time of the journey to work of households with different income<sup>23</sup>.

Figure 1: Average travel time of journeys to work for households with different income in the US



Source: Created by the author based on US DOT (2002)

<sup>21</sup> That is, keeping constant all characteristics of the housing unit itself (number and size of rooms, equipment, construction materials, etc.), and of the community (crime rate, prestige, medical and educational services, etc.).

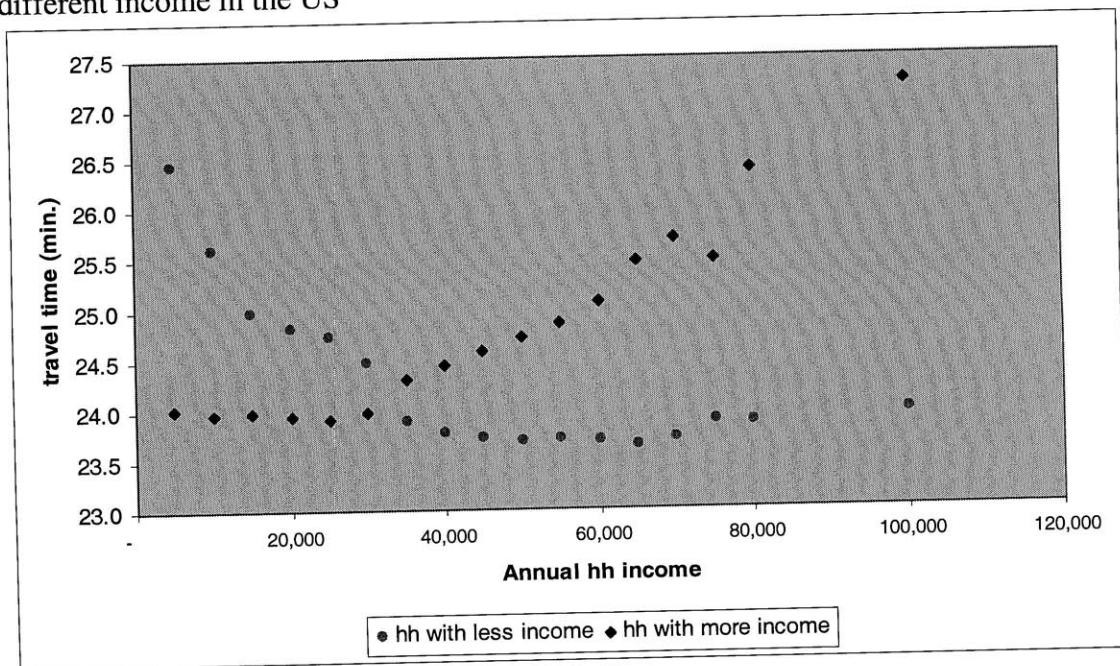
<sup>22</sup> For example, in a survey made in Northern California in the 1990's, 82% of people said they prefer a single-family home rather than other alternatives (Building Industry Association of Northern California, 1993). According to Cervero (1997), 90% of people in the US prefer to live in single detached house rather than multi-family housing.

<sup>23</sup> Each category is represented by the average of the lower and upper limits of the income interval. Households with more than \$100,000 of annual income are represented with an income of \$125,000, for the purpose of including them in the graph.

As can be seen in the previous graph, starting at a household income of \$32,500 per year, there is a general trend of people having longer commutes (in terms of travel time) as their incomes increase.

The following graph is based on the previous one. For different annual incomes it shows the average commute time of people whose incomes are higher than a certain income level, and the commute time of people whose income is less than the same income level.

Figure 2: Average travel time of the journey to work of groups of households with different income in the US



Source: Created by the author based on US DOT (2002)

This graph does not provide an accurate measure of the average travel time for each income level, since it does not weigh the commute times by the number of people in the different income categories. Nevertheless, the graph gives a proxy of the overall trend. Considering that the average income per households in the US for 2002 was \$42,409<sup>24</sup>, we conclude that people whose household's income is higher than the average tend to have longer commuting than those whose household's incomes are below the average.

<sup>24</sup> In 2002 dollars. Information retrieved from US Census Bureau's Web Site.

This result implies that for most people in the US, the elasticity of the willingness-to-pay for space with respect to income is higher than for reductions in commuting time.

Apparently, the American preference for large lots and single housing is less common in Europe and in developing countries<sup>25</sup>. In fact, in many cities in Europe and Latin America, a large proportion of high-income people live close to city centers, and low-income people tend to live in the periphery of the cities. There are also a few high-income communities located close to city centers in the US, such as Beacon Hill in Boston, and the Upper West Side in New York City.

People's expressions of preference for low-density settlements may be higher than their real-life choices and than the social-optimal. People may express their preference for single-family houses because, on average, this type of housing is more comfortable than multi-family housing. But the relevant comparison is between houses and apartments/condos of the same price. The ratio between the number of single-family housing units built per year and the number of multi-family housing units built per year may be a better indicator of people's preference. However, it may still not reflect the socially-optimal proportion of both type of housing, since in most cases owners of single-family houses use their cars more intensively than the rest of the population, creating more external costs (e.g. road congestion and pollution).

As I said in the beginning of this section, the willingness-to-pay for a housing unit ( $P$ ) and the cost to build the unit ( $C$ ) are functions of the FAR:

$$P = P(\text{FAR})$$

$$C = C(\text{FAR})$$

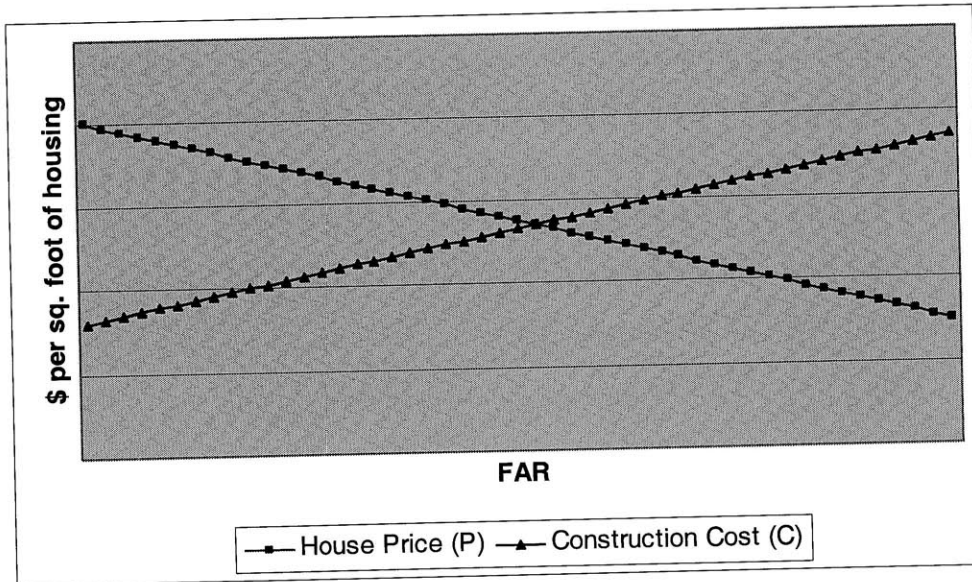
However, these  $P$  and  $C$  have opposite relations with the FAR. Whereas most consumers prefer low FARs, all else being equal, the cost of providing housing space increases with

---

<sup>25</sup> (Ingram, 1997), p. 1022. Nevertheless, similar preferences to the ones in the US have been reported in other parts of the world. In the 1970's in Sweden 90% of people preferred houses to apartments (Popenoe, 1977). The same percentage was reported for Chile (DII-UCh, 2000).

FAR. The following graph represents the cost and market price of a unit of housing space, as a function of the FAR, keeping all other variables constant:

Figure 3: Cost and price per unit of housing



Source: DiPasquale and Wheaton (1996)

We know that the higher the FAR, the higher the housing space the developer can sell, for a given amount of land. For every combination of cost and price of housing, there is a profit that a developer would obtain by building housing. In a perfect market, developers would bid for the land until making this profit equal to zero (in real life, until making profits equal to alternative return of the capital). Therefore, land values are equal to the maximum profit that can be obtained by developing the land. The profit  $p$  would be the following:

$$p = \text{FAR} * (P - C) \quad \text{Equation 1}$$

Where:

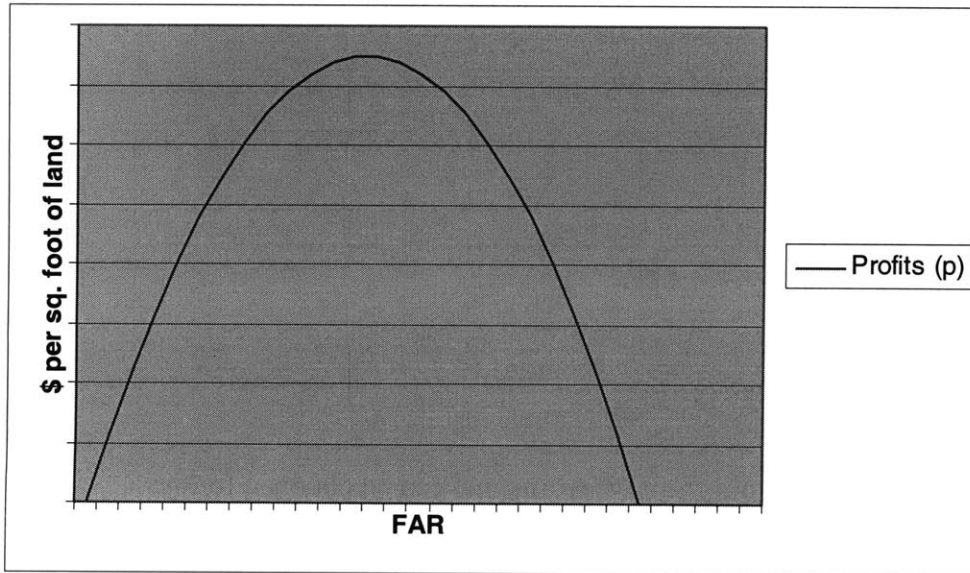
P is the price of a housing unit

C is its cost

FAR = housing space / land space

The following graph represents the profits that the developer would obtain at different FARs per unit of area of land:

Figure 4: Profits per unit of land



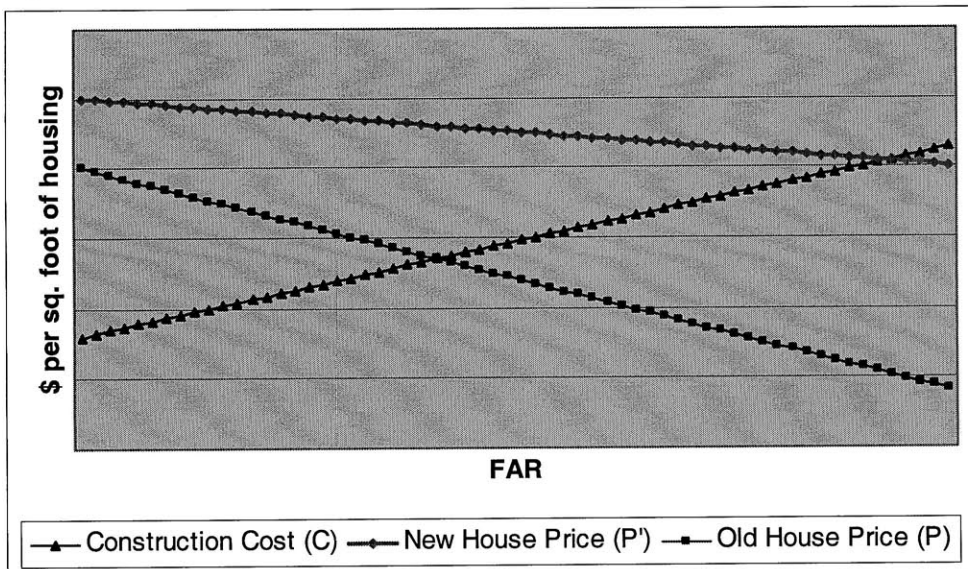
Source: DiPasquale and Wheaton (1996)

As can be seen in the graph, from the perspective of the developer, the best use of the land would be at the FAR that maximizes profits.

If demand for housing in a specific area rises because of the construction of rail transit in the area, the curve P in the figure of page 27 will move upwards. The new demand curve (P') may not be parallel to the old one (P), since the existence of rail transit could reduce congestion, making living in an environment with high density less annoying for every unit of increase in density.

The following graph represents the cost, the old market price (before the transit project serving the area is built), and the new market price (after the transit project is built) for a unit of housing space, as a function of FAR:

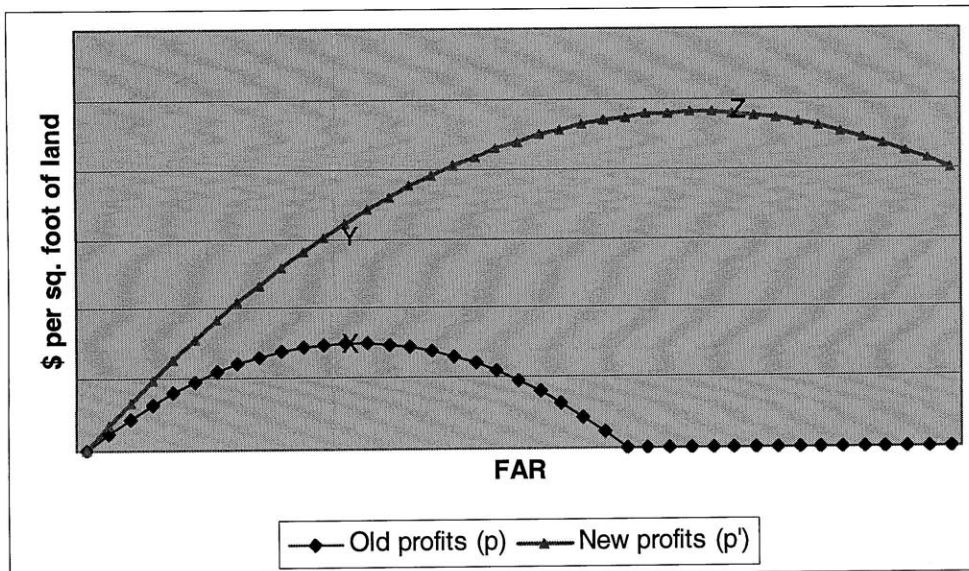
Figure 5: Shift in demand after new rail station opens



Source: DiPasquale and Wheaton (1996)

The following graph shows the old and new profits that can be obtained for the development of the land at different FARs:

Figure 6: Profits per unit of land, before and after a rise in demand



Source: DiPasquale and Wheaton (1996)

If the increase in accessibility raises demand for land in the area around stations, it will raise the profits that can be obtained by developing the land (and therefore land values), and will also raise the optimum FAR.

If zoning does not allow for higher densities than the ones existing in the area previous to the investment in transportation infrastructure, redevelopment will not take place. In that case, the value of the existing properties will increase and FAR will remain the same. Land values will only rise from point X to point Y in Figure 6. On the other hand, if redevelopment is allowed, land values will rise to the level Z in the same Figure. Sections 4.2 and 4.3 show that the cities that have seen the greatest impact on land values have been those where redevelopment at higher FARs has been possible.

### **3.4 Other conditions necessary for land values to increase**

Section 3.2 described how accessibility becomes capitalized into property values in competitive land markets. Section 3.3 mentioned that the increases of land values would be higher in places where redevelopment of the land at a higher density was possible. There are also other conditions that have been identified as necessary for land value to increase, including the following<sup>26</sup>:

- A growing economy: only where income is growing, are there opportunities for development, and therefore, land values increase
- Relatively high congestion in the streets: road congestion increases the cost of using private vehicles, and therefore attracts people to transit
- A low stock of vacant land around other sections of the rail transit: land in other areas of the city competes in the market against the land located next to transit stations, reducing prices
- Provision of pedestrian infrastructure: as most rail transit trips include a walking segment, the quality of the pedestrian infrastructure has an important effect on the likelihood of people choosing public transportation

---

<sup>26</sup> Cervero (1992) .

Another factor affecting land values is local externalities, i.e. the effects that adjacent properties have on the value of real estate. In many cases, the density of adjacent lots affects the value of land, for example because adjacent buildings reduce sunlight or produce congestion on the streets. In other cases, the presence of industries creates environmental degradation and hazards to local residents. Thus, local externalities can impede the redevelopment of an area, producing a sub-optimal outcome.

Two cities that suffer local externalities are Toronto and Cleveland. In both cases, heavy industries were the first to locate on the lakeshore, arguably the most beautiful location in both cities. The fact that factories remained there has scared potential developers from these areas, and has resulted in housing being built in other areas of these two cities.

As was pointed out in section 3.2, land values reflect consumer's surplus. The higher the difference between the willingness-to-pay of passengers for transportation service and the fare charged for the service, the higher the increases in land values will be. Therefore, systems that provide high level of service, with reliable and high frequencies, low travel times, high comfort, clean and safe facilities, and at reasonable fares, will have the highest impact on land values.

Modes with high level of service are the ones with the highest impact on land values. There is not evidence of an increase of land values caused by the provision of regular bus service in the last few years in the developed world. On the other hand, there is some evidence of a positive effect of rail transit on land values (see sections 4.2 and 4.3). This difference must be caused in part by the higher level of service of rail transit compared to the regular bus service, since there is no evidence of a specific preference for rail over bus for other reasons than their level of service<sup>27</sup>. In large metropolitan areas in the US buses tend to suffer from low schedule adherence, and long travel times because of congestion. Some bus rapid transit systems have had a positive effect on land values,

---

<sup>27</sup> See Ben-Akiva and Morikawa (2002).

even in the developed world<sup>28</sup>. This may be a consequence of the higher level of service of this mode as compared to regular buses.

Another reason for the different impact of buses and rail on land values are technological. Rail transit systems have higher sunk costs than other modes. This characteristic gives people the certainty that once built, rail transit will stay in service for a long time. In addition, as most rail transit systems have a right of way that is separated from road traffic, its performance is not affected by road congestion. These characteristics reduce the risk of real estate investing in the area around stations, compared to investing in the areas served exclusively by regular buses.

### **3.5 Who is benefited and who is affected by the construction of rail transit lines?**

As was said in section 3.2, each person has a different willingness-to-pay for using transit. For all transit users, their willingness-to-pay is higher than the fare, and this difference is their consumer's surplus. This surplus is reflected in the value of properties located in the area served by transit.

The effect of rail transit construction on property values depends on whether the city has one or more employment centers. In mono-centric cities, office space located in the central areas benefits from the construction of radial rail lines. They benefit because the wages firms pay to their employees have to compensate for employees' commuting costs<sup>29</sup>. If these costs diminish, wages will also diminish. These savings are capitalized then into office-space values. Similarly, in mono-centric cities, the value of residential properties located in the central areas is reduced after the construction of radial rail line,

---

<sup>28</sup> TRB (2003) reports that the BRT system of Brisbane, Australia, caused a 20% increase in property values around stops. It also mentions that the BRT systems in Ottawa and Pittsburgh have attracted development to the areas around stations.

<sup>29</sup> For example, Darien and Wheaton (2001) shows that firms located in zones with a more difficult commute in the Boston and Minneapolis-St. Paul metropolitan areas have to compensate their employees with higher wages than other firms.

at least in the short-term. The reason is that if transportation costs diminish, the benefits of living close to where jobs are will also diminish.

On the other hand, in a multi-centric city, firms located out of the central business district (CBD) benefit from the lower commuting costs of their employees, paying them lower wages than what firms in the CBD have to pay. In fact, many firms have migrated to the suburbs, seeking these lower wages (and lower land values), at the cost of giving up the agglomeration economies of downtowns<sup>30</sup>. The construction of radial rapid transit reduces the relative advantage of firms located in the secondary centers, and, therefore, reduces the value of commercial properties located in those areas. Meanwhile, housing properties located in any place in a multi-center city benefit from the reduction in the cost to commute to alternative employment centers.

According to this analysis, residential properties in the suburbs would be the ones that would have the highest gain in accessibility after the construction of radial rail transit lines. Moreover, high or mid-income people, who usually live in the suburbs in the US, are the ones who place the highest value on their time. Nevertheless, some studies have shown a meager effect of rail transit on land values in high-income suburban areas in the United States<sup>31</sup>. This may be a consequence of the low attraction of transit for people who live in the suburbs, or of the fact that zoning in the suburbs has not allowed for densification.

Land value increases may force some people to relocate. As was pointed out earlier, consumer's surplus, which determines property value increases, is a function of income. Therefore, in the short-term, low-income people may be priced-out of their properties. This possibility is not necessarily bad. First, if they are owners of their property, they would have the option to stay, and their decision to leave would be determined by the economic advantage of selling their properties. However, people's decisions to leave

---

<sup>30</sup> Suburbs now contain half of the office space and two-thirds of the new office space (Downs, 1992; Diamond and Noonan, 1996).

<sup>31</sup> For example, Nelson (1992).

their neighborhoods would produce external costs to the rest of the community. When many people move at the same time, there is a loss in the “social fabric” of cities<sup>32</sup>.

Gentrification would be less favorable for tenants than for homeowners. In the short term, as population is fixed, there has to be a reassignment of properties for the same number of residents in the city. After the rise in rents, priced-out tenants may be able to rent a marginally better property than the one they used to rent, for a similar price. As in the case of property owners, there may be a loss of the social fabric of the affected neighborhoods.

There are reasons to believe that the probability of rail transit causing gentrification is low. First, gentrification is usually a slow process. In most cases it only occurs when low-income people live in houses with extraordinary architectural characteristics, or where redevelopment is very easy. Even assuming that rail transit causes gentrification, the social benefits caused by rail transit may compensate for this cost.

Densification in the station areas may benefit low-income people. Rail transit requires high densities around stations to be sustained. The construction of rail transit encourages city governments to increase densities in the areas around stations. Densification may benefit low-income people, as that may increase the supply of affordable housing.

Finally, governments gain with land value increases. They get more revenue from property taxes. The productivity of the workers and firms also increases, attracting more investment and workers to the city or region (see section 3.2). This raise in investment spurs the economic activity of cities.

---

<sup>32</sup> See Jacobs (1961), part I.

### **3.6 Land values, location decisions and city structure**

The previous sections discussed the effect of transportation infrastructure on accessibility, and how accessibility increases land values. This section discusses the way rail transit shapes cities, both at the metropolitan level (macro level), and at the neighborhood level (micro level).

#### **3.6.1 Macro Level**

At the metropolitan level, rail transit provides a location advantage to areas around stations, and especially to city centers, the area that is usually the best served by transit. This advantage reduces the attractiveness of locating in the suburbs. The areas around rail stations tend to concentrate development, especially the kind of development that gains the most from location around them, namely employment and retail centers.

The effect of rail transit on different kinds of land uses varies according to their transportation costs. Office space gains more from accessibility than single-family housing, since the number of generated and attracted trips per unit of area of land is usually higher for offices than for this type of housing. In this section, I will demonstrate that on average, single-family housing is less trip-intensive than office space and retail space, at least in the US.

The following table shows the average number of trips generated per 1000 square feet of floor area by different land uses in the United States.

Table 1: Trip intensity per unit of floor area in the US

Land Use	Daily trips / 1000 square feet of floor area	Assumptions
Single Family Housing	7.2	<ul style="list-style-type: none"> <li>• Average new house's lot is 2,225 square feet <sup>a</sup></li> <li>• 3.8 people per unit <sup>b</sup></li> <li>• 4.3 trips per person <sup>c</sup></li> <li>• To be conservative, I assume all of them are to or from home</li> </ul>
Multi-Family Housing	7.7	<ul style="list-style-type: none"> <li>• Average new apartment/condo is 1,105 square feet <sup>a</sup></li> <li>• 2.0 people per unit <sup>b</sup></li> <li>• 4.3 trips per person <sup>c</sup></li> <li>• I assume all of them are to or from home</li> </ul>
Office Buildings	9.9	<ul style="list-style-type: none"> <li>• Average new office is 250 square feet per employee <sup>d</sup></li> <li>• 3.32 vehicle trips per employee on weekdays, 0.54 on Saturdays and 0.22 on Sundays <sup>b</sup></li> <li>• To be conservative, I assume all of them drive alone</li> </ul>
24 h Convenience Stores	759	<ul style="list-style-type: none"> <li>• 738 vehicle trips per 1000 square feet of gross floor area on weekdays, 863 on Saturdays, 758 on Sundays <sup>b</sup></li> <li>• To be conservative, I assume all of them drive alone</li> </ul>
Pharmacies	90	<ul style="list-style-type: none"> <li>• 90 vehicle trips per 1000 square feet of gross floor area on weekdays <sup>b</sup></li> <li>• I assume the same rate for weekends</li> <li>• To be conservative, I assume all of them drive alone</li> </ul>

<sup>a</sup> US Census Bureau (1999)

<sup>b</sup> ITE (1997)

<sup>c</sup> BTS (2002)

<sup>d</sup> Garreau (1991)

Table 1 only considers floor areas. To compare the intensity of ground areas, it is necessary to account for the floor-area ratio. The following table presents estimations of the number of daily trips per 1000 square feet of ground area:

Table 2: Trip intensity per unit of ground area

Land Use	Daily trips / 1000 square feet of ground area	Assumptions
Single-Family Housing	1.1	New houses have an average lot area of 0.35 acres, so average FAR is 0.15 <sup>a</sup>
Low density Multi-Family/ Townhouses	7.7	Assuming FAR equals 1.0 <sup>b</sup>
Mid density Multi-Family Housing	19.3	Assuming FAR equals 2.5 <sup>c</sup>
High density Multi-Family Housing	34.7	Assuming FAR equals 4.5 <sup>d</sup>
Office Buildings	9.9 – 50.0	For FARs between 1.0-5.0 <sup>e</sup>
24 h Convenience Stores	152-759	For FARs between 0.2-1.0
Pharmacies	45-180	For FARs between 0.5-2.0 <sup>f</sup>

<sup>a</sup> US Census Bureau (1999)

<sup>b</sup> As a comparison, the maximum FAR allowance in districts that permit townhouses but not more intense uses in Chicago is 1.2 (City of Chicago, 2003), and in Washington D.C. is 1.8 (DCOZ, 2002)

<sup>c</sup> According to US Census Bureau (1999), 89% of the multiple-units built in the US in 1999 were in buildings of 3 or fewer floors, so they fit near the low and mid-density category of multi-family units

<sup>d</sup> As a comparison, the maximum FAR allowed for residential areas in Chicago is 10.0 (city of Chicago, 2003) and in Washington D.C. is 6.0 (DCOZ, 2002)

<sup>e</sup> According to EIA (2003), 84% of office buildings in the US are one- or two-floor high, and therefore have a FAR below 2.0

<sup>f</sup> According to EIA (2003), 73% of retail and services buildings in the US are one-floor high, and 18% are two-floor high

As we can see, single-family housing generates and attracts fewer trips than all the other uses included in the table, and retail space is often more intense than multi-family housing and office space. These results were obtained even with conservative assumptions, i.e. assumptions that would not benefit my hypothesis (that residential uses are less trip-intensive than office and retail space), so it is a robust conclusion.

Shopping centers also have high trip-intensity. A survey in six metropolitan areas found that the number of trips per 1000 square feet of retail shopping varies from around 3 per peak-hour for super regional shopping centers to around 14 per peak-hour for community

shopping centers<sup>33</sup>. As we see, these numbers are much higher than the trip intensities of housing and office space.

Even though these results apply to the US and the trip-intensity should differ for cities with different modal shares, the high difference between the resulting rates of the different uses suggest that the trip-intensity ranking of these land-uses should be the same for cities in the developing world, such as Mexico City and Santiago. Moreover, it is likely that as a lower proportion of people own cars in these cities than in the US, and their discount rate is higher (as average income per capita is lower) they shop more often than people in developed countries. This characteristic would make retail space uses even more trip-intense than in the US.

Given their high trip-intensity, it seems logical that retail stores are willing to pay the most for accessible locations, followed by commercial space and housing. Nevertheless, there are other reasons that suggest that the trip-intensity of retail space is not as high as it appears in Table 2. One reason is that some stores prefer to locate in large plots of land, where they can offer parking space to their clientele at an affordable price. The availability of parking allows clients to carry the products they buy in their cars. Another reason is that some stores may want to build parking facilities to make it difficult for people without a car to come, as a way of selecting their clientele. The design of most shopping malls reflects this intention<sup>34</sup>.

There are some agglomeration economies for retail. One is the economy that exists when similar shops locate together, making it easier for consumers to compare the products of the different stores in a single trip. Shops only benefit from this reduction in cost if the products they sell are close but not perfect substitutes to each other. Otherwise they cannot exert any market power<sup>35</sup>. A classical example of this phenomenon is the clustering of jewelry, antiques, expensive clothes, and cars stores that have arisen in many cities around the world.

---

<sup>33</sup> TRB (1992). The rates are an average of the midday and afternoon peak periods.

<sup>34</sup> This is especially true in countries where not everybody can afford a car, such as Mexico and Chile.

<sup>35</sup> See Boulding (1966).

Another location economy is destination accessibility (see section 3.1). The clustering of shops allows clients to make linked-trips, or even better, one-stop shopping. This is one of the main reasons why shopping centers exist.

As the number of clients traveling to stores is higher than the number of employees traveling to stores, the main consideration retailers have when making their location decision is the accessibility of the prospective customers. Moreover, shops have very good substitutes, whereas jobs do not have perfect substitutes. Therefore, people change stores more often than they change jobs, and they are willing to travel farther to their jobs than to stores<sup>36</sup>. Locating close to the clients is essential. As customers live in dispersed areas, especially in US cities, retail needs to follow population, and also locates in dispersed areas.

Firms also have incentives to locate in accessible places, clustered with other firms. By locating in accessible places, they gain a broader workforce base. People are willing to travel to work a given time and distance, and beyond this limit there is a very steep increase in the wage they would have to get to accept a job<sup>37</sup>. Accessibility and clustering allow firms to have more face-to-face contact with other firms, to access specialized services<sup>38</sup>, and to facilitate external transactions<sup>39</sup>. An accessible location, hopefully with high traffic, may also promote the name and image of a company.

There are many reasons why families may want to locate close to rail transit stations. These systems enhance the accessibility of the areas around stations. Residents gain a larger area to find jobs, to choose a school for their children, and to select the place where they want to buy and have fun. Transportation costs may be reduced, both in terms of time and money. Contrary to retail and firms, housing has very small agglomeration economies. The capacity to sustain shops at walking distance is one of them. But, as

---

<sup>36</sup> Walker (1998).

<sup>37</sup> According to Garreau (1991) this threshold is around 45 minutes each-way.

<sup>38</sup> See Jacobs (1961). For example only with a cluster of office buildings it is possible to sustain services such as restaurants, printing services, mail delivery offices, office supply stores, banks, etc.

<sup>39</sup> Cervero (1997), Bollinger (1998).

discussed in section 3.3, most people in the US prefer to live in low-density settlements, which cannot sustain shops at walking distance.

There is a lot of evidence suggesting that in developed countries, households' location decision is based on social and economic factors such as the availability of well served and affordable housing, more than on the availability of transit per se<sup>40</sup>. Retail and offices on the other hand, tend to choose locations based on the accessibility to clients, employees and to other firms. These characteristics suggest that if households move to the areas around stations in the first place, this will attract firms and shops, but not necessarily the other way around. This situation may not be different in developing countries.

The incentives for cities to compete for attracting firms and retail makes it necessary for metropolitan areas to agree with their cities on a plan to avoid attracting land-uses that are not traffic-intensive next to the stations. Firms and retail provide more taxes than the cost they impose on cities in the US. Then cities tend to compete to attract them, especially those with low-income residents, which are less concerned about their impact on congestion<sup>41</sup>. Some of these land uses, such as heavy industries, scare other trip-intensive uses away, so they should be avoided in the areas around stations<sup>42</sup>.

The fact that cities in the US pay for public schools produces the so-called Tiebout sorting, where people are segregated into cities of homogenous incomes. This sorting can become an additional barrier to redevelopment. The situation in Mexico and Chile is different. Although in both countries municipalities collect property taxes and pay for certain services to local residents, in Mexico schools and medical services are funded by the federal and state governments. In Chile, although schools are funded by

---

<sup>40</sup> See Zhang (2000) for a description of this phenomenon in Chicago. Another study for Sydney found that people that relocated to the suburbs increased the duration of their journey to work (Burnley et al, 1997), which suggests that other factors have a more important role in the housing location choice than job location.

<sup>41</sup> DiPasquale and Wheaton (1996), page 339.

<sup>42</sup> The failure to redevelop the industrial land located next to the alignment of the light-rail in San Diego may be one of the reasons of its low ridership (Cervero, 1994b).

municipalities, people are not forced to attend schools in the municipality where they live<sup>43</sup>.

### 3.6.2 Micro Level

At the micro or neighborhood level, rail transit systems usually foster dense development. Depending on the type of rail technology (heavy/light rail, electric/diesel traction, third rail/catenaries) and of station (elevated, at grade or underground) the areas adjacent to rail stations may become desirable places to locate. In contrast, most areas next to highways are not desirable places to live because of air pollution, noise and congestion in the access ramps.

The dense development and pedestrian flows that some rail transit stations promote, create a favorable environment for shops to locate. Contrary to cars, transit provides a connecting service. The usage of transit requires a connection to other mode, either to walk, take a bus or drive a vehicle. Several studies have proved a strong aversion of people to modal transfers, especially when buses are involved. When using rail transit, many people walk to their final destination. These pedestrians are potential customers of the shops located near stations.

High densities around stations provide the base of the customer needed by certain services to exist. For example, several studies have estimated that in the US a convenience store that can be reached in a five-minute walk can only be sustained with densities above 10 units or 25 persons per acre (62 persons per hectare)<sup>44</sup>. Similar densities may be necessary for dry-clean services, post offices and cafes. The clustering of different shops around stations allows clients to make chained-trips, even if they do not use transit. In fact, the opening of stores around stations has proven to be one of the main mechanisms through which rail transit raises residential property values<sup>45</sup>.

---

<sup>43</sup> Zegras (2000), page 86.

<sup>44</sup> Condon (2000); Marshall (2000), page 12.

<sup>45</sup> For example, Bowes and Ihlandfeldt (2000) proved that this factor was very important in the outer sections of the MARTA rail transit system in Atlanta.

The effect of rail transit stations on retail and office space values has proved to exist only in close proximity to the stations, whereas for residential properties the increases in values has reached properties located farther away<sup>46</sup>. This phenomenon is explained by the fact that retail needs pedestrian flows to be sustained. These flows dissipate fast as distance from the stations increases. The area of impact on property values is especially big for commuter trains, and for stations with park-and-ride facilities. However, these facilities have a negative effect on the areas immediately adjacent to the stations, because of aesthetical impact, the barrier these facilities create to pedestrians, and a perceived effect on crime (see section 4.4.9). Park-and-ride facilities on the other hand, benefit residential properties located farther away from the stations.

The construction of a rail transit station in a neighborhood does not necessarily benefit the commercial activities of that specific area. In Lille, France, the opening of rail transit stations in low-income areas encouraged local dwellers to go to other areas of the city to shop, damaging the commercial activities of those low-income areas<sup>47</sup>. Something similar happened in Barakaldo with Bilbao's subway<sup>48</sup>.

The clustering of office space around stations stimulates the opening of more office space, because of agglomeration economies. It also stimulates the development of firms that serve them, such as restaurants, printing stores, office supply stores, etc.

---

<sup>46</sup> For example, Cambridge Systematic, et al (1998) proved that in San Francisco, single-family houses located between 2,000 and 2,500 feet of BART stations still had a price premium, whereas retail space only had a premium up to 1,000 feet, and office space up to 2,000 feet.

<sup>47</sup> Walmsley and Perrett (1992).

<sup>48</sup> Mikel Murga, personal communication with the author, 8/20/2003.

## 4 Literature Review: The Effect of Rail Transit Construction on Land Values

This Chapter reviews different studies about the effect that rail transit systems have had on land values in cities in the developed world. It also discusses why the results appear to be contradictory, and why the effects have not been the same in different cities and in different sections of the same systems.

### 4.1 General considerations

Several papers have tried to determine the effect of rail transit on land values. Most of them have used hedonic price models. These models assume that goods (real estate in this case) are bundles of attributes, and that for each of these attributes people are willing to pay, if they like them, or demand a compensation for accepting them, if they do not. Hedonic price models are able to determine the price premium paid for each attribute in a sample of transactions.

Most hedonic price models have assumed linear relations between prices and the variables that determine them. These kinds of relations have the following form:

$$P = \alpha + \sum_i \beta_i * Z_i + \sum_j \gamma_j * L_j \quad \text{Equation 2}$$

Where:

$\alpha$  is a constant

$\beta_i$  are parameters that reflect the value paid for the physical characteristics of the property or land

$Z_i$  are the physical characteristics of the property or land

$\gamma_j$  are parameters that reflect the value paid for the location characteristics of the property or land

$L_j$  are the location characteristics of the property or land

Alternatively, it could be argued that the effect of increases in the magnitude of the physical or location characteristics have a decreasing marginal effect on property values. In those cases, Cobb-Douglas specifications, such as the following, are more appropriate.

$$P = \alpha * \prod_i Z_i^{\beta_i} * \prod_j L_j^{\gamma_j} \quad \text{Equation 3}$$

In this cases  $\beta_i$  and  $\gamma_j$  are the elasticities of property prices with respect to the attributes  $Z_i$  and  $L_j$ .

Most studies on the effect of rail transit on property values have used one of these two specifications in multiple regression models. Linear specifications have been more common because of their simplicity, and their acceptable capacity to predict dispersion of property values.

Not all studies have used hedonic price models. Others have used matched pairs and repeat sale ratios techniques. Compared to hedonic price models, these models are easier to estimate, and require less information. On the other hand, they are less accurate than hedonic price models, since they do not control for other variables that affect property values, such as economic cycles, and physical and location characteristics of the properties.

Many studies have analyzed rents instead of sale prices. Rental contracts have other specific characteristics than the price, such as the extension, concessions and others. Sale prices are more standard and therefore can reflect the effects of transit on land values more accurately. Most of the studies that are reviewed in the following sections have used sale prices.

## 4.2 Studies on commercial properties

The results of the studies on the impact of rail transit on property values have been mixed. While some studies have found significant effects, others have not.

Studies done for BART in the San Francisco Metropolitan Area have not found conclusive effects on the value of adjacent commercial properties. A study done few years after the opening of the system did not find evidence that BART raised commercial property values around Walnut Creek station and Mission District<sup>49</sup>. Another study done few years later (Landis, et al, 1994), could not find any effect on commercial property either. Other studies on the contrary, analyzing longer periods, have found significant price premiums for commercial and office properties, especially in downtown San Francisco and downtown Oakland<sup>50</sup>. In both areas high-density development is common.

For Atlanta the results have also been contradictory. Bollinger et al (1998) did not find evidence of a premium for commercial properties located one mile or less from MARTA stations. On the other hand, Nelson (1999) found that commercial properties in Atlanta that were located close to rail stations, and were located in areas where high densities were allowed, had higher values than comparable properties in other areas of the city. The study identified the formation of special districts, and the relaxation of minimum parking as additional factors that increased property values.

Many studies have shown that Washington D.C.'s subway has had a significant impact on the value of land located close to stations. Using a hedonic price model, Damm et al (1980) found price-elasticity with respect to distance of -0.69 for commercial property within 2,500 feet of the subway. In both Washington D.C. and Atlanta, the increases of land values were in anticipation rather than as a response to rail station opening<sup>51</sup>.

---

<sup>49</sup> Falcke (1978).

<sup>50</sup> See Cervero and Landis (1997).

<sup>51</sup> Cervero (1992).

The effects of light rail systems on land values have also been non-conclusive. Weinstein and Clower (1999) used a matched-pairs methodology to assess the impact of Dallas Area Rapid Transit (DART) on land values. The study concluded that there was a 30% value-added premium for commercial properties located close to stations.

A study for Santa Clara County found price premiums of 23% for commercial parcels located near light rail stations, and 120% for commercial land in business districts located near commuter rail stations<sup>52</sup>. Santa Clara County had heavy congestion as a result of high economic growth in the 1990's. The county has actively promoted Transit Oriented Development (TOD) of the areas around stations. Some of the mechanisms that were used include "...tax-exempt financing, sliding-scale impact fees, public assistance with land assembly, and overlay zones to allow for higher densities than the norm"<sup>53</sup>.

In a study for New York City, using transaction data from 1985 to 1988 and records of intended change of use, it was proved that commercial firms' property values were more affected than housing and retail by the distance to subway's stations<sup>54</sup>.

### **4.3 Studies on residential properties**

Just like for commercial property values, the studies that been done on the impact of rail transit on residential property values in the US have not had conclusive results.

Cities with a long history of rail transit tend to have increases in land values when new extensions are built. A study on the effect of the Lindenwold line in Philadelphia concluded that properties with access to rail had a price premium of 6.4%<sup>55</sup>. A study for the PATCO line that links Philadelphia with Lindenwold, found that increases in land

---

<sup>52</sup> Cervero and Duncan (2001).

<sup>53</sup> Cervero and Duncan (2001).

<sup>54</sup> Anas and Armstrong (1993).

<sup>55</sup> Voith (1993).

values were equivalent to the total travel cost savings of the passengers<sup>56</sup>. A study for Chicago proved that three years before the opening of the orange line, the value of land located within a 1½ miles radius of the stations rose by 17%<sup>57</sup>.

Cities that have started building new rail system in the last few years have seen low changes on land values after the opening of the first few lines. A study on the effect of Miami's Metrorail found no evidence of price premium for residential properties<sup>58</sup>. A study for Atlanta found that MARTA raised housing values in low-income neighborhoods but decreased values in high-income zones<sup>59</sup>. Another study for Atlanta found that high-income areas had the highest land-value increases, especially areas located about 12 miles from the city center<sup>60</sup>. The effect proved to be more intense in areas between one-half to one mile from the stations, where the accessibility is not hurt by the negative local externalities of the rail stations. According to the paper, these negative externalities are crime and pollution.

Some other new systems have had positive effects on residential property values. A study for several Californian rail systems (Caltrain, BART, and San Diego's, Sacramento and Santa Clara's light rails), found that single-family housing capitalized the accessibility provided by them<sup>61</sup>. The highest effect was for BART, and in the case of Caltrain, which is a commuter train, there was a decrease in property prices near stations. This decrease was probably a consequence of the usage of diesel locomotives, which may have been perceived as heavy pollutant. A matched-pair study for apartment rents in San Francisco, found a price premium of 15% for units located at walking distance from suburban BART stations<sup>62</sup>.

The effect of rail transit on single-family housing values has proven to be low, as we can expect from the discussion in section 3.6.1. A study for Toronto found that housing units

---

<sup>56</sup> Boyce et al (1972).

<sup>57</sup> McDonald and Osuji (1995).

<sup>58</sup> Gatzlaff and Smith (1993).

<sup>59</sup> Nelson (1992).

<sup>60</sup> Bowes and Ihlandfeldt (2000).

<sup>61</sup> Landis, et al (1994).

<sup>62</sup> Cervero (1996).

located close to subway stations had a price premium, controlling for other location and structural characteristics<sup>63</sup>. This premium was equivalent to 4,000 Canadian-dollars (of 1995) for a typical house in the city<sup>64</sup>, just around 2% of the average sale price. Another study for Toronto also found a very modest price-premium for houses located around the Spadina subway line. The study used a hedonic price model<sup>65</sup>. For the same city, Dewees (1976) used a multivariate regression to assess the impact of the Bloor-Danforth line. The study found that within 1/3 of a mile to each station, rent gradients became steeper after the construction of the line, indicating a positive impact of the line on rent values.

Other cities have had the same effect of single-family houses value premiums being less than apartment or condos' premiums for locations around rail transit stations. A study for Washington D.C. found no price premiums for single family housing located up to 2,500 feet from stations. The value of land though was found to have a price elasticity of  $-0.19$  with respect to distance for multi-family housing<sup>66</sup>.

Even in New York some studies have not been able to find an effect of rail transit on the value of housing units. Using transaction data from 1985 to 1988, a study determined the effect of New York's subway on the value of distinct types of housing properties. The study found that for both single family and row-house values stayed constant up to 200 meters from the station, after which they had a steady decline of around \$  $0.67/\text{ft}^2$  per meter of distance to the stations. Apartment prices instead, showed a moderate increase in value at farther locations from the subway stations<sup>67</sup>.

Some studies have shown higher impacts of rail transit on land values in the UK than in the US. An estimation of the land value increases generated by the Jubilee Line in

---

<sup>63</sup> Haider and Miller (2000).

<sup>64</sup> Defined as a detached house, with air-conditioned, four bedrooms, two washrooms, one parking space and a fireplace.

<sup>65</sup> Bajic (1983).

<sup>66</sup> Damm et al (1980).

<sup>67</sup> Anas and Armstrong (1993).

London was £13 billion, almost four times the construction cost, which was £3.5 billion<sup>68</sup>.

#### **4.4 Why have the studies shown different results?**

The studies to determine the effects of rail transit on land values have produced different results for different cities, and even for distinct parts of the same cities. The following sections present some reasons to explain these results.

##### **4.4.1 Different methodologies to measure land value changes**

The methodologies used in these studies have varied from hedonic prices models to more simple matched-pair comparisons or repeat-sale ratios. As was pointed out in section 4.1, these methods are less capable of controlling for other factors that affect land values, different than access to rail transit. This lack of control over other factors may lead to wrong conclusions.

One study that lack adequate control over other factors is Anas and Armstrong (1993). The study stratified the properties in classes (one to two-families residential, walk-up residential, apartments, etc.). The regression equations estimated property values per square foot, but without considering any characteristic of the property other than distance to subway stations. These estimations then are very rough, and the conclusions of the study cannot be taken as definitive.

Unfortunately, there is no agreement among researchers on what is the best method to estimate hedonic-price models. Moreover, the available data and its quality is not the same for all cities, restricting the degree of complexity and accuracy of the models.

---

<sup>68</sup> Riley (2001).

#### 4.4.2 Different technologies/annoyance to local residents

As was said in section 3.6.2, some rail transit technologies produce external costs to their surrounding areas, in the form of pollution, noise, vibration, visual intrusion, and other. These costs affect property values around the alignments.

Even though many highways provide similar or better accessibility than rail transit, their pollution, aesthetic impact and noise usually cause land values next to them to be lower than in other areas of the cities. For example, in Santa Clara County, commercial land within half a mile of freeways was found to have a lower value than similar land in other places<sup>69</sup>. Similar effects may occur with modes that are perceived as polluting, such as buses or trains with diesel locomotives.

There are contradictory reports regarding the effect of connecting buses on land values. Cervero (1992) concluded that the value of office space in Atlanta and Washington D.C. rose less around terminal stations than around other stations, probably because of the presence of connecting diesel buses. On the other hand, a study for Atlanta found that neither elevated stations, nor the existence of more than average number of buses serving a station had any impact on land values<sup>70</sup>. These two characteristics are some of the most annoying ones of rail stations.

The construction of rail transit stations increases the demand for parking in the surrounding areas, and makes it more difficult for local residents to find empty spaces. This is an additional annoying characteristic of stations, but can be reduced with parking-permit schemes. In the case where parking lots are built around stations, there is usually not any positive effect on the value of land located around stations<sup>71</sup>.

The level of service provided by rail systems of different technologies is not the same. Heavy rail usually provides faster service with fewer stops, and with higher adherence to

---

<sup>69</sup> Cervero and Duncan (2001).

<sup>70</sup> Bowes and Ihlandfeldt (2000).

<sup>71</sup> See Bowes and Ihlandfeldt (2000).

the schedules than light rail. Consequently, the effect of heavy rail on land value has proven to be higher than the one of light rail<sup>72</sup>.

#### **4.4.3 Different appeal to the public**

The effect of rail transit on land values depends on the average income of riders. As was pointed out in section 3.2, the increases in land values are in part a capitalization of the consumer's surplus of riders. If low-income people account for most of the ridership, it will be their consumer's surplus that will be reflected on land-value. As their willingness-to-pay to save time is usually lower than the one of high-income people, the effect on land values may be lower than if the same number of high-income people used the system.

The value of retail properties is affected by the flow of purchasing power per unit of time of the location. It is not necessarily the case that the higher the incomes of people walking in a location, the higher property values are. Different stores are specialized in serving people of different income, so they are attracted to the zones where people of those incomes are. Nevertheless, for a given flow of people, the higher their income, the higher the increases in land values that are likely to occur.

The fact that MARTA had a positive impact on land values in low-income areas and a lower effect on high-income areas may be a consequence of the system's high attractiveness to low-income residents. The high number of low-income riders may make other people stigmatize MARTA as an inferior form of mobility. The problem is not exclusive to Atlanta. Many high-income communities in the United States have rejected rail transit extensions to their area (e.g. Georgetown in Washington D.C., Beacon Hill in Boston), most likely for the same reason. The situation is not very different in Mexico City, where communities in the western part of the city have rejected possible extensions of the metro.

---

<sup>72</sup> Cervero (1997).

There are several benefits for metros to have passengers from different income-levels, other than fairness considerations. One of the benefits is that people of same income usually have similar mobility patterns, including similar origins and destinations. A diverse mass of riders provides a more dispersed pattern of origins and destinations in time, benefiting transit operators. For example, in most cities in the US most high-income people move towards downtown in the morning peak, and back in the afternoon. Many low-income people who live in downtown do the opposite. By attracting both groups, transit gains a demand balanced in space and time.

Another reason for seeking an income-diverse clientele is economies of scale. By providing the service to more people, rail transit reduces its cost, and clients benefit from a better quality of service. By having more passengers, trains can run more frequently. Higher frequencies benefit all passengers. An increase in the flow of passengers is positive up to the point where the additional passengers generate a higher marginal decrease in the comfort of other passengers, than the added frequency they allow.

#### **4.4.4 Different opportunities for redevelopment around stations**

In many of the cases mentioned in sections 4.2 and 4.3, the gains in accessibility could not be transformed into redevelopment opportunities because of zoning. As was mentioned in section 3.3, the existence of redevelopment opportunities maximizes land values, so in those cases land values could not be maximized.

As we saw in sections 4.2 and 4.3, some of the cities with the highest increases in land values after the opening of rail transit lines have been those where densification was allowed or even encouraged, like Washington D.C. or downtown San Francisco. Nevertheless, density does not allow for land values to grow per se. If demand for locating in an area does not increase, a relaxation of zoning would not produce a change in development patterns.

None of the studies on the effect of rail transit on property values considered the effect of zoning in full details. If density is restricted, the fact that rail transit did not affect

property values in a given city does not mean that rail transit cannot raise property values under more flexible zoning. In fact, there is some evidence that many of the cities that did not have an increase in land values, did not allow for densification of the station areas. Some cities in the San Francisco Metropolitan Area even “downzoned” (i.e. reduced the maximum FARs) the station areas, fearing densification and congestion<sup>73</sup>. There may also be cases where cities forbid shops to locate around stations. As was pointed out in section 3.6.2, these shops provide additional benefits to local residents.

The existence of many different owners of land around stations, and the free-riding attitude of some of them, makes redevelopment become very difficult without the direct involvement of city governments. To trigger redevelopment, governments need to convince residents to share the cost of redevelopment, zone them away, or coordinate land- assembling.

There are also other barriers for redevelopment, which may have prevented land values to grow after the opening of rail lines. In some of the cities mentioned in sections 4.2 and 4.3, many sites around stations were already built. The cost of demolition and the cost of losing rent revenue during construction periods may be too high to justify redevelopment. Moreover, in some cities there were historic districts that could not be altered, impeding redevelopment.

#### **4.4.5 Different conditions of the real estate market**

Property values are very sensitive to the conditions of the economy. Because of the long lag between the decision to construct a building and its completion, short-run variations in demand can only be absorbed through changes in prices<sup>74</sup>.

The rate of growth of cities, and the elasticity of the provision of urban land also affects land values. In metropolitan areas that are undergoing fast development and where there is an inelastic provision of land, the gains in accessibility provided by rail transit can be

---

<sup>73</sup> Huang (1996).

<sup>74</sup> DiPasquale and Wheaton (1996), page 242.

converted in redevelopment opportunities. In the cases where cities are growing at a slower pace, or where the provision of urban land is elastic, the increase in accessibility does not justify redevelopment, and therefore the existing pattern of development is maintained. These conditions minimize the increases of land values around stations. As we saw in the case studies, Washington D.C.'s metro has had a positive impact on land values. The city has been undergoing rapid population and economic growth in the last decades. The results in San Francisco are mixed. Even though the city has grown fast in the last decades, the availability of land has allowed for sprawling to occur, and has made redevelopment less attractive.

Most of the studies on the effect of rail transit on property values have failed to consider that it can take time for land value increases to materialize. Property owners constrain demand when prices are low, by waiting for better conditions before selling their properties. They only offer more land when prices are high, attenuating in part the cycles of short-term oscillations of sale prices. Therefore, if an area gained more accessibility, instead of its price rising, the number of properties offered for sale could increase, and therefore on the short-term property values would not rise up to their long-term level. For example, some studies suggest that in San Francisco the effect of BART on land values has taken some time to materialize<sup>75</sup>.

There is evidence that the property market suffers from adaptive or backward-looking expectations. Developers and property owners expect prices to continue their current trends<sup>76</sup>. This characteristic causes property values to be unstable and cyclical<sup>77</sup>, making it difficult to determine the impact of rail transit on land values in a short period after the opening of a new rail line.

---

<sup>75</sup> Cervero and Landis (1997). There are also counterexamples such as the area around the Orange Line in Chicago, whose land values rose in anticipation of the construction of the subway (McDonald and Osuji, 1995).

<sup>76</sup> See Case and Shiller (1988).

<sup>77</sup> DiPasquale and Wheaton (1996), Chapter 10.

#### **4.4.6 Provision of pedestrian facilities**

In many of the cases where land values increased as a consequence of the construction of rail transit, there has been a special care for providing pedestrian infrastructure to facilitate the access to stations. The improvement of pedestrian facilities and of the built environment, is probably one of the main reasons explaining the success of many rail transit systems around the world<sup>78</sup>.

The relation between the distance people are willing to walk to access to a station, and the number of potential riders is usually not linear, but rather geometrical. The maximum distance people are willing to walk to the station can be understood as the radius of the circle of influence of each station, if we assume that people can walk in straight lines from their origins to the station. Under this assumption, a 41% increase in the maximum walking distance would produce a 100% increase in the number of passengers, assuming homogenous densities.

Some weather conditions can make walking uncomfortable, regardless of the characteristics of the sidewalks. The hot weather may be one of the reasons to explain the low ridership in Miami's rail system, at least during days with high temperatures.

#### **4.4.7 Accessibility that transit provides**

Transit systems that provide high accessibility have higher impact on land values than other systems. Households' location and people's trip decisions are influenced by accessibility. The low effect of small rail transit systems on land values may be a consequence of the reduced accessibility they provide. On the other hand, other systems that provide access to more destinations, have had positive effects on land uses and land values.

Ridership is a good proxy of the accessibility that a system provides. In fact, we can see that the systems with the highest modal shares are the ones that have had the highest

---

<sup>78</sup> One example is Strasbourg light rail, which has had a positive impact on development, due in part to the improvement of pedestrian facilities around stations.

effect on land values in the US, such as the subways of New York, Chicago and Washington DC.

For office space and housing, the value of accessibility is not specific to a station within a rail transit network<sup>79</sup>. We should then expect land values for these uses to have similar prices all around the alignment, all else being equal<sup>80</sup>. Of course other characteristics of the station make land values to vary. For retail space, especially for large-scale retail, the relative location in the network is more important. Stations located in the margin of the network have lower accessibility than the ones located in the center and especially in intersections. The reason may be that people avoid connections when they go shopping, but not so much when they go working.

The relative scarcity of highly accessible land is a necessary condition for transit having an impact on land values. Only in areas with relatively high congestion levels will transit be competitive with other modes, and therefore provide an advantage to the firms and families located next to stations.

Systems that provide regional service tend to have a higher impact on land values than those with only local service. For example in Santa Clara, the impact on commercial land values of commuter train stations serving business districts was higher than the effect of light rail serving those areas<sup>81</sup>. This difference may stem from the fact that this commuter rail allows employees to easily access their offices without having to pay the high cost of living in Silicon Valley.

Rail transit has network externalities as the construction of additional lines causes an increase in ridership in the existing lines. Nevertheless, as most cities first build rail transit in the corridors with the highest demand, these benefits are decreasing for every

---

<sup>79</sup> People may not care about the relative location of their job, as long as it is close to any station of a rail transit system. This is compatible with our discussion in section 3.6.1 on people willing to accept longer trips to their jobs than to shops.

<sup>80</sup> Cervero (1992) concluded that office space values in Atlanta and Washington D.C. grew in direct proportion of the overall ridership of the system, and not in proportion to the traffic at the particular stations.

<sup>81</sup> Cervero and Duncan (2001).

successive new extension. By providing bus-connecting services, transit agencies can capture part of these network externalities. In most modern subways, the strong resistance of people to make connections makes network externality limited to potential trips involving one or fewer connections.

#### **4.4.8 Local externalities**

The sole construction of a rail line does not make an area a desirable place to live. In many cases, the presence of heavy industries, annoying transportation infrastructure, or in some cases the presence of a high proportion of people of a certain ethnical or racial group, may scare development away. These are all local externalities, which affect land values.

There is strong evidence that heavy industries and highways preclude housing development. Many cities have built rail lines along industrial corridors or highway medians, taking advantage of the lower cost of land. Ridership in these lines has almost always been very low. For example San Francisco's BART has some sections built in highway medians, and St. Louis' metro has some sections along old railways going through industrial areas. In both cases, ridership is lower than in other lines of the same systems, and there have been low changes on land uses along the alignments.

#### **4.4.9 Effects of Rail transit on crimes**

Several papers have assessed the effect of rail transit on crime. The results have not been conclusive. In theory, rail transit facilitates the access of people from one community to the other, some of whom may be criminals. The perceived increase in crimes may reduce property values around stations.

A study for Atlanta found that, controlling for variables such as density of low-income people, vacant housing, retail and manufacturing employment, and distance to the CBD, the areas around stations had higher crime rates than other areas in the city. Crime rates were even higher in stations with parking lots<sup>82</sup>.

---

<sup>82</sup> Bowes and Ihlandfeldt (2000).

#### **4.4.10 Unbalance between transit value proposition and land values**

For land values to increase and for land uses to become more intensive, there needs to be a balance between property values and the value proposition of rail transit.

Mexico City may be a case of a city that does not have this balance. The city's subway is very crowded, and there is a perception of insecurity among potential users. The fare is currently only around 20¢. As it is now, the metro's value proposition is only attractive to low-income people. Nevertheless, the subway only serves the Federal District, which is the central part of the metropolitan area, where land values are the highest. Therefore, most people willing to use the subway cannot afford living in the zones around stations. This mismatch may reduce the impact of the metro on land values and land uses around stations (more discussion about Mexico City in Chapter 5).

The opposite situation happens when the fares of rail transit are too expensive for the people that live next to the stations. This may be the case in some parts of San Juan, where Tren Urbano, a rail transit system that is planned to be inaugurated in 2004, will charge \$1.50 for a one-way ride<sup>83</sup>. Meanwhile, buses running in the same corridor will continue to charge 25 cents. The perspective of Tren Urbano is gloomy, considering that the system is hoping to bring 60% of its riders from current bus users. A smaller difference between fares of the two modes may attract more people to Tren Urbano, inducing more changes on land uses. An upgrading of the service provided by buses (e.g. free transfer to the metro, low-cost monthly passes) may reduce the opposition to an increase in bus fares.

---

<sup>83</sup> ATI (2003).

## 5 Mexico City and the Metro

This Chapter includes a review of the history of urban development of the Mexico City Metropolitan Area (MCMA) in the 20<sup>th</sup> century. It also describes the evolution of public transportation in the metropolitan area. Then, an analysis of the evolution of ridership in the metro is presented. Section 5.3 includes a revision of the existing literature about the effects of the metro on urban development, and a quantitative analysis of the effects of the construction of three lines in the 1990's on population, average income per capita, and employment in the areas around stations.

### 5.1 Urban development in Mexico City

During the 20<sup>th</sup> century, the MCMA grew considerably. Up to the 1920's, all the population lived in the 12 central *divisiones* of the city. Only in the 1930's the city expanded to the adjacent areas, initially *Coyoacán* and *Azcapotzalco*. From the 1930's to the 1950's, the ring of *delegaciones* located around the central area grew at a faster pace than the city center. The latter concentrated 98% of the population of the urban area in 1930, but only 78% in 1950<sup>84</sup>. Trams, and lately buses, facilitated the growth of this inner periphery<sup>85</sup>.

As in most Latin American countries, the Mexican government implemented an industrialization plan after World War II. This plan generated a massive immigration from the countryside to the largest cities.

It was not until the 1950's that Mexico City surpassed the limits of the DF. At the beginning the crossing to the State of Mexico was in the northern part of the city<sup>86</sup>. This growth was made possible in part by the construction of the *Periférico*, the first beltway built in Mexico City, the investment in water drainage, and the provision of drinking

---

<sup>84</sup> Garza and Damián (1991).

<sup>85</sup> Garza and Damián (1991), page 38.

<sup>86</sup> Navarro and González (1989).

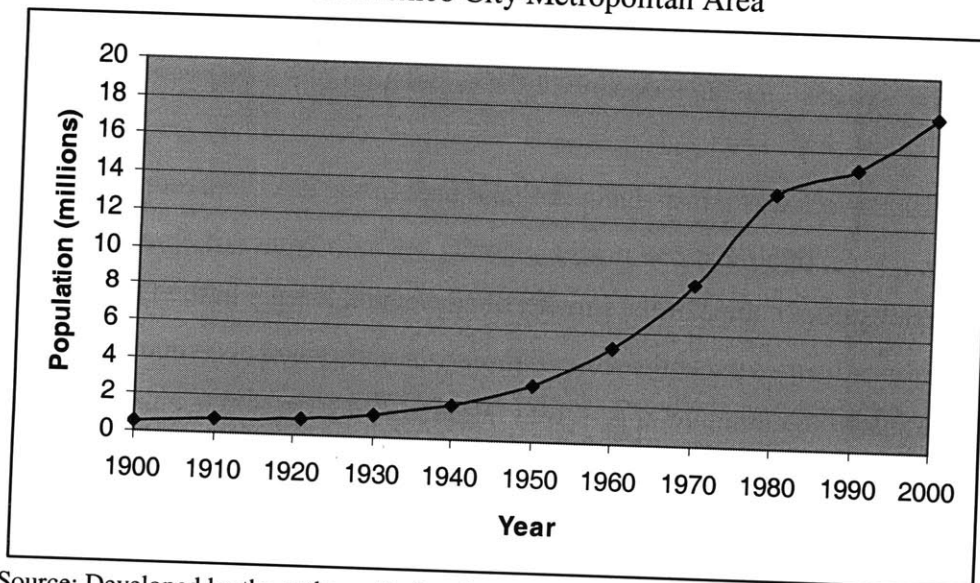
water. The State of Mexico attracted both new factories, and old factories being relocated from the city center<sup>87</sup>.

In the 1960's, there was a fast growth of squatter settlements in the State of Mexico. The process was spurred by immigration, by a strict ban on new land development in the DF<sup>88</sup>, and a permissive attitude of the State of Mexico with respect to illegal fractioning of land<sup>89</sup>. By 1970, the portion of the metropolitan areas that was located in the State of Mexico accounted for 21% of the population<sup>90</sup>.

By 1980, the growth of the metropolitan area had produced its joining with the cities of Toluca (Southwest) and Cuernavaca (South)<sup>91</sup>. The growth of Mexico City has created a megalopolis, which thereafter has also incorporated Puebla (Southeast).

The following graph shows the number of residents in the Mexico City Metropolitan Area:

Figure 7: Residents in the Mexico City Metropolitan Area



Source: Developed by the author with data from Lezama et al (2002)

<sup>87</sup> Garza and Damián (1991).

<sup>88</sup> Scheingart (2001), page 226.

<sup>89</sup> Duhau (1991), page 147.

<sup>90</sup> Garza and Damián (1991).

<sup>91</sup> Garza and Damián (1991), page 27.

The highest growth rate occurred in the 1950's, when the metropolitan area's population grew 5.6% per year on average.

Mexico City, as most other metropolitan areas in Latin America, has a segregated pattern of housing development. Between 1900 and 1910, the first signs of socio-economic segregation appeared in the city, with the development of a series of high-income communities in the southwest of the city, including *Juarez*, *Cuauhtémoc*, *Roma* and *Condesa*. These communities were built by private developers, and included a better quality of urban services than the rest of the city<sup>92</sup>. The Mexican revolution did not reverse this trend.

In the 1950's, the fast immigration of people did not produce an increase in density, in part because of the policy of DF's Mayor Uruchutu, whose government was very strict with the eviction of illegal settlements and the banning of new industries in the DF<sup>93</sup>.

In 1985 an earthquake produced serious damage in the central area of Mexico City. Many buildings in this area had to be torn down. Many of the former dwellers of these buildings moved to the State of Mexico, causing a decline of the population of the city center.

Between 1970 and 1990 there was a fast change of land uses in the city. The four central *delegaciones* suffered a loss of almost one million people, but an increase of almost 2,000 hectares of commercial space, a third of the growth of commercial space in the DF in that period. The *delegaciones Itzapalapa* and *Gustavo Madero* not only had enormous increases of land dedicated to commercial activities, almost 1,700 and 800 hectares respectively, but also gained population<sup>94</sup>.

The big increase in the amount of space dedicated to commerce in the city center, in spite of the loss of population, can have several interpretations. For some reasons, the city

---

<sup>92</sup> Ibarra (1991).

<sup>93</sup> Gilat (2002).

<sup>94</sup> Delgado (2001), page 91.

centers specialized in the provision of commercial services, oriented not necessary to its own population but to the entire metropolitan area. Apparently, the increase in the attractiveness of the city center for retail, may have driven property values up, and may have forced the displacement of the inhabitants of this zone. A study proved that most of the population loss was indeed caused by the closure of renting units, and their transformation to other uses, mainly commercial and service activities<sup>95</sup>. It is remarkable that the loss of 1 million people happened at the same time that the metropolitan area gained almost 6.5 million people.

In the 1970's and 1980's, there was a rapid growth in population density in the periphery of the city. The following graph shows this change.

Table 3: Variation in urbanized area and population, 1970-1987

Area of the City	Increase in Urbanized Area (hectares)	Increase in Population
Inner City	800	-1,000,000
Intermediate Area	11,800	1,400,000
Second Ring	9,400	2,900,000
Third Ring	24,200	2,200,000

Taken from Delgado (1991)

The areas in Table 3 include the following *delegaciones* and municipalities:

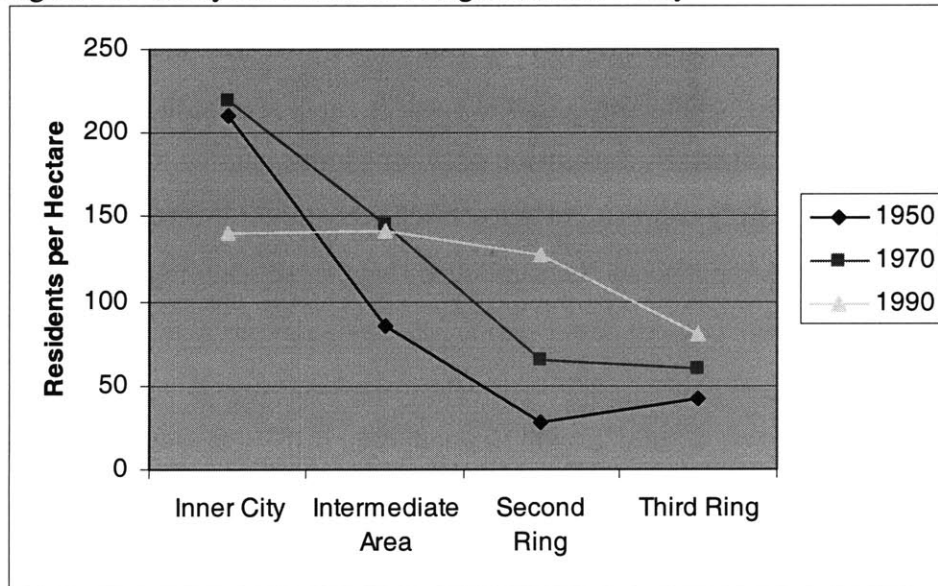
- Inner City: *Cuauhtémoc, Venustiano Carranza, Miguel Hidalgo, Benito Juarez*
- Intermediate Area: *Gustavo Madero, Coyoacán, Iztapalapa, Azcapotzalco, Álvaro Obregón, Iztacalco*
- Second Ring: *Naucalpán, Tlalnepantla, Ecatepec, Netzahualcóyotl, Magdalena Contreras, Tlalpan, Xochimilco*
- Third Ring: All other

The density of these four zones is represented in the following graph:

---

<sup>95</sup> Coulomb (1984).

Figure 8: Density for concentric rings in Mexico City



Taken from Delgado (1991). Values were approximated.

As can be seen in the graph, there was a fast flattening of urban densities between 1970 and 1990. This flattening was caused by a dramatic decrease of the population of the inner city, a slight decrease of population in the intermediate area, and an increase of population in the outer rings. As we will see in the following sections, the decrease in the population of the central area was caused in part by 1985's earthquake, and by a change of land uses from residential to commercial and service, fostered in part by the increase accessibility of the central area that the metro produced. In the same period, total densities for the metropolitan area decreased from around 148 persons per hectare to 120<sup>96</sup>.

The federal government, through its housing assistance programs, has had an important impact on the development of the city. The government's programs have consisted only on subsidies for the construction of new housing units<sup>97</sup>. As the buying of new houses is subsidized, and the purchasing old houses is not, sprawl has been encouraged. In the 1980's, the economic crisis made the agency in charge of subsidizing housing suffer

<sup>96</sup> Delgado (1991).

<sup>97</sup> Scheingart (1991), page 233.

severe budget constraints. Rather than reducing the number of housing units being subsidized, the agency reduced the amount of subsidy per person, reducing the average lot size<sup>98</sup>. This decrease in lot sizes may have been another cause of the increase in density in the periphery between 1970 and 1990.

*Delegaciones* and Municipalities have many attributes, including zoning and collecting property taxes. The federal entities (Federal District and State of Mexico in this case) have veto power over zoning decisions<sup>99</sup>.

In the second part of the 20<sup>th</sup> century, high-income communities continued to grow in the west and southwest section of the cities, whereas the East has continued to house some of the largest low-income communities. An increasing proportion of new developments for high-income people are in the form of gated communities, and very few high-income communities remain well integrated to the rest of the city, *Polanco* being one of the few example<sup>100</sup>.

Segregation in Mexico City is not at the *delegación*-municipality level as it is the case in Santiago<sup>101</sup>. The coefficient of variation of average income for the *delegaciones*-municipalities (i.e. the standard deviation of average income per capita in the different entities divided by the mean of their average income) is only 0.40, compared to 0.77 for the municipalities in the Santiago Metropolitan Area. At the district level, this coefficient is 0.52 for the MCMA<sup>102</sup>.

The following figure shows the concentration of commercial and service jobs in the 135 districts of the Mexico City Metropolitan Area.

---

<sup>98</sup> Schteingart (1991), page 240.

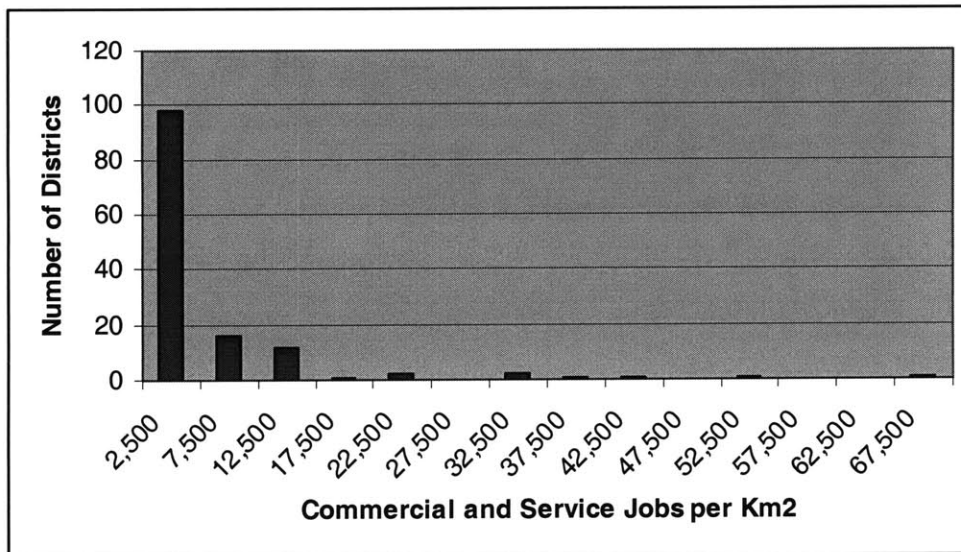
<sup>99</sup> Gilat (2002) page 106.

<sup>100</sup> Hiernaux (1999).

<sup>101</sup> In the Mexico City Metropolitan Area there are 16 *delegaciones* and 27 municipalities, totaling 43 entities. In Santiago there is a similar number of municipalities, 34, so comparisons at this level are meaningful.

<sup>102</sup> Data for Mexico from Census 2000. There are 135 districts in the MCMA.

Figure 9: Density of commercial and service jobs in districts of the MCMA



Source: Economic Census 1998

The nine districts with densities above 15,000 jobs in the commercial and service sectors per square kilometer, are in the *delegaciones Cuauhtémoc, Miguel Hidalgo* and *Benito Juárez*. They represent 1.2% of the area of the MCMA, but they concentrate 45.1% of all commercial and service jobs. Three geographic clusters can be identified: *Zócalo* and *Morelos* districts in downtown, *Del Valle* and *Ciudad de los Deportes* districts along *Insurgentes* Avenue in *Benito Juárez*, and the districts *Zona Rosa, Condesa, Chapultepec* and *Anahuac* in the limit of the three above-mentioned *delegaciones*. After 1998, a new concentration of office space has emerged in the *Santa Fe* area.

As other metropolitan areas in the developing countries, Mexico City does not have a well-structured market for rents of affordable houses. 65% of the housing stock is not legal, so it cannot be formally traded<sup>103</sup>.

In 1942, the DF passed a law freezing rents in the city center. This policy caused an accelerated deterioration of the housing stock of this area, since owners had no incentive to invest in adequate maintenance. The downtown area suffered a steady decline since the 1950's to the 1990's. In recent years, there have been some signs of recovery. The current

<sup>103</sup> Navarro and González (1989), page 116.

DF government administration has been expropriating some old and deteriorated units, and relocating their dwellers to enhance the built environment of the historic center of the city<sup>104</sup>. A private company, called *Centro Histórico*, has been purchasing old buildings to restore and resell them. The initial results of this firm have been positive, and it is expecting to have profits by 2006<sup>105</sup>.

A study for the DF showed that there is a general pattern in which high-income people locate close to the city-center. This rule has very few exceptions<sup>106</sup>. By the mid-1990's, land values around the city center were almost three times as expensive as land in the periphery of the DF<sup>107</sup>.

## 5.2 Public transportation and the metro

### 5.2.1 History of public transportation

By the 1930's, buses and trams were the only providers of transit service in Mexico City. Trams were owned and operated by a foreign company, whereas buses' property was dispersed among many different owners associated in the *Alianza de Camioneros*. The flexibility of buses made them gain modal share in detriment of trams in the 1940's, and buses became the mode with the highest share after World War II. In 1946, the national government nationalized the trams and formed the *Servicios Eléctricos del DF* (STE)<sup>108</sup>.

In the 1950's three trends can be distinguished with respect to public transportation. First, there was an impressive increase in demand, in part because of the growth of the city (see section 5.1). Buses captured most of this demand. A second trend is STE's substitution of trams for trolleys, and an absolute reduction in the demand for electric engine modes. The

---

<sup>104</sup> Personal communication with María Teresa Atrián from SEDUVI, 1/27/2004.

<sup>105</sup> *Rendirá Centro Histórico Utilidades*. Retrieved from El Universal newspaper, 2/18/2004, [www.eluniversal.com.mx](http://www.eluniversal.com.mx).

<sup>106</sup> Grezbord et al (1999).

<sup>107</sup> CdM (1996).

<sup>108</sup> Navarro and González (1989).

third process is a rapid increase in the number of cars, and the growth of congestion in the streets<sup>109</sup>. Whereas in 1950 there were 72,000 cars in the metropolitan area, by 1964 there were 320,000, more than 10% growth per year<sup>110</sup>.

Up to the 1960's buses did not operate as an integrated system, but rather organized in individual lines, most of them linking the periphery of the city with the center. This form of operation caused tremendous congestion in the city center.

In the late 1950's, *Ingenieros Contratistas Asociados* (ICA), the company that then built the metro, made a report on the future of public transportation in Mexico City. The report recommended the construction of an underground train. The report included detailed financial and geo-technique viability studies, but lacked a detailed forecast of the number of potential passenger that the system would capture. By the time the report was written no origin-destination survey had been made, and the government did not even have a detailed study about the existing bus lines<sup>111</sup>.

The initial project considered three metro lines, which would form a ring around the city center, and all connect to each other. Buses, trams and trolleys were going to be banned from the corridors served by the metro. Though integration with other modes was mentioned as a long-term objective, the original plan did not consider any form of fare or operational integration. Suburban and intercity buses were going to be banned from the city center, so connecting centers would need to be built around terminal stations.

The metro has explicitly been planned, designed and managed to serve low-income people<sup>112</sup>. Fares have always been very low. For 17 years fares were not modified, in spite of the high inflation. By the early 1980's the fare was symbolic (see figure on page

---

<sup>109</sup> Navarro and González (1989).

<sup>110</sup> Garza and Damián (1991).

<sup>111</sup> Navarro and González (1989).

<sup>112</sup> Navarro and González (1989), page 94.

146). In recent years, fares have increased, but still Mexico City's subway has one of the lowest fares in the world<sup>113</sup>.

The alignments of the lines have also been designed to serve low-income communities. The first three lines were built along the corridors that workers used to go to downtown, effectively by-passing most mid- and high-income communities.

Up to these days the metro still attracts low-income people almost exclusively. According to Navarro (1993), during the 1980's 92% of Mexico City's metro users earned less than 3 minimum wages. Another survey made in the 1980's to determine the economical activity of the passengers, showed that 32% of them were employees with no supervision responsibility, 31% had blue-collar employments, and 21% were self-employed. The average wage among them was close to the minimum wage. There was a negative correlation between modal share and people's income<sup>114</sup>. The orientation of the metro towards low-income people may have caused a stigmatization of the system as a low-quality mode.

It was not until 1968, under the Díaz Ordaz administration (1964-1970), that the construction of the subway began. The first line was going to be inaugurated for 1968's Olympic games. The construction suffered some delays and the first section could only be inaugurated in September 1969. In the following 15 months, Line 2, almost the entire Line 1, and the first 5 kilometers of Line 3 were inaugurated<sup>115</sup>. A public company that would operate the metro was formed: *Sistema de Transporte Colectivo* (STC).

---

<sup>113</sup> The current fare is only 2 pesos, approximately 20 cents of a dollar.

<sup>114</sup> Navarro (1993), page 177.

<sup>115</sup> Retrieved from [www.urbanrail.net](http://www.urbanrail.net).

Initially, the subway had positive effects on the rest of the transit system. In spite of the lack of explicit integration, bus operator adapted their routes to feed terminal stations, so fewer of them entered the city center<sup>116</sup>. Ridership in the subway grew very fast (see Figure 11).

In spite of the high ridership of the first three lines, the Echeverría administration (1970-1976) did not promote further extensions of the Metro. The only expansion of the system in this period was the completion of the last segment of Line 1<sup>117</sup>. Some of the reasons for postponing further expansions of the metro were the political pressure of the *Alianza de Camioneros*<sup>118</sup>, the high cost that the first three lines had, and the fact that there were no obvious corridors to serve after the construction of the first three lines.

The Lopez Portillo administration (1976-1982) developed a new and ambitious urban plan for the DF<sup>119</sup>. New avenues called *Ejes Viales* would be built to reduce congestion in the city. The plan envisioned that these avenues would attract retail, office space, and high-density housing development, and therefore would serve to decentralize activities in the city. Additionally, the *Circuito Interior* an inner beltway linking the employment and administrative sub-centers of *Tepeyac, Pantitlán, Santa Ana, Villa Coapa, Tizapán, Tacubaya, Tacuba, and Azcapotzalco*, would be built. Close to this beltway, new metro lines would be built<sup>120</sup>. This plan opened the second phase of development of the metro.

In this new phase of development of the metro, the government intended to use rail transit to induce demand rather than to respond to existing demand, as it was the case with the first three lines. In a risky bet, the government decided that the new lines would not cross the city center. Lines 4, 5, 6 and 7 were built during this phase, which encompasses the López Portillo and De la Madrid administrations (1972-1982 and 1982-1988,

---

<sup>116</sup> Navarro and González (1989).

<sup>117</sup> This segment was *Tacubaya – Observatorio* (Retrieved from [www.urbanrail.net](http://www.urbanrail.net)).

<sup>118</sup> Navarro and González (1989), page 90.

<sup>119</sup> The plan was a response to the increase in the price of oil, Mexico's main export, and to the finding of immense new reserves in the Gulf of Mexico.

<sup>120</sup> Navarro and González (1989).

respectively). After 1985's earthquake, the urban development plan of the DF was revised, and 65% of the *Ejes Viales* planned in 1982 were discarded<sup>121</sup>.

In the second phase of development of its network, the metro preserved its basic objective: to serve low-income people. One of the goals of the new lines was to facilitate the commute of workers to the industrial district of the northern part of the Metropolitan area, as a response of the lobbying of the industrial associations of that part of the city<sup>122</sup>.

By 1981, the private bus operators were in a terminal financial crisis. The DF overtook the operation and created a public company, *Ruta-100*, to operate all buses in the DF.

By the mid 1980's the government of the DF had total control over the operation of the main transit services. It owned the STE, the metro, and *Ruta-100*. For the first time an integrated transit system was in operation. In 1983 trolley lines were restructured to complement rather than to compete against the metro. *Ruta-100* started to provide trunk service along the newly built *Ejes Viales* using articulated-buses, and feeder service from the main metro terminals<sup>123</sup>. In 1986, a transit pass for STC, STE and *Ruta-100* services was created. In the same year, a presidential decree banned the entrance of any bus from the State of Mexico beyond the metro terminals<sup>124</sup>, and STE closed the last tramline in operation<sup>125</sup>.

By the late 1980's, it was evident that lines 4, 5, 6 and 7 had failed to capture the expected demand. On the other hand, the continuing growth in ridership in the first three lines, was causing crowding conditions. The government adopted a new strategy for the metro: new lines would be built to relieve demand on the first three lines. This strategy inspired the construction of lines 8 and 9. Additionally, two lines would be built in the eastern part of the city, surpassing the limits of the DF. These two lines were lines A and B.

---

<sup>121</sup> Orrego et al (2000).

<sup>122</sup> Navarro and González (1989), page 97.

<sup>123</sup> Navarro and González (1989), page 42.

<sup>124</sup> Navarro and González (1989), page 99.

<sup>125</sup> Garza and Damián (1991), page 38.

From the mid-1980's there has been a steady increase in the modal share of *colectivos*. Originally *colectivos* were shared taxis, and starting in 1982 they became gasoline-fueled minibuses<sup>126</sup>. *Colectivos* adapted very easily to the pattern of development that has prevailed in Mexico City in the last twenty years: squatter settlements in the periphery, primarily in the State of Mexico. These settlement lacked paved roads, so buses could not enter to them easily. *Colectivos* connected these settlements primarily with terminal stations, such as *Indios Verdes* and *Cuatro Caminos*. Starting in 1984, special infrastructure for *colectivos* has been built in every new station. Taking advantage of their semi-legal status, *colectivos* violated the restrictions to enter the DF from the State of Mexico. Their fast growth determined the collapse of the public bus operator *Ruta-100* in 1997, and the end of the integrated transit pass.

In 1996, a new development plan for the subway was made. The plan called for the following extensions (terminal stations are within parenthesis)<sup>127</sup>:

- Line 4 to the North (*Santa Clara*)
- Line 5 to the North (*Tlalnepantla*)
- Line 6 to the East (*Villa Aragón*)
- Line 7 to the South (*San Jerónimo*)
- Line 8 to the North (*Indios Verdes*), and to the South (*Acoxta*)
- Line 8 to the West (*Hipódromo*)
- A new line, Line 10, along *Periférico* from *Cuicuilco* to *Eulalia Guzmán*
- A new line, Line 11 from *Bellas Artes* to *Santa Monica* in the Northwest of the metropolitan area
- A new line, Line 12, along the *Eje 8 Sur*, from *Santa Lucía* to *Constitución de 1917*
- 8 light rail lines in different parts of the metropolitan area
- New commuter lines, including one to the Northwest of the MCMA

---

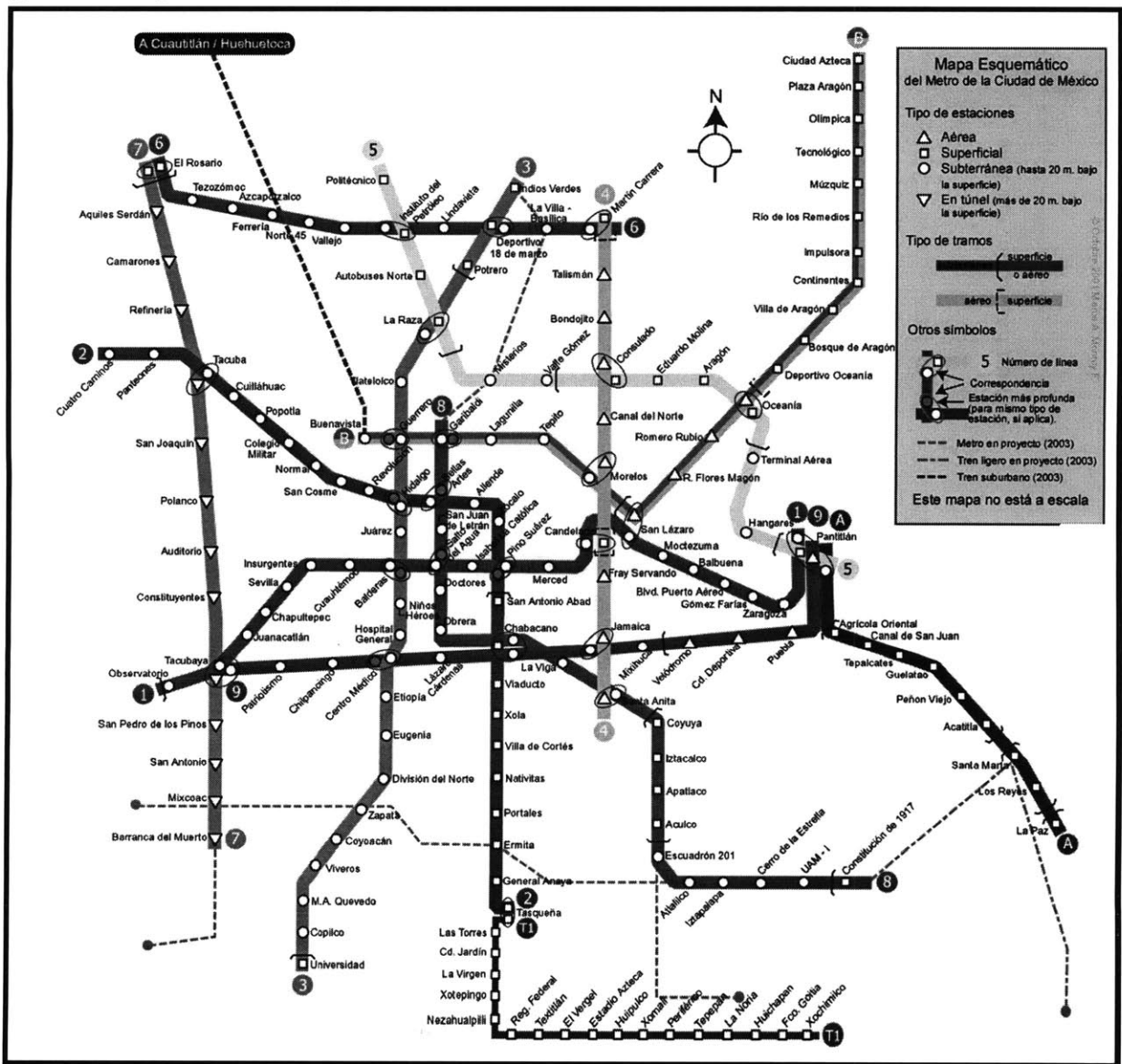
<sup>126</sup> Navarro and González (1989), page 46.

<sup>127</sup> SETRAVI (1996).

In spite of the existence of these plans, no extension is being built by the first semester of 2004. The government of the DF has recently announced the construction of a BRT line along *Insurgentes*, the same corridor that was going to be used for Line 10.

The following is a map of the current network. The *tren ligero* (light rail), which is owned and operated by the STE, is included. Some of the projected extensions and new lines are also included in the map.

Figure 10: Map of Mexico City's Metro

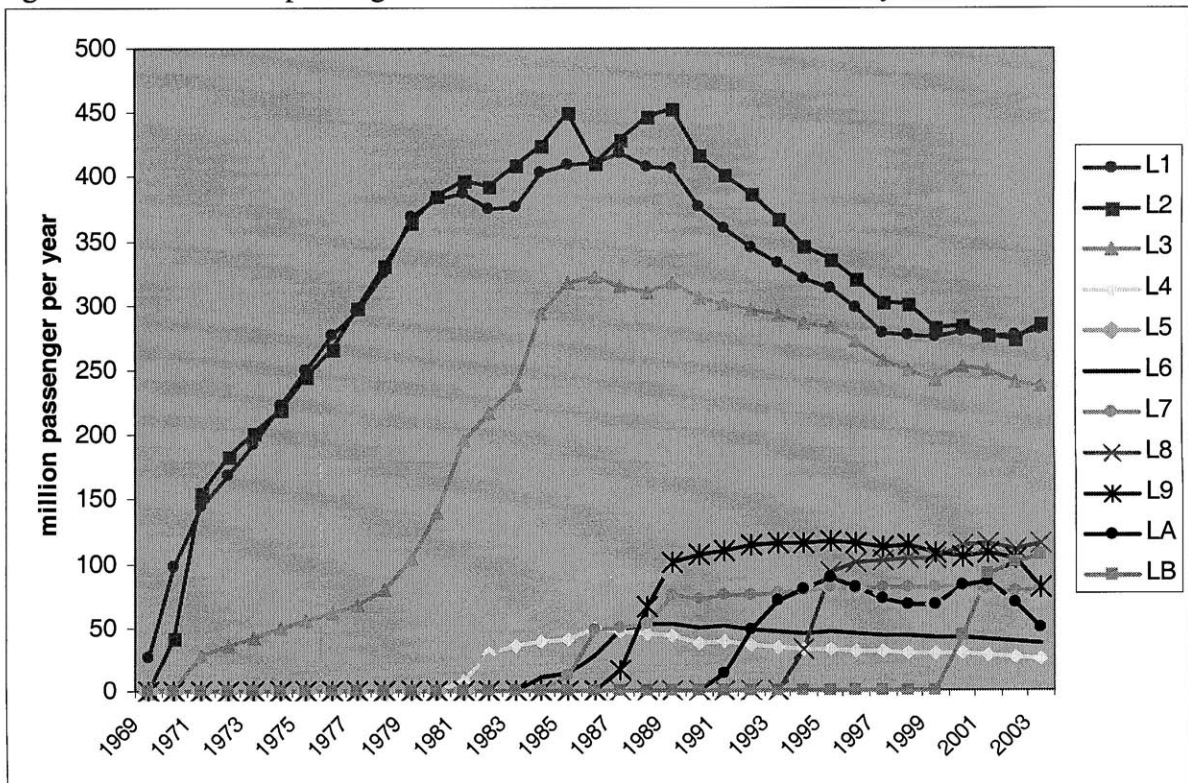


Source: <http://web.media.mit.edu/~mmonroy/metro/metro/mapa.html>

### 5.2.2 Metro and its ridership

In Mexico City passengers are charged a flat fare, regardless of the station where they board or their destination. The following table presents the annual number of passengers using the system per line. Passengers are imputed to the station where they board the system.

Figure 11: Number of passengers in the different lines in Mexico City 1969-2003



Source: See Appendix 2

As we see in the previous figure, lines 1, 2 and 3 carry most of the passengers, accounting for 59% of boardings in 2003.

Ridership in the first ten years of operation was very high under any standard. In 1980, the metro transported more than 900 million passengers with only 50 km of lines.

Subsequent lines were not as successful as the first three lines though. Not only they

failed to attract as many riders as the first three lines, but also they did not produce network effects in the first three lines, i.e. they did not induce more ridership in them.

Starting around 1986, there has been a steady decrease in the number of passengers in the first three lines, and since 1989, there is an overall decrease in the number of passengers in the entire system (see figure on page 146). The decrease was momentarily reversed in 1995, and in the 1999-2000 period.

### **5.3 Effects of the metro on the city**

#### **5.3.1 Commented review of existing literature**

There is evidence to conclude that the metro has fueled the expansion of the metropolitan area in Mexico City. The metropolitan area has a very even pattern of development, with densities not varying a lot in the periphery from what they are in the city center. By the 1960's the rapid growth of the metropolitan area produced an increase in congestion that hampered the continuation of the expansion of the city. As we see in the following table, by 1970, average density in the metropolitan area was higher than in 1960.

Table 4: Population and density in the MCMA

Year	According to DGP (1982)		According to Lezama et al (2002)	
	Population	Density (inhabitants / hectare)	Population	Density (inhabitants / hectare)
1900	541,000	200	540,000	
1910	721,000	180	730,000	
1921	906,000	195	900,000	
1930	1,230,000	143	1,220,000	
1940	1,760,000	150	1,780,000	150
1953	3,480,000	144	2,980,000 (1950)	
1960	5,186,000	144	5,160,000	105
1970	8,797,000	156	8,650,000	127
1980	14,500,000	145	13,730,000	
1990			15,050,000	
2000			17,900,000	122

Source: As indicated

None of the studies referred to in the table has a detailed description on how they estimated densities. UITP (2001) reported a density of 107 persons per hectare for Mexico City in 1995, considering city parks, transportation infrastructure, hospitals, utilities, urban wasteland and educational infrastructure as parts of the urban area. It is then highly likely that the two studies shown on

Table 4 did not include some of these land uses into their estimation of population density.

In the 1970's, after the opening of the first three lines of the metro, the expansion of the metropolitan area continued at a fast pace, reversing the increase in density of the 1960's. As we see in the previous table, in spite of an immense increase in population, densities in 1980 were lower than in 1970. The construction of the metro may be of the main reasons to explain this fast decentralization of the metropolitan area. Another reason may be the extensive construction of roads after the Lopez Portillo. In the 1980's, the sprawling effect of the metro and roads apparently declined, and there was an increase in density and in the number of floors per buildings in the municipalities of the State of Mexico that were part of the MCMA<sup>128</sup>.

Most of the large redevelopment projects of the last few years have been made by private investors. Most of these projects have focused on the mid- and high-income markets, and have been located on the western and southern part of the city. The residents and employees of the new developments have very different income from Metro's passengers, and in fact the metro does not extend to these rapidly growing areas.

Rather than concentrating development, the metro seems to have encouraged sprawling, by reducing travel times. Much of the growth in the periphery has been of low-income housing in the State of Mexico. Many of the residents in this area use buses to access the terminal stations of the metro, and connect from there to the CBD. Many residents from surrounding cities (Toluca, Pachuca, Tlaxcala, Puebla and Cuernavaca) also connect to the metro in terminal stations.

Most likely, the development of the metro made the city center more accessible, and attracted commercial activities. As we said in section 5.1, after the opening of the metro, retail in the city center increased its orientation to the entire metropolitan area, rather than to the reducing number of local residents. Almost certainly, the large volume of traffic

---

<sup>128</sup> Schteingart (1991).

the metro was able to transport, provided the ideal conditions for commerce to exploit agglomeration economies (see section 3.6.1). The attractiveness of the city center for commercial firms may have driven prices up, spurring the migration of residents to the periphery of the metropolitan area. This was a push factor; people were pushed-away of the city center by high land values. One symptom of this push is the loss of 350 thousand people in 30 years in *delegación Cuauhtémoc*<sup>129</sup>.

In addition to the push generated by increasing land values that may have been generated by the construction of the metro, there was an additional push factor: the destruction caused by 1985's earthquake. The earthquake reduced the housing stock in the city center, and therefore fostered redevelopment, switching to more profitable uses of land. The earthquake may have facilitated the conversion from housing to commercial uses that was mentioned in section 5.1.

Along with making the city center more attractive for commercial uses, the existence of the metro may have raised the attractiveness of land in the periphery for housing uses. This raise in the attractiveness of the periphery would be a consequence of the reduction in the cost and time of commute to the city center, where most jobs and services are located, as described in section 5.1<sup>130</sup>. This is a pull-factor, i.e. people are pulled-in to the periphery by the reduction in transportation costs to the city center.

There is evidence to discard the idea that the flattening of the demand curve in the MCMA (see Figure 8), has been caused by massive employment decentralization. Data shows that in the MCMA jobs have not dispersed more than people in recent years<sup>131</sup>.

---

<sup>129</sup> Orrego et al (2000).

<sup>130</sup> As we saw in section 3.5, in mono-centric cities the construction of radial transportation infrastructure, such as lines 1, 2 and 3 in Mexico City, decreases the attractiveness of living in the city center, and reduces housing property in this zone.

<sup>131</sup> Gakenheimer et al (2002) page 219.

The *Ejes Viales* have failed to attract the development forecasted in the plan made by the Lopez Portillo administration. This failure may be a consequence of the non-completion of the corridors and the rail lines as they were planned.

The extension of the subway network to the sub centers of *Tepeyac, Pantitlán, Tizapán, Tacubaya, Tacuba and Azcapotzalco* has changed land uses in these zones. There has been an increase in the number of stores in these areas, which has driven rents up, and has produced the displacement of the low-income housing that was located around stations<sup>132</sup>.

In most cases, the opening of new stations has attracted large numbers of street vendors. Apparently, the clientele of these vendors are metro riders. Although no formal study has been done to support this claim, many people think that the presence of street vendors also attracts crime. There is a common believe that the presence of street vendors produce a decline on property values<sup>133</sup>.

There have very few studies about the effect of Mexico City's subway on land values. Most studies in this area have been qualitative, and according to them, this effect has been negative because the metro has scared mid- and high-income housing development. Navarro and González (1990) state that for low-income housing, the effect has been positive. This report bases this statement on the fact that whereas the advertisement of low-income housing stresses the proximity to subway stations, the opposite happens for mid- and high-income housing.

Using a hedonic price model, Ochoa (no date) assessed the value of proximity to subway stations in the *Colonia del Valle Sur* in the DF. This area comprises the land located around stations *Etiopía, Eugenia, División del Norte, Zapata* and *Coyoacán* along Line 3 of the metro. The study used the following Cobb-Douglas specification of property values:

---

<sup>132</sup> Navarro and González (1989).

<sup>133</sup> This idea was expressed by all the Mexicans interviewed for this report (see list of people that were interviewed Appendix 1).

$$P_i = \beta_0 * FAR_i^{\beta_1} * Age_i^{\beta_2} * D_i^{\beta_3} \quad \text{Equation 4}$$

Where:

$P_i$  = is the price of property i per square meter of construction

$FAR_i$  = is the floor-area ration of property i (see section 3.3 for a description)

$Age_i$  = is the time number of years since property i was built

$D_i$  = is the distance from the closest metro station to property i

The model did not include income information, because it assumed that the area is homogenous with respect to this variable (it is a high-mid income area). Eighty-nine properties were included in the analysis.

The result showed that the premium paid by proximity to the metro is positive, but very low. Of the eighty-nine properties, the maximum premium paid was 0.16% of the total value. This low value may reflect the little attraction that the metro has on high mid-income people, where motorization rate is very high.

### 5.3.2 An analysis of the effects of the metro lines 8, A and B on land uses

This section describes an analysis I made on the effect of three metro lines on land uses in the MCMA. These three lines are lines A, 8 and B, the last three lines to be opened.

Line A was opened in 1991 and extends for 17 km. It begins in *Pantitlán*, in the East of the DF, passing through *Iztapalapa* near its border with *Nezahualcóyotl*, and ends in the municipality of *La Paz*. This was the first line to cross the DF-State of Mexico border, and the only metro line that uses steel wheels.

Line 8 opened in 1994. This line extends from the downtown area to the center of *Iztapalapa*. It has achieved the fourth largest ridership among lines of the system, after lines 1, 2 and 3. In its downtown segment, it runs parallel to lines 2 and 3 (North-South direction), providing some relieve to these lines. Its total extension is 20 km.

Line B is the last line that has been built. Its first segment was opened in December 1999, and in 2001 it was completed. It has 23.7 km, and it is the longest line of the system. As line A, this line crosses the border between the DF and the State of Mexico. Its northeastern terminal is in the *Ecatepec* municipality, and its southwestern terminal is next to a closed railroad station, *Buenavista*, in the edge of downtown.

Using data from the housing and population Censuses of 1990 and 2000, and the Economic Censuses of 1994 and 1998, I tested the hypothesis that the construction of the three lines generated changes on land uses in the area around stations. To test if the hypothesis is valid for housing uses, I compared the change in population, and income per capita of three types of zones:

- Those not located close to any metro station (called X-type zones)
- Those located next to the lines built between 1990 and 2000 (called Y-type zones)
- Those located close to the previously-built lines (called Z-type zones)

To test if the hypothesis holds for commercial, service and manufacturing land uses, I compared the changes in the number of jobs in the same three types of zones described before. In this case, the data was taken from the Economic Census of 1994 and 1998. As Line A was opened long before 1994, I did not include it in this comparison.

I made some assumptions and simplifications. All zones to be compared were to be located in the same municipalities where the three lines were built. The comparison was made for zones that had similar incomes per capita and densities in 1990, as well as similar distances to the city center.

The analysis only considered zones in the DF. The reasons I had was that the real estate market in the State of Mexico is less formal than in the DF (see discussion in section 5.1), that the overall change of land uses in the outermost part of the metropolitan area is much faster and may be affected by the urbanization of new land, therefore affecting the results, and that the dimension of the blocks in the State of Mexico may not follow the usual dimensions of the rest of the city (this is important because I used the number of blocks

per AGEB to estimate densities). In the DF in contrast, the amount of urban land may have changed less in this period, reducing the risk of obtaining large changes in population as consequence of these changes.

The censuses of 1990, 1994, 1998 and 2000 used similar zones. Each municipality or *delegación* was partitioned into small zones, called *Áreas Geográficas Básicas* (AGEBs). AGEBs in the DF had an average of 27.6 blocks, with a standard deviation of 20.0. Some AGEBS were split in the subsequent censuses. All the comparisons were made using 1990's AGEBS. Data for AGEBS that were split was consolidated to make the comparisons meaningful.

In the MCMA, groups of AGEBS form districts. Districts are always within a single municipality, except for some cases in the State of Mexico. AGEBS are in all cases part of only one municipality. At the time this thesis was being completed, I did not have digitalized data of the location of each AGEB, but I did have the information that was gathered for them in the four census that were mentioned before.

It was not possible to obtain an automatically generated list of the AGEBS located close to metro stations. I had access to a map of the AGEBS, from which I made a list of the ones with borders located up to two blocks from each station of the five *delegaciones* and three municipalities in which the stations on lines 8, A and B are located. These *delegaciones* are *Cuauhtemoc*, *Iztacalco*, *Iztapalapa*, *Venustiano Carranza* and *Gustavo Madero*. The municipalities are *Ecatepec*, *Nezahualcóyotl* and *La Paz*.

The choice of two blocks was somehow arbitrary, but reasonable. In Latin America blocks used to have a square shape and have a standard longitude called “cuadra”, which varied from 100 to 150 meters. This pattern has remained in use in most part of the cities of Latin America<sup>134</sup>. Two blocks are then equivalent to around 200 to 300 meters. As on average AGEBS have 20 blocks, if we assume they are square shaped, the distance from the station to the geographic center would be between 970 and 620 meters, which is

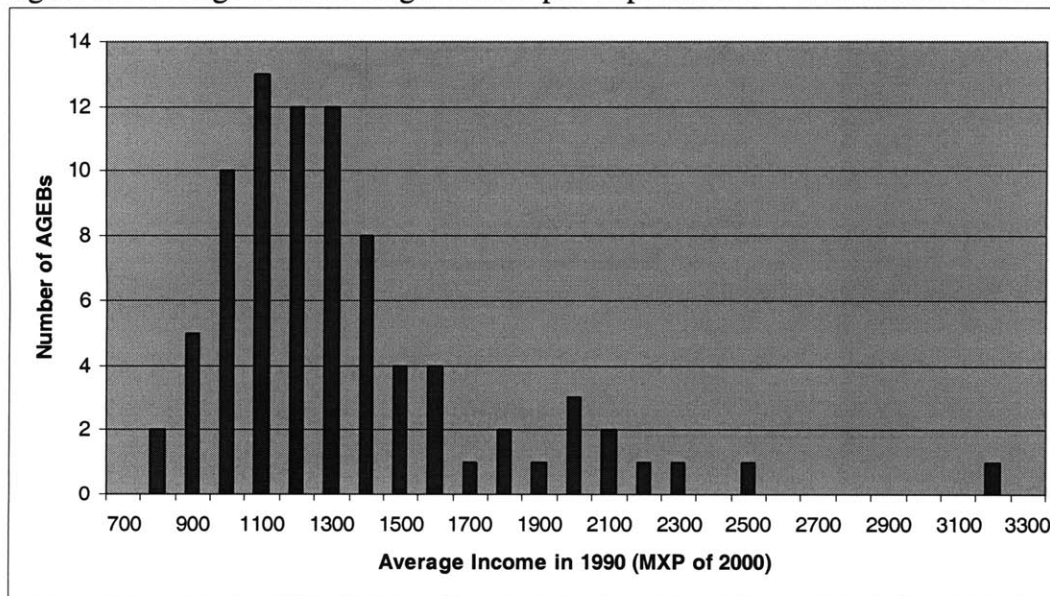
---

<sup>134</sup> López and Ibarra, 1997

similar to the maximum distance from metro stations at which changes on land uses have been identified in other parts of the world. The large number of AGEBs included in the analysis should reduce the errors associated with the differences in the shape of the AGEBs and in the dimension of the blocks.

To compare the changes in population and income per capita of the AGEBs that gained direct access to the metro in the 1990's with the changes in other AGEBs, I split Y-type AGEBs in homogenous groups in terms of density, income per capita and distance to the city center. To do this, I first sorted the 83 Y-type AGEBs by income per capita in 1990, and graphed the number of these AGEBs in different income categories. The result is shown in the following figure:

Figure 12: Histogram of Average Income per Capita in 1990 of 83 selected AGEBs

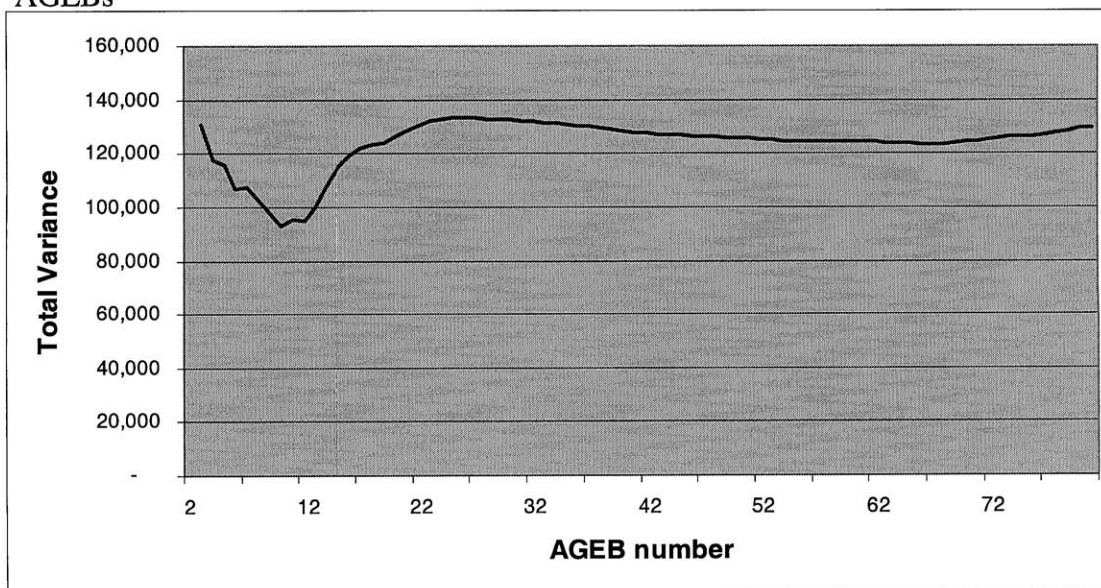


Source: Developed by author

As we see in the figure, there is one AGEB whose income is far higher than the rest. To reduce the variation of income per capita between these AGEBs, I decided to take this AGEB out of the analysis. Eliminating this AGEB would allow me to restrict the range of income of the areas to which we will compare these AGEBs.

I then made a list of the 82 remaining AGEBs sorted by average income per capita. For each AGEB, I estimated the summation of the variance of average income per capita of two groups of AGEBs: one group included the AGEBs that had less income per capita than the AGEB I was considering, and the other group included all the other AGEBs (including the one that was being considered). This function is defined for every AGEB, except for the ones with the highest and the lowest income per capita. My objective was to choose the two groups for which this function is the minimum. The result is shown in the following graph:

Figure 13: Summation of variances of average income per capita of two groups of AGEBs



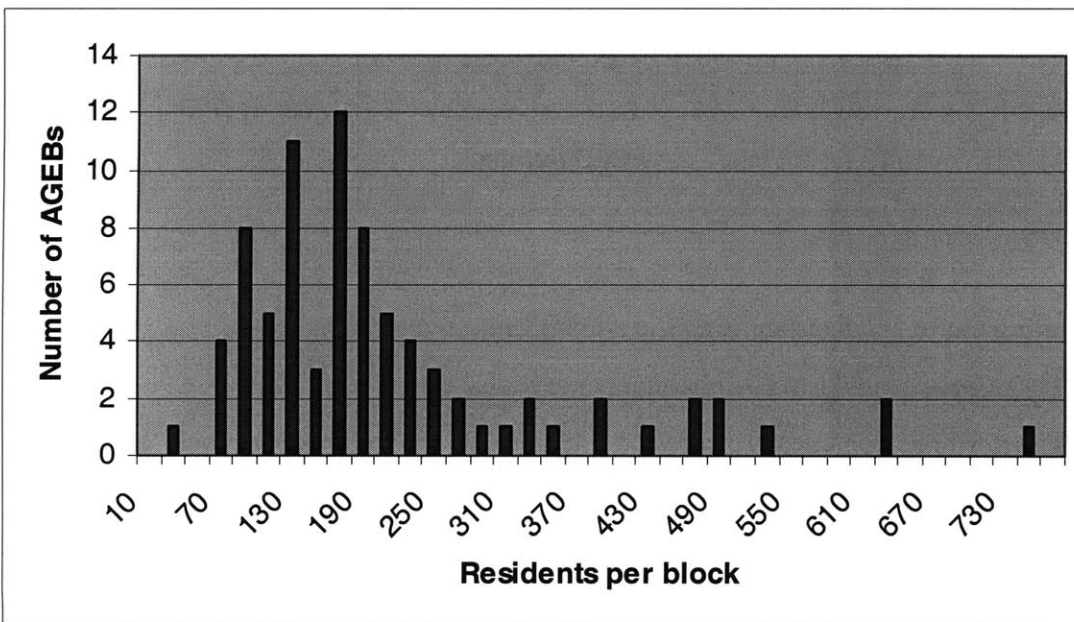
Source: Developed by author

The minimum variance resulted by dividing the AGEBs in the following groups:

- Group 1: Those with average income per capita in 1990 from MXP 2,545 to MXP 1,911 (pesos of 2000). This last figure corresponds to the average income per capita of the AGEB with the 10<sup>th</sup> largest income per capita. As can be seen in the previous graph, this is the AGEB for which the calculated function is minimum
- Group 2: Those with average income per capita in 1990 from MXP 1,800 to MXP 781 (pesos of 2000)

I made a similar analysis for density. As was pointed out earlier, I did not have the exact area of each AGEB. Nevertheless, the census reports the number of blocks per AGEB, which is a proxy of the area (see discussion on page 84). With this information, I made the following graph, which does not include the AGEB I eliminated from the analysis because of its high income:

Figure 14: Histogram of Residents per Block in 1990 for 82 selected AGEBs

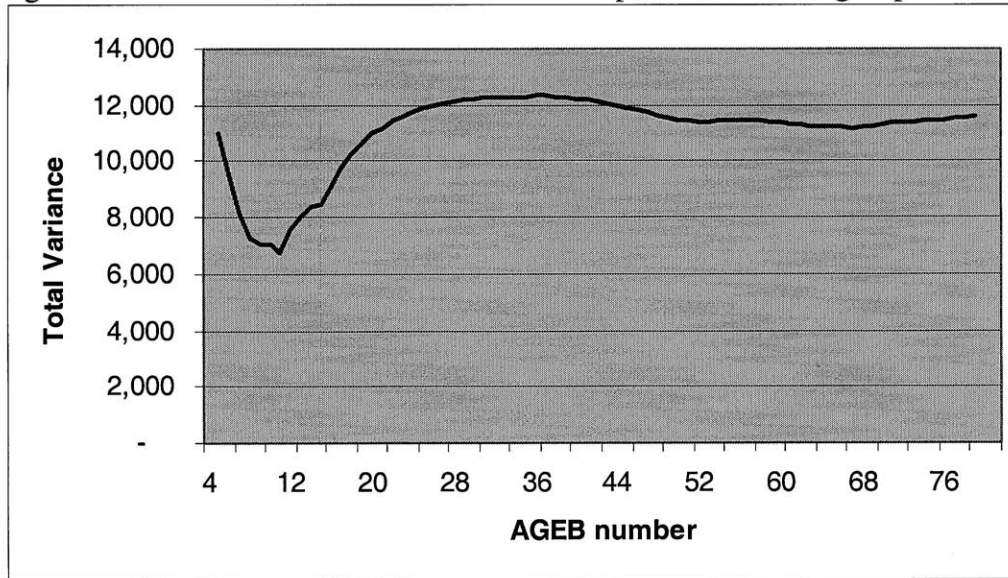


Source: Developed by the author

As can be seen in the graph, there are three AGEBs whose densities are well higher than the rest, and one whose density is well below the rest. To reduce the range of density of the group, I eliminated these four AGEBs.

I then calculated the summation of the variance resulting from splitting the remaining AGEBS into two groups, as was done with the income. The following figure graphs this function:

Figure 15: Summation of variances of residents per block of two groups of AGEBS



Source: Developed by the author

The resulting curve suggests splitting the AGEBS into two groups:

- Those between 341 to 67 inhabitants per block
- Those whose densities are between 538 and 394 inhabitants per block. The latter is the density of the AGEB with the 11<sup>th</sup> largest density, as seen on the graph

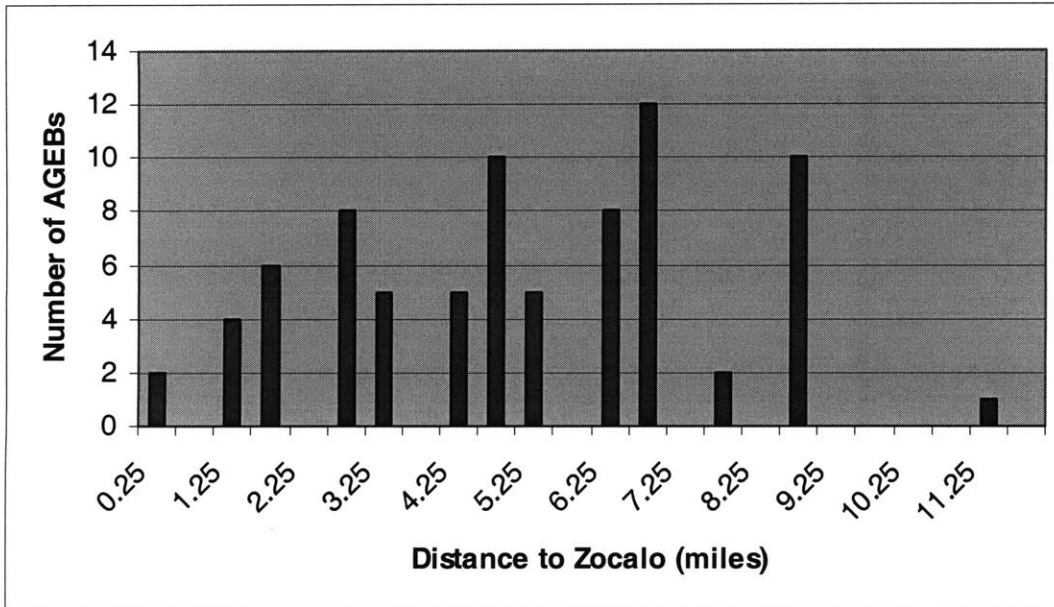
The range of the AGEBS with low densities very broad, so I estimate a new partitioning of the AGEBS in three groups. Using a similar procedure, I found that the following ranges would minimize the sum of the variance, while reducing the range of AGEBS with low density:

- Group 1: AGEBS with densities between 190 and 67 inhabitants per block
- Group 2: AGEBS with densities between 341 and 194 inhabitants per block
- Group 3: AGEBS with densities between 538 and 394 inhabitants per block

Similarly to what I did for average income and density, I made a graph of the histogram of the distance of AGEBS to the city center. I did not have a database with these distances, but I did have the name of the district each AGEB belongs to, and the distance from all districts to the district that includes the *Zócalo*, the central square in Mexico City. Therefore, I assumed each AGEB was located at the same distance from the *Zócalo*

as the district it belongs. The following is the graph of the histogram, including only the 78 AGEBS I had not eliminated:

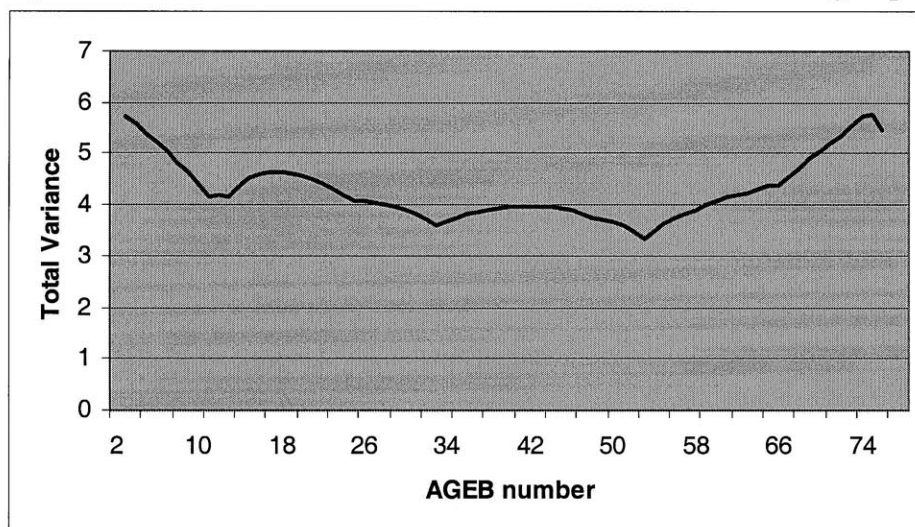
Figure 16: Histogram of Distance to Zócalo for selected 78 AGEBS



Source: Developed by the author

In this case, one AGEBS is way out of the rest in terms of distance to the city center, so I decided to eliminate it from the analysis. With the resulting AGEBS, I found the way to group them so that the summation of the variance of the distance to the city center of both group be minimized, as I did with income per capita and with density. The following graph shows the result:

Figure 17: Summation of variances of distance to Zócalo of two groups of AGEBS



Source: Developed by the author

So the summation of the variance is minimized when the 77 AGEBS are divided into the following groups:

- Group 1: Those with distance to the city center between 0 and 3.1 miles
- Group 2: Those with distances to the city center between 4.4 and 9.0 miles

Then, I defined 12 categories of AGEB, resulting from 2 categories for income, 3 for density and 2 for distance to the city center. In all cases the groups with number 1 are the ones that are positively correlated with income. The following table presents the correlation of income with the measures we are using for density and with distance to the city center, for all AGEBS in the DF:

Table 5: Correlation of Density and Distance to Zócalo with Average Income per Capita for AGEBS in the MCMA

	<b>Correlation with Average Income per Capita</b>
Density	- 0.18
Distance to <i>Zócalo</i>	- 0.07

Source: Developed by the author from Census 1990

So as this table shows, the closer to the city center and the lower the density, the higher the average income per capita is<sup>135</sup>. Therefore I called the groups of AGEBs with the lowest density, and with the lowest distance to the city center “Group 1”.

The following table shows how many of the AGEBs located next to the stations of lines A, B and 8, and that were not eliminated from the analysis, exist in each category:

Table 6: Number of the 77 selected AGEBs in each of the twelve categories

<b>Group Name</b>	<b>Density Group</b>	<b>Income Group</b>	<b>Distance Group</b>	<b>Number of AGEBs</b>
A	1	1	1	1
B			2	6
C		2	1	9
D			2	31
E	2	1	1	0
F			2	0
G		2	1	7
H			2	15
I	3	1	1	2
J			2	0
K		2	1	6
L			2	0
<b>Total</b>				<b>77</b>

Source: Developed by the author

As can be seen in the table, more than half of these AGEBs are in the low income and high distance from the city center categories.

As I said before, I compared the variation in population between 1990 and 2000 of the AGEBs that gained accessibility to the metro in the 1990’s (77 out of the original 83), in

<sup>135</sup> This confirms the theory presented in Greizbord et al (1999).

each of these 12 categories, with other AGEBS in the same some, density and distance to the city center categories.

As can be seen in the last table, several groups have very few of the 77 studied AGEBS. The low numbers of AGEBS in some groups make their comparison with other AGEBS not very relevant, since there is a high probability that changes in population and employment of these AGEBS may be affected by another factor other than access to the metro. Therefore I only studied the 6 groups that include 6 or more of the 77 AGEBS. In the following pages I describe the results for each of these 6 groups.

*5.3.2.1 Group B: High income, Low density, High distance to the city center*

The following table shows the characteristics, and changes in population and average income per capita between the Census 1990 and the Census 2000 of the three types of AGEBS. They are all part of the same group of AGEBS defined by ranges of income per capita, residential density and distance to the city center.

Table 7: Comparison of changes in population and average income per capita of AGEBS with high income, low density and high distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Average Distance to the <i>Zócalo</i>	Inhabitants per block 1990	Change in population 1990-2000	Average Income per Capita 1990 (MXP 2000)	Change in average income 1990-2000
X - Not close to any Metro station	13	6.2	121	27.9%	2,091	3.8%
Y - With direct access to the Metro since the 1990's	6	4.9	140	-3.6%	2,124	-7.9%
Z - With direct access to the Metro before the 1990's	0					

Source: Developed by the author

As we see, there were no Z-AGEBS (those with previous access to the Metro) in this category. The AGEBS that gained access to the metro in the 1990's had higher population average density and income per capita than other AGEBS with similar characteristics.

However, they experienced a decrease in population in the 1990's, and a negative change in income per capita, compared to increases of both values in X-AGEBs. This difference may be partially explained by the fact that Y-AGEBs are slightly closer to the city center than X-AGEBs. As was pointed out before, there has been a general flattening of the density curve in Mexico City in the last few decades.

The following table shows the changes in employment for this group of AGEBs. As I did not have the number of blocks per AGEB in 1994, I assumed they were the same as in 1990. I used this assumption for all the tables reporting density of jobs.

Table 8: Comparison of changes in employment for AGEBs with high income, low density and high distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Manufacturing jobs per block 1994	Change in manufacturing jobs	Commercial and Service jobs per block 1994	Change in commercial and service jobs
X - Not close to any Metro station	13	3.5	425%	5.6	366%
Y - With direct access to the Metro since the 1990's	5	5.1	-57%	5.8	39%
Z - With direct access to the Metro before the 1990's	0				

Source: Developed by the author

As I said before, I am not including AGEBs located next to line A in this table, so that is why there are fewer Y-AGEBs in this table than in the previous one.

As we see in this table, the AGEBs located close to the new lines of the metro had similar job densities than X-AGEBs. But in the 1994-1998 period there was an impressive

difference in the creation of jobs in both areas, with X-AGEBs creating more commercial and service jobs than Y-AGEBs, and the latter even reducing the number of manufacturing jobs.

In general terms, for Group B AGEBS, the metro failed to bring more residents, income per capita, manufacturing jobs or commercial-service jobs than to other AGEBS with similar characteristics in terms of income per capita, population density and distance to city center.

*5.3.2.2 Group C: Low income, Low density, Low distance to the city center*

The following table shows the characteristics, and changes in population and average income per capita between the Census 1990 and the Census 2000 for AGEBS in Group C.

Table 9: Comparison of changes in population and average income per capita of AGEBS with low income, low density, low distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Average Distance to the <i>Zócalo</i>	Inhabitants per block 1990	Change in population 1990-2000	Average Income per Capita 1990 (MXP 2000)	Change in average income 1990-2000
X - Not close to any Metro station	37	2.6	135	-11.1%	1,308	15.5%
Y - With direct access to the Metro since the 1990's	9	2.7	134	-6.3%	1,177	16.9%
Z - With direct access to the Metro before the 1990's	17	2.1	151	-14.4%	1,390	18.4%

Source: Developed by the author

As we see in this table, in 1990 Y-AGEBS were very similar to X-AGEBS in terms of distance to the city center and density, and slightly less dense and located farther from the

city center then Z-AGEBs. Even though the three types of AGEBs had a reduction in the number of residents in this period, the reduction was less severe for Y-AGEBs. There was not a high difference in the change of income per capita of the three types of AGEBs.

In the following table I present the changes in employment for this group of AGEBs:

Table 10: Comparison of changes in employment for AGEBs with low income, low density, low distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Manufacturing jobs per block 1994	Change in manufacturing jobs	Commercial and Service jobs per block 1994	Change in commercial and service jobs
X - Not close to any Metro station	37	19.9	-18%	17.1	14%
Y - With direct access to the Metro since the 1990's	9	4.6	7%	5.8	-30%
Z - With direct access to the Metro before the 1990's	17	13.2	-13%	40.9	2%

Source: Developed by the author

In this case we see that Y-AGEBs had a lower density of jobs than X-AGEBs. Contrary to what we would expect from our discussion in section 3.6.1, in this case manufacturing jobs increased and commercial and service employment decreased in Y-AGEBs. Even more, in the same period, X-AGEBs had an increase of commercial and job services, exacerbating their advantage in the density of these jobs with respect to Y-AGEBs.

### 5.3.2.3 *Group D: Low income, Low density, High distance to the city center*

The following table shows the characteristics, and changes in population and average income per capita between the Census 1990 and the Census 2000 for AGEBs in Group D.

Table 11: Comparison of changes in population and average income per capita of AGEBS with low income, low density, high distance to the city center, sorted by accessibility to metro

Type – Characteristics of AGEBS	Number of AGEBS	Average Distance to the <i>Zócalo</i>	Inhabitants per block 1990	Change in population 1990-2000	Average Income per Capita 1990 (MXP 2000)	Change in average income 1990-2000
X - Not close to any Metro station	167	7.0	130	14.9%	1,185	18.1%
Y - With direct access to the Metro since the 1990's	31	6.6	118	16.5%	1,215	15.3%
Z - With direct access to the Metro before the 1990's	4	5.4	114	-3.5%	1,492	6.5%

Source: Developed by the author

In this case we can see that Y-AGEBS behaved very similarly to X-AGEBS in terms of changes in population and income per capita. Their performance though, was better than Z-AGEBS'. The slightly higher population growth of Y-AGEBS over X-AGEBS may be caused in part by a lower density at the beginning of the period (1990).

The following table compares the changes in employment:

Table 12: Comparison of changes in employment for AGEBS with low income, low density, high distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Manufacturing jobs per block 1994	Change in manufacturing jobs	Commercial and Service jobs per block 1994	Change in commercial and service jobs
X - Not close to any Metro station	167	8.2	10%	4.5	25%
Y - With direct access to the Metro since the 1990's	14	8.7	32%	5.8	44%
Z - With direct access to the Metro before the 1990's	4	3.3	62%	6.5	59%

Source: Developed by the author

The number of Y-AGEBS is much lower than in the previous table, because 17 of the Y-AGEBS of that table are located close to stations in line A.

As we see in this table, Y-AGEBS began the period with a similar density of jobs to X-AGEBS, and both for manufacturing and commercial and service jobs they had a higher growth than X-AGEBS.

Overall, there seems to be a positive effect, i.e. the metro attracted firms to its surrounding area.

#### 5.3.2.4 *Group G: Low income, Medium density, Low distance to the city center*

The following table shows the characteristics, and changes in population and average income per capita between the Census 1990 and the Census 2000 for AGEBS in Group G.

Table 13: Comparison of changes in population and average income per capita of AGEBS with low income, medium density, low distance to the city center, sorted by accessibility to metro

Type – Characteristics of AGEBS	Number of AGEBS	Average Distance to the <i>Zócalo</i>	Inhabitants per block 1990	Change in population 1990-2000	Average Income per Capita 1990 (MXP 2000)	Change in average income 1990-2000
X - Not close to any Metro station	26	2.1	246	-9.6%	1,326	15.0%
Y - With direct access to the Metro since the 1990's	7	1.5	247	-14.2%	1,231	14.9%
Z - With direct access to the Metro before the 1990's	36	2.0	241	-12.8%	1,394	8.9%

Source: Developed by the author

For this group we can see that in 1990 Y-AGEBS had a similar number of residents per block than the other two types of AGEBS. Income was slightly lower in Y-AGEBS than in the other types of AGEBS, and they tended to locate closer to the city center than the rest. All the AGEBS had a decrease in population, but the reduction was higher in Y-AGEBS. There was not an important difference between the growth in income in X- and Y-AGEBS.

The following table shows the changes in the number of jobs:

Table 14: Comparison of changes in employment for AGEBS with low income, medium density, low distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Manufacturing jobs per block 1994	Change in manufacturing jobs	Commercial and Service jobs per block 1994	Change in commercial and service jobs
X - Not close to any Metro station	26	45.5	-7%	45.3	4%
Y - With direct access to the Metro since the 1990's	7	33.3	-21%	142.9	-46%
Z - With direct access to the Metro before the 1990's	36	34.1	-3%	83.2	-3%

Source: Developed by the author

As the table shows, there was a significant difference in the change of the number of jobs between X- and Y-type AGEBS. Whereas X-AGEBS had a modest increase in commercial and service jobs, Y-AGEBS has a significant decrease, even though the high initial concentration of these jobs in Y-AGEBS means that by 1998 these AGEBS still had a higher density of these jobs than X-type AGEBS.

*5.3.2.5 Group H: Low income, Medium density, High distance to the city center*

The following table shows the characteristics, and changes in population and average income per capita between the Census 1990 and the Census 2000 for AGEBS in Group H.

Table 15: Comparison of changes in population and average income per capita of AGEBS with low income, medium density, high distance to the city center, sorted by accessibility to metro

Type – Characteristics of AGEBS	Number of AGEBS	Average Distance to the <i>Zócalo</i>	Inhabitants per block 1990	Change in population 1990-2000	Average Income per Capita 1990 (MXP 2000)	Change in average income 1990-2000
X - Not close to any Metro station	71	6.0	245	-6.7%	1,191	13.8%
Y - With direct access to the Metro since the 1990's	15	6.5	241	-5.7%	1,210	10.6%
Z - With direct access to the Metro before the 1990's	0					

Source: Developed by the author

In this case we can see that X and Y-type AGEBS started from very similar residential densities and income per capita. The change in these indicators in both types of AGEBS was very similar.

The following table shows the changes in the number of jobs:

Table 16: Comparison of changes in employment for AGEBS with low income, medium density, high distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Manufacturing jobs per block 1994	Change in manufacturing jobs	Commercial and Service jobs per block 1994	Change in commercial and service jobs
X - Not close to any Metro station	71	12.7	-2%	10.0	-3%
Y - With direct access to the Metro since the 1990's	7	16.9	-36%	25.3	-18%
Z - With direct access to the Metro before the 1990's	0				

Source: Developed by the author

In this case we see a similar situation to group G, where Y-AGEBS had a higher density of jobs in 1994, but suffered a higher lost of jobs than X-AGEBS. Also for manufacturing jobs, Y-AGEBS suffer a higher lost than X-AGEBS.

#### 5.3.2.6 *Group K: Low income, High density, Low distance to the city center*

The following table shows the characteristics, and changes in population and average income per capita between the Census 1990 and the Census 2000 for AGEBS in Group K.

Table 17: Comparison of changes in population and average income per capita of AGEBs with low income, high density, low distance to the city center, sorted by accessibility to metro

Type – Characteristics of AGEBs	Number of AGEBS	Average Distance to the <i>Zócalo</i>	Inhabitants per block 1990	Change in population 1990-2000	Average Income per Capita 1990 (MXP 2000)	Change in average income 1990-2000
X - Not close to any Metro station	7	2.0	470	-11.4%	1,343	-3.3%
Y - With direct access to the Metro since the 1990's	6	1.9	465	-9.5%	1,368	-5.2%
Z - With direct access to the Metro before the 1990's	3	2.2	477	-7.9%	1,422	-4.8%

Source: Developed by the author

As for all other groups, the stations that gained access to the metro in the 1990's did not have a significant higher increase in population than X-AGEBs. In fact in this case both types of AGEB had a similar change in population, which was negative in both cases. The change of income in the three types of AGEBs is also similar.

The following table shows the changes in the number of jobs:

Table 18: Comparison of changes in employment for AGEBS with low income, high density, low distance to the city center, sorted by accessibility to metro

Characteristics	Number of AGEBS	Manufacturing jobs per block 1994	Change in manufacturing jobs	Commercial and Service jobs per block 1994	Change in commercial and service jobs
X - Not close to any Metro station	7	29.5	-4%	80.0	-9%
Y - With direct access to the Metro since the 1990's	6	100.9	-13%	76.1	13%
Z - With direct access to the Metro before the 1990's	3	28.6	-9%	94.8	-23%

Source: Developed by the author

This group, along with group D are the only ones in which Y-AGEBS had a significantly better performance than X-AGEBS, in terms of the relative increase in the number of commercial and service jobs. Manufacturing jobs diminished in Y-AGEBS even more than in X- and Z-type AGEBS.

### 5.3.2.7 Conclusions of the analysis

In general terms, the construction of the metro in the 1990's, did not produce a major positive effect on population growth or income per capita increase in the areas around stations, for any of the studied groups. Only in two groups of AGEBS, C and D, there was a higher positive relative growth in the number of manufacturing jobs in Y-type AGEBS than in X-type AGEBS. For commercial and service jobs, the same thing happened only in two groups, D and K.

One reason that could explain the low increase in commercial activities around stations is that the construction of the metro made it easier to local residents to go to the city center to make their purchases, instead of relying on local stores. As we said in section 3.6.2,

this phenomenon has been reported for cities such as Bilbao and Lille in Europe. To test this hypothesis, I compared the change in commercial and service jobs in the 77 AGEBs by *delegación*, with that of comparable AGEBs that did not gained direct access to the metro in the 1990's. The results are the following:

Table 19: Change in Employment in AGEBS in the DF in Mexico City, sorted by delegación

Delegación	Characteristics	X – Not close to any Metro station	Y – With direct access to the Metro since the 1990's	Z – With direct access to the Metro before the 1990's
Gustavo Madero	Number of AGEBS	142	7	47
	Commercial and Service jobs per block 1994	6.0	2.8	28.0
	Change in commercial and service jobs	9%	69%	-9%
Iztacalco	Number of AGEBS	62	9	3
	Commercial and Service jobs per block 1994	8.0	17.7	81.4
	Change in commercial and service jobs	33%	42%	-32%
Iztapalapa	Number of AGEBS	188	19	0
	Commercial and Service jobs per block 1994	5.7	11.9	
	Change in commercial and service jobs	28%	5%	
Cuauhtémoc	Number of AGEBS	30	10	28
	Commercial and Service jobs per block 1994	67.1	153.0	244.0
	Change in commercial and service jobs	-2%	-41%	-14%
Venustiano Carranza	Number of AGEBS	43	6	54
	Commercial and Service jobs per block 1994	12.3	15.5	34.7
	Change in commercial and service jobs	40%	-14%	-1%

Source: Developed by the author

As we see, in *delegación Cuauhtémoc*, which is the one located in the center of the city, the performance of the Y-AGEBS was very bad compared to X-AGEBS, and it is were Y-AGEBS suffered the highest relative decrease of the five *delegaciones*. This result makes

the hypothesis that people started going to downtown to shop not very credible, since otherwise Y-AGEBs in downtown would have shown an increase in commercial activity.

One of the reasons to explain the low impact of the lines that were built in the 1990's in Mexico City is that the city has a lot of land around metro stations available for redevelopment. Therefore, there is not scarcity for metro-accessible land. As we said in section 3.4, a relative scarcity of accessibility is a necessary condition for and values to increase.

Another possible explanation for the low impact we observed is that it takes a lot of time for land to redevelop, and that no impact may have been yet visible by 2000. This is a viable explanation, and it coincides with what has been observed in other parts of the world (see section 4.4.5). Nevertheless, the performance of Z-type AGEBs was in almost all cases worse than X-type AGEBs as can be seen in the tables presented from page 92 to page 105, in terms of growth in population, in income per capita and in the number of jobs. This result makes the time lag explanation not very credible.

The low impact that these lines have had on land uses do not mean that the other lines in Mexico City have not had any impact. In fact, as we discussed in section 5.3.1, there is a lot of evidence that the metro has been one of the factors producing the loss in population of the city center, its specialization in tertiary activities, the growth of the metropolitan area, and the reinforcement of previously existing secondary centers. Nevertheless, most of this change may have occurred before the 1990's, the period that was analyzed in this Chapter, and mainly caused by the construction of the first three lines of Mexico City's Metro.

## **6 Santiago and the Metro**

This Chapter includes a review of the history of urban development and public transportation in Santiago in the 20<sup>th</sup> century. There is also a discussion about the evolution of ridership in Santiago's metro. Section 6.3 includes a revision of the literature on the effects of the metro on urban development, and a quantitative analysis of the effects of the construction of the metro on population and average income per capita in the areas around stations.

### **6.1 Urban development in Santiago**

Up to 1940, Santiago had a compact city center, which concentrated the main commercial and cultural activities of the city. Most high- and mid-income people lived in this area. Low-income people had different types of housing: many located in rural areas around the city where they rented land in subdivisions and build their own houses; other rented rooms in the most deteriorated parts of the city; finally, some other occupied public land illegally<sup>136</sup>.

Chile, as Mexico, implemented a centrally planned industrialization strategy in the period after World War II. This plan considered the location of industries in the main cities. This strategy induced a massive immigration from the countryside to Santiago. As can be seen in the following table, the growth of population in Santiago in the 1950's and 1960's was way above the growth of previous periods:

---

<sup>136</sup> De Ramón (1990)

Table 20: Population in Santiago de Chile

Year	Population	Average yearly growth up to the year of the following row
1940	1,100,000	2.0%
1952	1,400,000	5.2%
1960	2,100,000	2.9%
1970	2,800,000	2.8%
1982	3,900,000	1.9%
1992	4,700,000	2.0%
2001	5,600,000	

Source: Rodriguez and Winchester (2001) data for 1952-1992. Data for 1940 is urban inhabitants of the Santiago Province, from Chile (1960). Data for 2001 from DICTUC (2003)

The growth of population and of car ownership in the 1950's and 1960's caused an increase of congestion in the central city. In the 1950's high-income dwellers migrated to the East of the city, in a very fast process<sup>137</sup>. The houses they left would become multi-family housing for the new immigrants.

High-income people moved first to *Providencia*, and few years later also moved further east, to *Las Condes*. These two municipalities, along with the neighbor municipalities of *Vitacura*, *Lo Barnechea*, *La Reina* and *Ñuñoa* form the so-called *Zona Oriente* (Eastern Zone). This zone still houses almost all high-income people of the city, and almost no other social groups. By 2002 these six municipalities had 15% of the population of the metropolitan area<sup>138</sup>, and in 1998 their residents received around 45% of the income of the metropolitan area<sup>139</sup>.

The income segregation at the municipality level is higher in Santiago than in Mexico City. In 1998, the coefficient of variation of average income per capita of the

<sup>137</sup> Gross (1991), page 37.

<sup>138</sup> Census 2002, data retrieved from [www.ine.cl](http://www.ine.cl).

<sup>139</sup> Average income 1998 per municipality retrieved from [www.ine.cl](http://www.ine.cl), weighted by 2002 population. See Appendix 3 for data.

municipalities within the Santiago metropolitan area was 0.77. The same coefficient for *delegaciones* and municipalities in the MCMA in 2002 was only 0.40<sup>140</sup>.

The massive immigration to Santiago exacerbated the shortage of housing in the city, especially for low-income people. As a response, in 1953 the national government created the *Corporación de la Vivienda* (CORVI), which was in charge of the construction of housing for the poor. The government's housing programs provide housing for a significant part of the population in the 1960's. To reduce the cost per unit of housing, CORVI tended to buy land in the suburbs of the city, exacerbating the segregated pattern of the city. During the Frei Montalva administration (1964-1970), the government's housing program was responsible for 60% of the units built during the period<sup>141</sup>. In spite of this effort, the shortage would become more intense and cause serious political conflicts in the following decade.

In 1957 the first land invasion took place in Santiago. This invasion became then a neighborhood, *La Victoria*<sup>142</sup>. This was the first of many more invasions to come. They grew exponentially during the Allende administration (1970-1973), as a response to the very few evictions undertaken by the police during that administration, which openly sympathized with land invasions. In those years, for the first time, land with high value was invaded<sup>143</sup>.

Chile suffered a drastic switch of its urban development laws after 1973's coup. In the 1970's, there was a lift of the urban border, which generated an important increase in land values outside the former border<sup>144</sup>. There were also massive evictions of illegal settlements from the *Zona Oriente*, which exacerbated segregation even more.

---

<sup>140</sup> See section 5.1 for assumptions and comments.

<sup>141</sup> Sabatini and Arenas (2000).

<sup>142</sup> Gross (1991) page 37.

<sup>143</sup> It is well known that invasions take place in land of low value to minimize the risk of being evicted. See Sabatini and Arenas (2000).

<sup>144</sup> Sabatini (2000).

In the 1980's the city witnessed the construction of the first shopping malls. Malls have fostered the development of town centers around them, and provide badly needed services in the periphery of the metropolitan area. Moreover, shopping malls in traditionally low-income areas have attracted development for people of different income, helping to reduce segregation<sup>145</sup>.

An urban renewal program for Santiago was established in 1985. The program considers subsidies for the construction of new buildings or the restoration of existing units. The subsidy is for up to UF 200 (approximately \$5,400) for new housing units. The program has fostered the construction of more than 10,000 new units in the downtown area, most of them in the form of multi-family housing<sup>146</sup>.

The very fast pace of construction of housing for the poor in the 1980's and 1990's, has produced for the first time in modern history a reduction in the estimated shortage of units for the poor, and a reduction in the number of illegal settlements. This kind of settlements are now extremely infrequent in Santiago, accounting for less than 1% of the housing stock in Santiago, compared to more than 40% in Mexico City, Bogotá, Caracas and Lima and 20% in Rio de Janeiro and Sao Paulo<sup>147</sup>.

The Santiago Metropolitan Area comprises at least 34 *comunas* or municipalities, each of which has its own government. Among other attributions, municipalities are in charge of establishing zoning codes and collect property taxes.

Mid-income people tend to locate in either *comunas* close to the city center (*San Miguel, Independencia, Santiago*) or certain suburban municipalities, such as *La Florida* and *Maipú*. According to recent reports, there has been a switch in demand by middle-income people, from houses in the periphery to multi-family housing in downtown. The Santiago

---

<sup>145</sup> Sabatini (2000).

<sup>146</sup> Information retrieved from <http://www.cordes.cl/barrios/index.htm>.

<sup>147</sup> Clickevsky (2000), cited in Arriagada and Simioni (2001).

municipality has become the one with the highest number of new units built in the last few years<sup>148</sup>.

Low-income people tend to locate in the periphery of the metropolitan area, clustered in certain municipalities such as *La Pintana, Pudahuel and Puente Alto*. The government has located its housing projects in municipalities already occupied by low-income people. The government is still an important actor in the housing market in Chile. More than 40% of housing units built every year have a direct or indirect subsidy of the national government<sup>149</sup>.

Santiago has a well-developed formal market for new houses. On the other hand, the market for used houses and rents is formal only for the high-income segment, in part because of the effect of the government in this area<sup>150</sup>. Some examples of government's action that impede the development of these markets are the exclusive focus on promoting house ownership instead of renting, and the restrictions imposed on the selling of subsidized units.

Multi-family housing accounts for an important share of the housing stock in the Metropolitan area, a 22.4% in 2002<sup>151</sup>. In recent years apartments/condos have surpassed houses in terms of the number of units built per year. Multi-family housing is highly concentrated the municipalities of *Santiago, Providencia* and *Las Condes*.

The city has two main employment clusters. The main one is the Central Business District, located in the municipality of Santiago, which in 1991 accounted for 31.5% of the employment in the metropolitan area<sup>152</sup>. A new cluster emerged in the area of *Providencia* in the 1980's, and then extended to *Las Condes* in the 1990's. These two municipalities account for 10.3% and 6.3% of the jobs in the metropolitan area

---

<sup>148</sup> See for example El Mercurio, March 11, 2004 "Pabellón de la Construcción: Departamentos lideraron preferencias habitacionales del 2003".

<sup>149</sup> Cummings and DiPasquale (2000).

<sup>150</sup> Cummings and DiPasquale (2000).

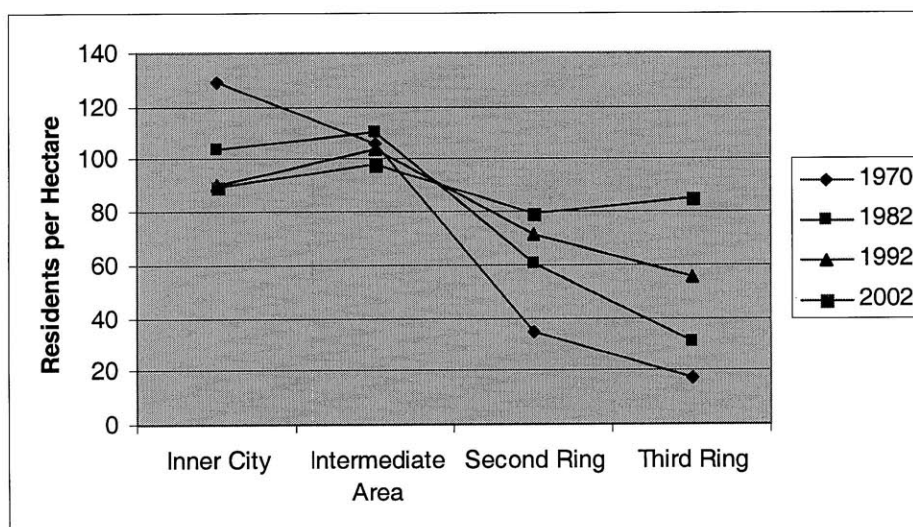
<sup>151</sup> Census 2002, retrieved from [www.ine.cl](http://www.ine.cl).

<sup>152</sup> From Sectra (1991).

respectively<sup>153</sup>. The share of these two employment centers in white-collar jobs is even higher. These three municipalities plus *Vitacura* and *Huechuraba* account for 96% of square meters of office space in the metropolitan area<sup>154</sup>.

In the last few decades there has been a homogenization of densities in the metropolitan area. The following figure shows the curve of densities in concentric rings around the city center. All densities were estimated by dividing the population for the specific years by the urban area of each municipality in 2002<sup>155</sup>.

Figure 18: Density for concentric rings in Santiago



See Appendix 3 for sources and assumptions

As we see in the graph, the loss of population in the inner city stopped in the 1990's. From the 1970's, the population in the intermediate city has been very stable, and development has concentrated in the second and third ring.

The concentration of housing in the low-income periphery municipalities has been an important driver of the flattening of the curve. The *Zona Oriente* has a very different pattern of development than the rest of the metropolitan area. There has not been any

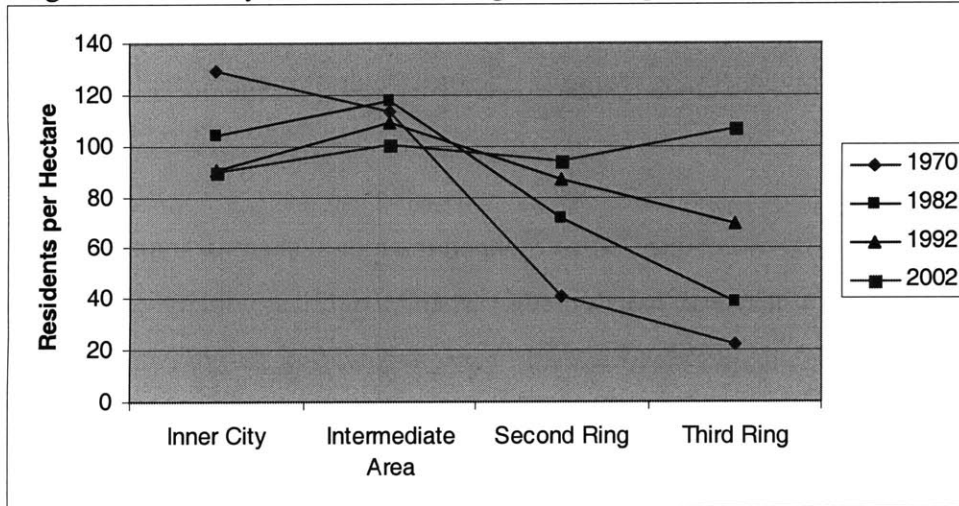
<sup>153</sup> From Sectra (1991).

<sup>154</sup> Rodriguez and Winchester (2001).

<sup>155</sup> Not reliable estimations of urban area per municipality for 1970, 1982 and 1992 were found.

government-sponsored social housing program in this area for decades, because of the high value of land. If we take this zone out of the analysis, the outer ring would be denser than the city center, as seen on the next figure.

Figure 19: Density for concentric rings in Santiago, excluding Zona Oriente



See Appendix 3 for sources and assumptions

Contrary to the previous graph, in this case there is a decrease in the population of the intermediate area. This difference is caused by not including *Ñuñoa*, whose population grew between 1970 and 2002.

We can see that excluding the *Zona Oriente*, the third ring is the zone with the highest population density. Given the fact that the two main employment clusters are one the city center, and the other close to the city center, this distribution of population is very inefficient.

## 6.2 Public transportation and the metro

### 6.2.1 History of public transportation

At the beginning of the 20<sup>th</sup> century, Santiago had an extensive tram system. Up to the 1930's, trams were the main transportation mode in the city. By 1930 they carried approximately 200 million passengers per year<sup>156</sup>. All trams in Santiago were privately owned, being the Electric Bond & Share, from the US, the owner of most of the lines by then.

In the 1940's, the growth in the number of buses reduced the modal share of trams. In 1945 the national government nationalized all the trams, and a public company was formed to operate them. This company was named *Empresa Nacional de Transporte*, which in 1953 changed name to *Empresa de Transportes Colectivos del Estado (ETC)*<sup>157</sup>.

Soon after its formation, the ETC started to replace trams with buses. In 1947 the first trolleys entered to service in Santiago<sup>158</sup>. The number of buses owned by the ETC and by private operators increased significantly in the 1950's and 1960's. In 1958 the ETC closed the last tramline<sup>159</sup>.

In the 1960's the growth of the city was causing a fast increase in congestion. The government assumed a more active role in public transportation regulation. It started controlling fares, routes and frequencies of the services operated by private firms, and assigned routes in tendering processes. A regional master plan for Santiago was developed in 1960, which identified the need for the establishment of a metropolitan transit system. By the late 1960's the ETC reached its peak share, serving around 10% of the trips in Santiago<sup>160</sup>.

---

<sup>156</sup> Morales (1988), page 21. This is almost the same ridership of Santiago's Metro in 2003.

<sup>157</sup> Morrison (1992).

<sup>158</sup> Information retrieved from <http://www.tramz.com/cl/tb/tb.html>.

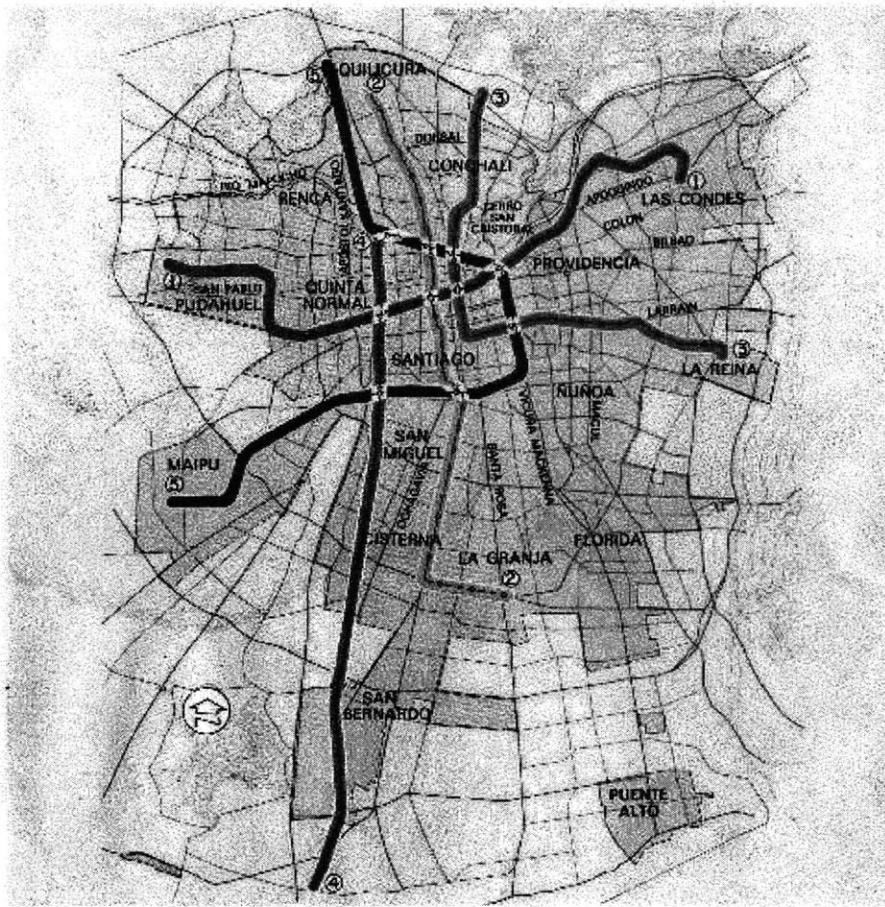
<sup>159</sup> Morrison (1992).

<sup>160</sup> Darbéra (1992).

The Frei Montalva administration (1964-1970) implemented several projects to modernize Santiago: Route 5, which runs along Chile, was enhanced to highway standard and placed below ground level in its downtown section; the construction of a new beltway, *Américo Vespucio* was initiated; and a new metro was planned, and the works for the first line began.

The original plan for the metro considered five lines, totaling 60 km<sup>161</sup>. The following map shows the alignment that the plan considers for these lines.

Figure 20: Original Metro Plan in Santiago



Source: [http://members.fortunecity.es/trecitoschilenos/metro\\_de\\_santiago.html](http://members.fortunecity.es/trecitoschilenos/metro_de_santiago.html)

<sup>161</sup> [www.urbanrail.net](http://www.urbanrail.net).

Although it had a different political agenda from the previous government, the Allende administration (1970-1973) continued the construction of the metro. Because of political turmoil, there were extensive delays in the construction.

The Pinochet administration (1973-1990) inherited a project that was running behind schedule and over budget. In the middle of the intense economic crisis of 1975, the works were stopped, and the entire plan was revised. To reduce costs, the government decided to build only lines 1 and 2 in a first phase, and postpone the construction of the other lines. Moreover, the government also decided to change the alignment of the eastern part of Line 1 to the *Providencia-Apoquindo* corridor instead of *Vitacura* Avenue. Line 2 was also moved from its planned alignment, *San Diego – Banderas*, the main north-south corridor of the city, to the median of Route 5.

The first phase of Line 1 was open to the public in 1976, and Line 2 opened in 1978. The extension of Line 1 to the East opened in 1980.

The initial results were disappointing overall. The final costs were much higher than what was planned. Ridership in the first few years was almost a third of what was considered in the original plan. Nevertheless, this difference may have been caused by a slower pace of construction than expected, by the lack of integration that the metro had with buses, which was an essential part of the master plan, and by the change of the alignment of Line 2.

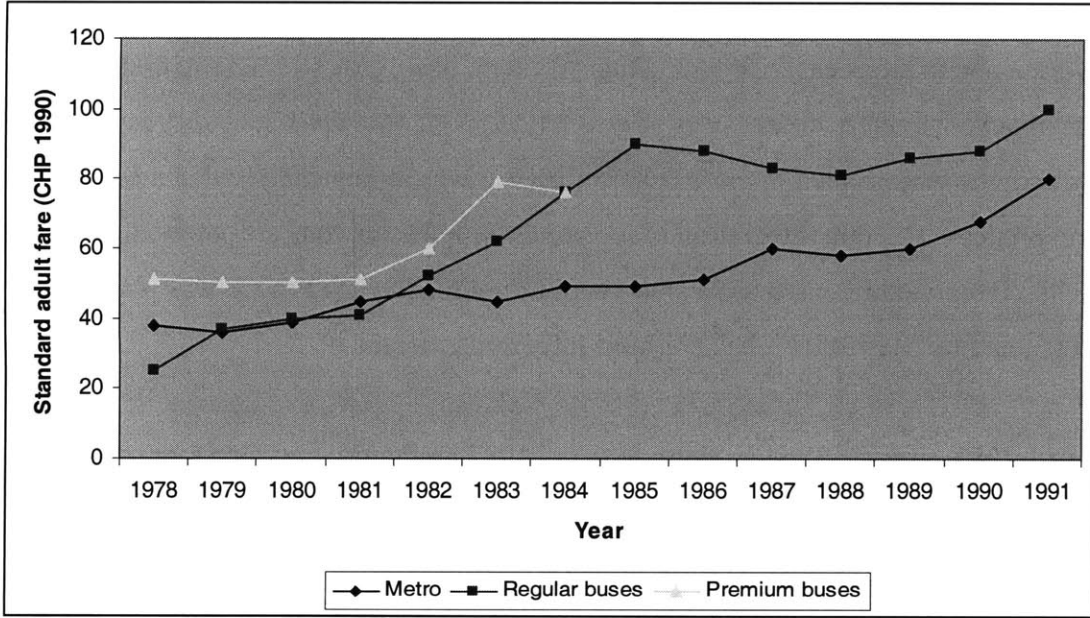
In 1978 the Pinochet administration decided to reorganize the entire urban transportation system of Santiago. That year ETC was closed, and the last remaining trolleybus line ceased operation. The provision of public transportation was liberalized in a gradual process that began in 1979.

The effects of deregulation of bus service were negative overall. In the 1980's, the number of buses grew 100%, compared to a modest 10% increase in ridership. Premium buses, which only carried seated passengers, ceased operation in this decade. Between

1978 and 1990, bus fares increased more than 300% in real terms. The average extension of the routes grew from 30 km in the late 1970's to 55 km in 1991 (roundtrip). The mean age of the fleet grew from 6 years in 1979 to 10 years in 1989<sup>162</sup>. Finally, the number of routes grew tremendously, as buses started to offer direct service between most municipality pairs. In a context of low income, the option of a one-seat-one-fare ride proved to be very attractive.

The following graph compares the average fare of buses and the metro from 1978 to 1991.

Figure 21: Bus and Metro Fares 1978-1991



Source: Darberá (1993). Figures were approximated.

The cease of the premium bus service can be explained by different reasons. One is that economic growth and the decrease in import tariffs paid by cars induced many of its customers to buy vehicles<sup>163</sup>. Another plausible reason is that people tended to take the first bus they could to their destination, since the value of the expected time after the next

<sup>162</sup> All figures taken from Darberá (1993).

<sup>163</sup> In 1977, the high tariffs that imported cars had to pay were lifted, significantly reducing the cost of buying a car. This produced a significant increase in the number of cars in Santiago.

arrival was higher than the extra benefit of the premium service. This characteristic would have made frequency the most important attribute for bus operator, and created economies of densities, which discourage operators to provide non-standard service.

Deregulation also generated some benefits. The increase in the number of buses and routes reduced headways, and the number of connections people needed to make. The reduction in the number of passengers per bus increased the chance of finding an empty seat. In fact, the problem of overcrowded bus, which was a serious one by 1978, almost disappeared in the 1980's<sup>164</sup>.

Up to the 1980's, the Metro lacked any formal integration with feeder buses. Many people used buses to reach stations, but there was no integrated fare or infrastructure to make these connections easy. To tackle this problem, in August 1987 Metro created a system of subcontracted feeder buses. The system, called *Metrobús*, had very modest results and was downscaled in the 1990's. In 2003 it was re-launched with a new route bidding process. The fare integration of *Metrobús* with the metro is still limited. A plan to reduce the integrated fare and use a smart card as unique payment mode was planned for late 2003, and by May 2004 it has not been fully implemented.

The 1982-1983 economic crises, along with the 1985 earthquake, created a heavy burden to the national budget, and postponed the plans for the expansion of Line 2 and the construction of Line 3. The only expansion of the network for 17 years was an extension of Line 2 to the north, inaugurated in 1987. Only in 1997 Line 5 was completed, and in 2000 it was expanded to downtown.

In 2001, the national government announced a plan to expand the network from 40 to 90 km in 2006. A new line, called Line 4, is being built along avenues *Tobalaba*, *Américo Vespucio* and *Vicuña Mackenna*. Additionally Line 2 is being extended in both directions, and Line 5 is being extended to the west. The next figure shows the lines that exist and the ones that are being built by the first semester of 2004.

---

<sup>164</sup> Darbéra (1993).



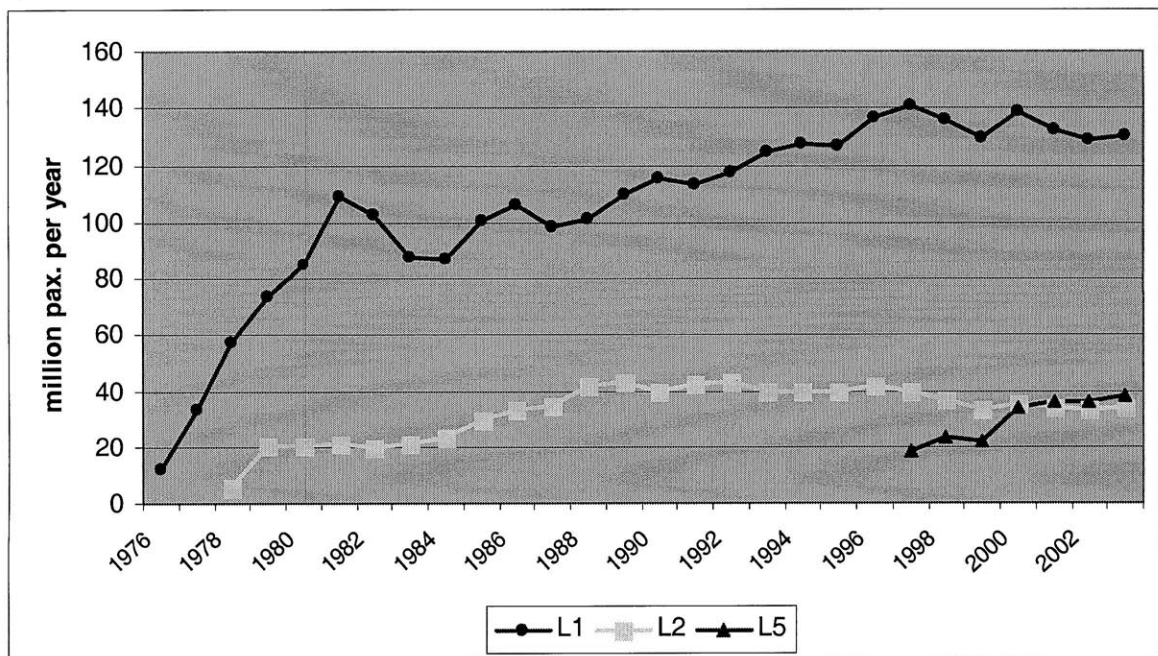
would begin at *Quinta Normal* station (Line 5), and end in *Maipú*, in the southwest of the metropolitan area.

In 2001, the national government announced a new urban transportation plan, which was then called *Transantiago*. The plan considers the integration of buses, metro and commuter trains. A new process of route tendering will be made, and companies will have to bid for one of eight packages of trunk routes or one of the complementary feeder services. A smart card will be used as the unique mean of payment. This card is already being used in the metro. Additionally, two bus rapid transit lines will be built<sup>165</sup>.

### 6.2.2 Metro and its ridership

The following table shows the number of passengers per line and per year in Santiago's metro. All the figures are the number of passenger-boardings in each line.

Figure 23: Number of passengers per line in Santiago



Source: Metro de Santiago (2003)

<sup>165</sup> Information retrieved from [www.transantiago.cl](http://www.transantiago.cl).

Since the early 1980's, Line 1 has been a success in terms of ridership. The line is located on Santiago's busiest corridor, *Alameda-Providencia -Apoquindo*. In 1981, a year after the opening of its eastern-most section, the line transported 109 million people. In 1997 it carried 141 million people, and since then it has had a slight decrease, probably because of the cool-down of the Chilean economy.

Since the early 1990's, the central section of Line 1 is experiencing congestion, in spite of an increase in the number of trains, and of the number of cars per train. In 1994, Metro implemented different fares for rush and non-rush hours, which has been able to curve the growth of ridership during rush hours<sup>166</sup>.

On the other hand, Line 2 has been a major failure in terms of ridership. In 2004 it only carried 34 million passengers, far from the maximum ridership it achieved in 1989, 44 million passengers. One of the plausible explanations for this poor performance is the fact that the line does not connect directly to downtown, but rather make people change line to get there. The need for connecting to access the city center may make the line less attractive than other one-seat options such as buses or shared taxis.

Line 5 has also carried meager traffic. In 2001, after the opening of its extension to downtown, the line transported 36 million passengers. Two stations (*Plaza de Armas* in downtown and *Bellavista de La Florida*, the terminal station in the south), account for 49% of the labor-day boardings<sup>167</sup>. The low-intensity of urban development in the rest of the alignment has determined low ridership.

During the 1980's ridership in the Metro grew very fast. One of the reasons for this growth was that buses' fares grew more than 100% in real terms (see figure on page 117). The increase in street congestion, particularly in the *Alameda-Providencia* corridor, improved the attractiveness of the metro. The growth of passenger flows in Metro was

---

<sup>166</sup> Between 1992 and 2002 the summation of the ridership in the one-peak hour of all line on labor days in Santiago, has decreased 20%, whereas overall ridership has increased 11% (Metro de Santiago 2003). This may have been in part caused by the differentiated fare, and part by the congestion of the system, which cause people to choose other modes at rush hour.

<sup>167</sup> Metro de Santiago (2003).

particularly strong in a period where the level of service of buses declined significantly, 1984-1986<sup>168</sup>.

There is a government policy to ask Metro to pay for its operational cost since 1979<sup>169</sup>. In 1990, the military government transferred 200 million dollars of the debt it subscribed to fund the construction of the original two lines to the metro. Recently Metro agreed to pay part of the investment costs of Line 4 and of the future extension of Line 2. To achieve these goals, Metro has maintained a fare which is much more higher than other metros' fares in Latin America<sup>170</sup>. This policy has been successful in producing an operational surplus since 1980, the year that the extension of Line 1 to the East was opened<sup>171</sup>. In spite of its self-sustaining fare policy, Metro's fares were lower than bus fares for most parts of the 1980's, as shown in the figure on page 117.

Contrary to the case of Mexico City, the metro in Santiago attracts middle and high-income people. In 2002 an internal survey of Metro showed that the percentage of riders who are university professionals varies from 21% to 38% at different times of the day, with other professionals accounting for 15% to 26%. Blue-collar employees are less than 2% of the riders, and people that are self-employed are less than 5%. In contrast with Mexico City's metro, students account for a very large portion of the riders, 25% to 35%<sup>172</sup>.

## **6.3 Effects of the metro on the city**

### **6.3.1 Commented review of existing literature**

Several studies have discussed the effect that Santiago's metro has had on land values and land uses. According to Galilea and Hurtado (1998), the metro has had a double

---

<sup>168</sup> Figueroa (1990).

<sup>169</sup> Morales (1988), page 35.

<sup>170</sup> In 2002, the average fare in Santiago's metro was 38 cents of a dollar, compared to 34 in Sao Paulo and 16 in Mexico City (information on Sao Paulo's fare from [www.metro.sp.gov.br](http://www.metro.sp.gov.br), for Santiago and Mexico City see Appendix 2).

<sup>171</sup> Morales (1988), page 32.

<sup>172</sup> Metro de Santiago (2003).

effect. On the one hand, they say it made the city center more oriented towards high-income employment, specifically in the tertiary sector (e.g. financial sector), but on the other, they say this specialization has been in detriment of the industries sector that existed in the area up to the early 1970's<sup>173</sup>.

The decadence of industrial firms located in the city center appears to be more related to the change of economic conditions of Chile than to the construction of the metro. The manufacturing sector in all regions of the country had a strong transformation with the economic reform of the 1970's and 1980's, reducing its share in the GDP<sup>174</sup>, and re-orienting itself towards foreign markets. The entire country, and not only the central area of Santiago, has specialized in service and commercial activities. Therefore it does not seem just to blame the subway for the contraction of industrial activities in the city center.

Many studies have criticized Santiago's metro for serving almost exclusively mid and high-income people<sup>175</sup>. They blame the chosen alignment and the fare policy for excluding the poor. With respect to the chosen alignments, it is true that the first three lines do not go to low-income areas, probably with the exception is the westernmost part of Line 1 and the southernmost part of Line 2. Nevertheless, it has to be considered that low-income people tend to live in the periphery of the city, where it is less cost-effective to have mass transit service. Line 4 in Santiago is intended to serve Puente Alto, a predominantly low-income area.

There are a few studies about the effect that the subway had on land values. According to Galilea and Hurtado (1988), there was a spectacular increase in land values in the eastern part of the city, immediately before the opening of the extension of Line 1 to the east, and probably as a response to it. The following table shows the value of land in different parts of the city:

---

<sup>173</sup> Galilea and Hurtado (1988).

<sup>174</sup> In 1974, the year before the opening of the Metro in Santiago, manufacturing accounted for 25% of the GDP. In 1995 it accounted for 19%. In absolute terms the manufacturing has grown though.

<sup>175</sup> See for example Galilea and Hurtado (1988) and Navarro (1993), page 10.

Table 21: Value of land in different areas of Santiago (constant CHP of 1980 / m<sup>2</sup>)

Area	1969	1976	1977	1978	1980	1985
Average Santiago Metropolitan Area	602	285	445	866	442	931
Northern Sector	401	336	200	175	262	179
Southern Sector	201	101	110	64	362	393
Downtown	4,943	1,174	1,675	2,226	5,855	2,445
Eastern Sector	878	382	830	1,887	5,804	1,694
Western Sector	652	101	138	69	177	202

Source: Adapted for inflation from Galilea and Hurtado (1988)

The increase in land values was the highest in the *Providencia* municipality (located in the eastern sector). During this period the area around stations *Tobalaba*, *Los Leones* and *Pedro de Valdivia*, became the second largest employment center in Santiago. Land values got to their peak in 1981, but fell significantly when the economy entered into recession in 1982. Land values though increased compare to their initial value. At the beginning of the 1990's, *Providencia* was the municipality with the highest average land values in the city, and by 1997 it was second to *Las Condes*<sup>176</sup>.

It is not clear if the increase of land values was a response to the construction of the metro, but most likely the metro had some effect. The construction of the *Nueva Providencia*, and avenue under which the metro would run, and of several pedestrian streets between this avenue and *Providencia* may have also made the area more attractive. But there is no doubt that the large number of office buildings that have been constructed in the area benefit from the presence of the metro, and therefore office space in the area has a price premium. The construction boom in *Providencia* from 1977 to 1981 produced overinvestment in retail space. After the economic crisis of 1982-1985 many stores were vacant<sup>177</sup>. In the 1990's there was a fast reduction in vacant space, and a new boom in construction.

<sup>176</sup> Arriagada and Simioni (2001).

<sup>177</sup> Galilea and Hurtado (1988), page 57.

The downtown area also had a significant construction boom in the 1980's and 1990's. Many buildings were built especially around stations *Universidad de Chile* and *Santa Lucía*<sup>178</sup>. The municipality of Santiago invested heavily in improving the downtown area. The construction of two pedestrian streets, *Ahumada* and *Huérfanos* made the area very attractive. In the 1980's property values rose significantly in downtown, probably because of the growth of the financial sector, which was attracted to the area. Moreover, there was an increase of the proportion of space dedicated to retail, which gained a larger influence area after the opening of the metro<sup>179</sup>.

Contrary to the major changes on land uses in the eastern part of the city, land uses in the western part of the city did not have major changes after the opening of the metro. The fact that the eastern part of the city concentrates high-income people and professionals may have made the western part less attractive for office development. Nevertheless, this does not explain the lack of housing development in the area. Only in recent years, with the help of an urban redevelopment program, have new buildings been built around the western part of Line 1.

Until the 1990's, Line 2 failed to foster new development around its stations. Several reasons explain this failure:

- Most of the alignment is along an open-trench highway (Route 5), which may scare development away
- The line serves a mid-income community, *San Miguel*, and during the 1980's and 1990's, there was a big supply of mid-income single-family houses in the municipalities of *La Florida* and *Maipú*
- Probably only during the 1990's economic growth created a critical mass of mid-income people whose income was big enough to afford living in high-rises. In Latin America this form of housing is costly compared to the option of one-floor houses in the periphery (probably this is different in the US because of zoning in the suburbs)

---

<sup>178</sup> Figueroa, O (1990).

<sup>179</sup> Galilea and Hurtado (1988).

- There were few efforts by the government to induce redevelopment in the areas around stations. The urban renewal program that was mentioned in section 6.1, promoted the redevelopment of the area, but only from the 1990's
- The growth in commercial activities in the city center, and the construction of shopping malls in the periphery, deterred the construction of commercial space in the areas around stations
- The lack of big lots made the construction of shopping malls or high rises around stations too expensive to be made

Only from the mid-1990's multi-family housing geared towards mid-income people have become common in Santiago. The areas around Line 2 in *San Miguel*, and downtown have been two of the places where this type of development is taking place. In spite of the long time it took for redevelopment to occur in *San Miguel*, land values rose after the construction of the metro<sup>180</sup>, maybe as a result of developers holding on land to wait for the appropriate moment to develop it.

Six years after the opening of Line 5 the major changes in land uses around the alignment have occurred in the southernmost part. The area around station *Bellavista de La Florida* has continued its rapid development, triggered by the opening of a shopping mall in 1990, before the metro station was built. The station has helped fuel the attractiveness of the area for housing and development<sup>181</sup>. As there is no intensive housing development along Line 5, the line probably does not bring a significant number of customers to the shopping mall. Nevertheless, many people park their cars in the shopping mall, use the subway to go to their jobs<sup>182</sup>. Probably this behavior does not bother the mall, since it has not done anything to stop it. Probably some of the people who use the parking lots of the mall, stop for shopping or entertainment before going back home. Moreover, only during

---

<sup>180</sup> Galilea and Hurtado (1988), page 54.

<sup>181</sup> De Mattos (1999) quotes a manager of the mall, who expressed how the metro station has become an asset for Plaza Vespucio Shopping Center.

<sup>182</sup> According to DICTUC (2001), the Auto-Metro mode is the one that has the highest proportion of their users coming from the Southeastern part of the city, which is only served by line 5. Presumably, this is caused by the large supply of free parking in the mall.

weekends is the demand for parking space from shoppers comparable to the supply. This leaves a lot of available space for commuters on weekdays.

A significant portion of the areas around Line 5 still are devoted to industrial uses, and have not been redeveloped. The slow redevelopment of the areas may be caused by the interest of municipalities to preserve the tax-base provided by these industries, and avoid paying the cost of the services required by housing developments. It may also be the case that the owners of the industries are speculating with the land. Most likely, for the first industry to be redeveloped to more intense uses, the costs will exceed the benefits, because of the presence of other industries in the zone, which make it an undesirable place to live for most people. Nevertheless, the reduction in the number of industries would ultimately make the area more attractive, and therefore the profits that could be obtained by redeveloping the last few industries is probably very high. As was pointed out before, this is the kind of market failures that the government has to solve for redevelopment to occur.

In spite of the significant growth of metropolitan area from the time the metro opened, it is highly dubious that the metro had any effect promoting the extension of the metropolitan area. The lines do not go deep into the suburbs. The government's housing building plans, which has caused a reverse gradient of densities as seen in Figure 19, may have had a higher effect in the expansion of the metropolitan area. The increase of motorization rates and the lift of the urban boundary may have also had an important role fueling this expansion. Line 4, which will extend to *Puente Alto*, may change this situation, and promote development in the yet not fully urbanized municipality of *Pirque*. On the other hand, the provision of large parking facilities in terminal stations can promote sprawl, but the metro in Santiago does not have large parking facilities. The percentage of metro riders who access by driving their cars is only 4.5% in the morning rush hour and even less during the rest of the day<sup>183</sup>.

---

<sup>183</sup> Metro de Santiago (2003).

At a micro level, Galilea and Hurtado (1988) identified three impacts of the metro. First, housing has been displaced by commerce and service in the areas around stations<sup>184</sup>. Second, low-income residents have been displaced by more affluent people in downtown. Finally, in some areas of the city center, informal commercial activities have grown around stations<sup>185</sup>. Apparently, informal commerce has grown in periods of economic crisis (1982-1985, 1999-2003) but less so in other periods, and it is less common than in Mexico City.

Overall, there is a general consensus that the metro reinforced the intensification of land uses in the eastern part of Line 1 from the 1980's, and the emergence of a secondary commercial and employment center in *Providencia* and *Las Condes*. This redevelopment was triggered by an increase in demand for land in this area, which generated an enormous increase in land values (see table on page 124). It is also clear that Line 2 generated the densification of *San Miguel*, but only since the second part of the 1990's, twenty years after its opening. Finally, authors agreed that the metro has helped stop the decline of the city center in terms of population and business activity.

### **6.3.2 An analysis of the effects of the metro on land uses**

This section describes an analysis I made on the effect that Line 5 and the original two lines had on land uses in Santiago in the 1990's.

The first segment of Line 5 opened in 1997, linking *Bellavista de La Florida* to *Baquadano*, connecting to Line 1 in this station. In 2000 the line was extended to the west, crossing the downtown area, and ending in *Santa Ana*, where it connects to Line 2. In March 2004 a new extension to the West was opened.

I utilized the same methodology used in section 5.3.2, to estimate the effect of Line 5 on land uses. In this case, the analysis is based on the zones used in 1991's origin/destination

---

<sup>184</sup> Galilea and Hurtado (1988), page 60.

<sup>185</sup> Galilea and Hurtado (1988), page 62.

survey for Santiago<sup>186</sup>. The population, area and income per capita of these zones were compared to the same data for the zones of 2001's origin/destination survey for Santiago<sup>187</sup>. The changes on population and income per capita were estimated for zones around Line 5, zones around other lines, and zones without direct access to the metro<sup>188</sup>. The analysis considered all the zones of 19 municipalities of the metropolitan area<sup>189</sup>.

Most of the zones used in the 2001 origin/destination survey were exactly the same as 1991. Others are partitions or aggregations of the zones of 1991, and in other cases groups of 1991's zones were split into new zones. All these changes are accounted in the comparisons, so in all cases the comparisons are relevant.

Using the same methodology of section 5.3.2, I ranked the 23 1991's zones that gained access to the metro network with the construction of Line 5, by average income per capita in 1991. Then I separate them into two groups. The groups were chosen so that the summation of the variance of the average income per capita within the each group was minimized.

I formed similar groups based on population density in 1991. In this case two zones had densities way out of the rest, so I decided to discard them. The other 21 zones were divided in two groups, formed in such a way to minimize the summation of the variance of density.

The range of average income per capita and density for each of the groups are shown in the following table. As in the case of Mexico City, group 1 is the one with higher income and lower densities. Both variables were negatively correlated for the different zones of Santiago in 1991, as was also the case in Mexico City:

---

<sup>186</sup> Data provided to the author by Sectra. There were 521 traffic analysis zones in the survey.

<sup>187</sup> Data provided to the author by Sectra. There were 749 zones in this survey.

<sup>188</sup> As for the case of Mexico City, two blocks were considered the maximum distance to consider a zone adjacent to a station.

<sup>189</sup> Only municipalities at a similar distance to the city center were included. A full list of the included municipalities is included in Appendix 4.

Table 22: Upper and Lower limits of average income per capita and population density for zone groups in Santiago de Chile

Group	Limits	Average Income per capita 1991 (CHP of 2001)	Density 1991 (Residents / Ha)
1	Upper	174,491	91.2
	Lower	100,699	49.1
2	Upper	89,837	159.6
	Lower	32,300	102.1

Source: Developed by the author

The 21 districts were also divided into those located in the core of the central city, and the rest. What I mean by “the core of the central city” is the area with the highest concentration of office space in the municipality of Santiago, which forms a triangle limited by *Alameda Avenue*, *Mapocho River*, and *Ruta 5*. The high concentration of office space in this area makes it very likely that the response to an increase in accessibility in this zone was not the same as in the rest of the city. As the zones in the core of the city center have higher average income per capita than the rest of the zones in the 19 municipalities included in the analysis, I called the zones in this area “Group 1”.

There are then two groups based on income per capita, two based on density and two based on location. Therefore there are eight possible combinations of these groups. The following table shows the how many of the 21 studied zones and how many other zones of the 19 municipalities follow in these eight groups. The 21 zones that gained direct access to the metro with the construction of Line 5, were called zones type-Y following the names used in section 5.3.2. The rest of the zones were divided between those with direct access to the other two metro lines (type-Z), and those without access to the metro (type-X).

Table 23: Number of zones in each of the eight categories

Group Name	Income Group (high income = 1)	Density Group (low density = 1)	Location Group (core of central city = 1)	X – Zones: Not close to any Metro station	Y - With direct access to the Metro after the construction of Line 5	Z - With direct access to the Metro before the 1990's
A	1	1	1	8	5	1
B			2		2	1
C		2	1	4	3	1
D			2			2
E	2	1	1	20	5	7
F			2	1		1
G		2	1	39	6	13
H			2	5		3
<b>Total</b>				<b>77</b>	<b>21</b>	<b>29</b>

Source: Developed by the author

The low number of zones that gained access to the metro with the construction of Line 5 makes some groups have very low number of Y-zones: only 4 groups have 3 or more Y-zones. As was pointed out before, no meaningful conclusions can be drawn from changes in population or average income per capita with small samples, so only groups with 3 or more Y-zones were analyzed. The following four tables compare the population density in 1991, average income per capita in 1991, and the change of these indicators for these four groups:

*6.3.2.1 Group A: High income, Low density, Outside the city center*

The following table shows the characteristics, and changes in population and average income per capita between the origin-destination survey of 1991 and 2001 for the three types of zones:

Table 24: Comparison of changes in population and average income per capita of zones of group A in Santiago

Characteristics	Number of Zones	Inhabitants per hectare 1991	Change in population 1991-2001	Average Monthly Income per Capita 1991 (CHP 2001)	Change in average income per capita 1991-2001 (Constant CHP)
X - Not close to any Metro station	8	80.5	32%	\$ 149,579	174%
Y - With direct access to the Metro after the construction of Line 5	5	60.3	28%	\$ 115,009	36%
Z - With direct access to the Metro before the 1990's	1	69.5	37%	\$ 103,165	139%

Source: Developed by the author

As we see in this table, Y-zones had a similar change in population to X-zones. The average income per capita in the former zones grew at a much smaller rate than in the latter. No conclusion can be drawn from Z-type zones, since there is only one zone in this group, and its change in population and in income per capita is likely to be highly affected by other factors.

#### 6.3.2.2 Group C: High income, High density, Outside the city center

The following table shows the characteristics, and changes in population and average income per capita between the origin destination survey of 1991 and 2001 for the three types of zones:

Table 25: Comparison of changes in population and average income per capita of zones of group C in Santiago

Characteristics	Number of Zones	Inhabitants per hectare 1991	Change in population 1991-2001	Average Monthly Income per Capita 1991 (CHP 2001)	Change in average income per capita 1991-2001 (Constant CHP)
X - Not close to any Metro station	4	126.6	-4%	\$ 120,269	73%
Y - With direct access to the Metro after the construction of Line 5	3	114.1	5%	\$ 160,030	46%
Z - With direct access to the Metro before the 1990's	1	127.0	3%	\$ 165,128	106%

Source: Developed by the author

As we see in this table, Y-zones increased their population, whereas the comparable X-zones lost population. The average income per capita in the former zones grew at a much smaller rate than in the latter zones. As it was the case for the previous group, the low number of Z-type zones (one in this case) makes the changes of their population and income per capita non-representative of the effect of the metro.

### 6.3.2.3 Group E: Low income, Low density, Outside the city center

The following table shows the characteristics, and changes in population and average income per capita between the origin destination survey of 1991 and 2001 for the three types of zones:

Table 26: Comparison of changes in population and average income per capita of zones of group E in Santiago

Characteristics	Number of Zones	Inhabitants per hectare 1991	Change in population 1991-2001	Average Monthly Income per Capita 1991 (CHP 2001)	Change in average income per capita 1991-2001 (Constant CHP)
X - Not close to any Metro station	20	68.7	1%	\$ 47,912	154%
Y - With direct access to the Metro after the construction of Line 5	5	78.2	13%	\$ 80,171	87%
Z - With direct access to the Metro before the 1990's	7	68.8	13%	\$ 58,033	132%

Source: Developed by the author

As we see in this table, Y-zones had a higher growth in population than comparable X-zones. As in the previous two cases, the average income per capita in the former zones grew at a much smaller rate than in the latter zones. In this case there are seven Z-type zones, so comparisons between groups are meaningful. The change in population of Z-zones was similar to the one of Y-type zones, and its relative change in income per capita was in between the change of the other two groups.

#### *6.3.2.4 Group G: Low income, High density, Outside the city center*

The following table shows the characteristics, and changes in population and average income between the origin destination survey of 1991 and 2001 for the three types of zones:

Table 27: Comparison of changes in population and average income per capita of zones of group G in Santiago

Characteristics	Number of Zones	Inhabitants per hectare 1991	Change in population 1991-2001	Average Monthly Income per Capita 1991 (CHP 2001)	Change in average income per capita 1991-2001 (Constant CHP)
X - Not close to any Metro station	39	126.5	2%	\$ 51,937	134%
Y - With direct access to the Metro after the construction of Line 5	6	126.5	-2%	\$ 51,583	112%
Z - With direct access to the Metro before the 1990's	13	119.6	-3%	\$ 53,510	152%

Source: Developed by the author

As we see in this table, all the types of zones in this group had a similar change in population, which was nearly zero. Y-zones had a lower growth in income per capita than X-zones, which had less growth than Z-zones.

From the last four tables we can draw some conclusions. First, for some groups the population in the zones that gained access to the metro with Line 5 (Y-type zones) had a significant higher growth to the population in the areas without access to the metro, something that we could not see in Mexico City (see section 5.3.2). In all comparable cases, the change in average income per capita in Y-type zones was lower than for the other two types of zones.

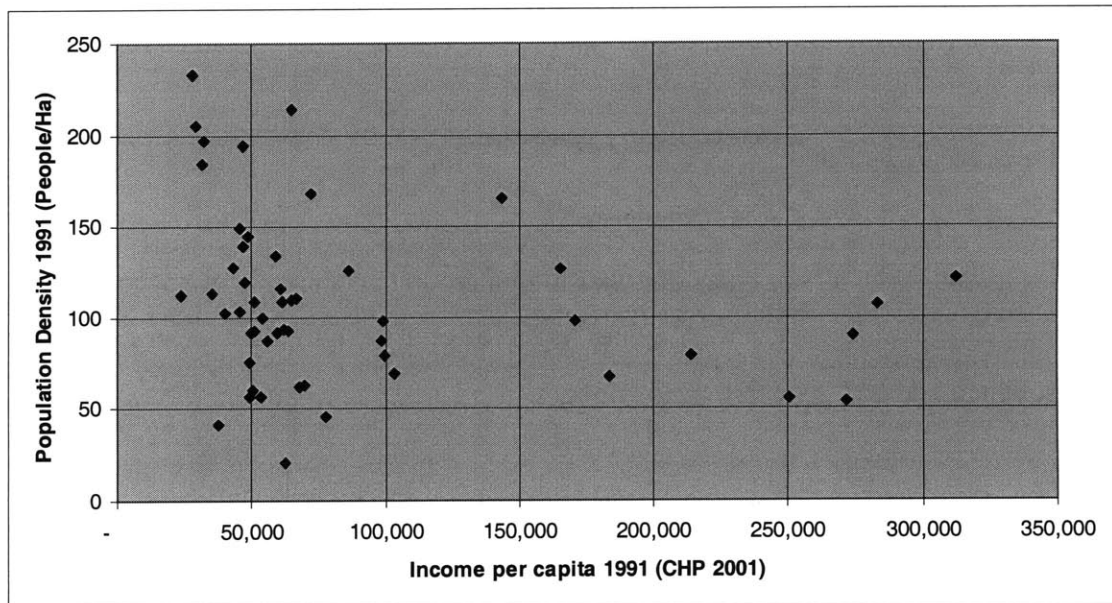
The low number of Z-zones included in two of the four groups made it impossible to test if the low increase in income per capita of Y-type zones may be a consequence of the little time between the opening of the line, and the measurement of income per capita (in 2001). In other words, we could not test if it may take time for the real estate market to adjust to the changes in accessibility and demand.

To evaluate if this hypothesis is true, I compared the changes in population and average income per capita between lines that had access to the metro before the 1990's (Z-zones),

and those that do not have direct access to the metro (X-zones), redefining the groups so that the number of zones in each group allows for meaningful comparisons.

The following graph shows the density and income per capita in 1991 of the zones located next to lines 1 and 2 (Z-zones).

Figure 24: Income per capita and population density of zones located next to lines 1 and 2 in Santiago, Chile



Source: Developed by author based Origin/Destination survey 1991

As can be seen in Figure 24, there is a big dispersion in the average income per capita, and much less in population density.

Using the same methodology described for Y-zones, I made a list of all Z-zones, and divide them into two homogenous groups according to their location in the core of the city center, three groups according to their income per capita and three groups according to their population density in 1991. As was done before, the groups were chosen to minimize the summation of the variance of income per capita or density of the different groups (see section 5.3.2 for further details). Some of the groups with the two highest income per capita had fewer than 3 Z-zones, making their changes in population and income per capita non good estimations of the effect of the metro itself, but subject to

other effects. Therefore, I merged the two groups with the highest income per capita. The ranges of the resulting groups are included in Table 28.

Table 28: Upper and Lower limits of average income per capita and population density for zone groups in Santiago de Chile

Group	Limits	Average Income per capita 1991 (CHP of 2001)	Density 1991 (Residents / Ha)
1	Upper	312,474	79.3
	Lower	165,128	21.1
2	Upper	143,586	168.6
	Lower	23,772	87.2
3	Upper	None	232.6
	Lower		184.4

Source: Developed by author

The following table presents the changes in population and average income per capita for the different groups. Only groups with three or more zones are included:

Table 29: Change in income per capita and population density for X and Z-zones in Santiago

Income Group (high income = 1)	Density Group (low density = 1)	Location Group (core of central city = 1)	Number of Zones		Relative change in population		Relative change in Income per capita	
			X - Not close to any Metro station	Z - With direct access to the Metro before the 1990's	X - Not close to any Metro station	Z - With direct access to the Metro before the 1990's	X - Not close to any Metro station	Z - With direct access to the Metro before the 1990's
1	1	2	8	4	37%	52%	133%	166%
1	2	2	8	5	19%	46%	79%	81%
2	1	2	19	11	59%	25%	142%	155%
2	2	2	89	24	-2%	-4%	131%	153%
2	2	1	6	3	6%	26%	122%	191%
2	3	2	23	6	-28%	-8%	170%	118%

Source: Developed by the author

As can be seen in the table, for four of the six groups, the zones located next to the lines built before 1990 (lines 1 and 2) had a higher increase in population than the ones located far from the Metro. In the case of zones with low income, intermediate density and outside the core downtown (combination 2-2-2), the difference between the two groups is almost null. Moreover, for this group the growth in the number of households for Z-zones was 9% versus 0% for X-zones (not shown in the table)<sup>190</sup>. As can be seen in the table, for all the high-income areas population growth in Z-zones was higher than for X-zones, confirming the observations that the metro in Santiago attracts middle and high-income people.

With respect to changes of income per capita, in all but one case the change of income per capita was higher in Z-type zones than in X-type zones. This difference can be a consequence of people of relatively higher income's locating close to the metro (gentrification), or of an increase in income of the people located next to the stations, as a consequence of the reduction of transportation costs.

The results in the last table confirms that the areas around lines 1 and 2 went through a development process in the 1990's that was significantly different from the one of areas without direct access to the metro. This development was characterized in most cases by a faster growth in population and average income per capita than in the rest of the city. This difference does not prove by itself that the metro caused this change, but it suggests that it did. At the very least these results prove that for most groups of zones, the metro by itself did not hinder housing development and neither did it produce decreases in average income per capita of the residents. The higher population and income per capita growth around lines 1 and 2 compared to Line 5 may be an indication that it takes time for redevelopment around stations to occur, or that lines 1 and 2 had a different impact on land uses than Line 5.

---

<sup>190</sup> This may indicate that these zones had very high number of people per unit of floor area, but predominantly single-family houses, so not so many people per ground area (population density). Redevelopment may have occurred in the form of apartment buildings, with fewer people per household, and much lower people per floor area, as appears to be by the more than proportional increase in income per capita for Z-zones.

## **7 Reasons to Explain the Different Impacts in Both Cities**

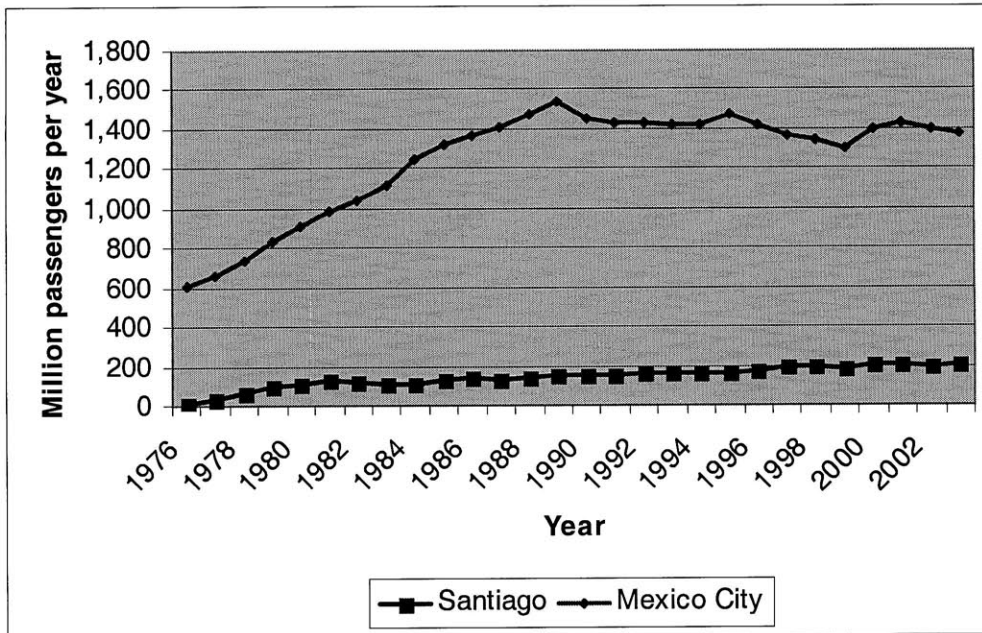
There are several reasons that can explain the difference between the impacts that the metros of Mexico City and Santiago have had on the land uses. In this Chapter I will test two hypotheses, namely that the impacts in Santiago have been higher than in Mexico City because of differences in the intensity of use of the systems, and because of differences in the average income per capita of their passengers.

### **7.1 Differences in the intensity of use**

One reason that can explain the difference in the impact of both systems is the difference in intensity of use. We will expect that systems with big flows of people per station to attract retail to the areas around stations, since retail can draw clients from these flows. The location of retail around stations may then attract some housing development. Therefore if this hypothesis were true, the metro in Santiago would be used more intensively than the metro in Mexico City.

Just to have an idea of the difference in magnitude of both metros, the following graph presents the number of riders per year:

Figure 25: number of passengers per year

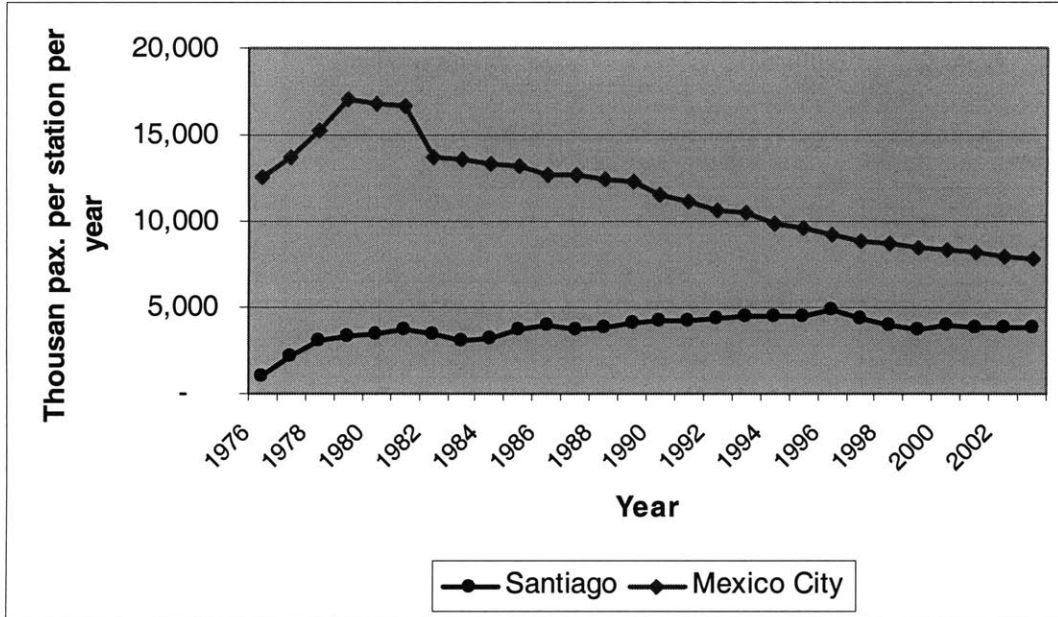


Source: See Appendix 2

As we see in the graph, both systems have a completely different magnitude, being the ridership in Mexico City almost six times larger than in Santiago. The metro in Santiago though has experimented a more steady growth in the number of passengers, whereas the peak of ridership in Mexico City was in 1989, and since then it has had an overall decrease with some fluctuations.

The following graphs show the evolution in the number of passengers per station in both systems:

Figure 26: Passengers per station in Mexico City and Santiago



Source: See Appendix 2

As can be seen in the graph, the intensity of use has suffered a steep decrease in Mexico since the early 1980's, especially in 1982 with the opening of lines 4 and 5. The initial intensity was very high by international standards, and the construction of any new line was likely to reduce the average intensity. Still now the intensity of use of Mexico City is comparable to that of other subways of similar dimension, as seen on the following table.

Table 30: Passengers per station in selected subways around the world in 1998

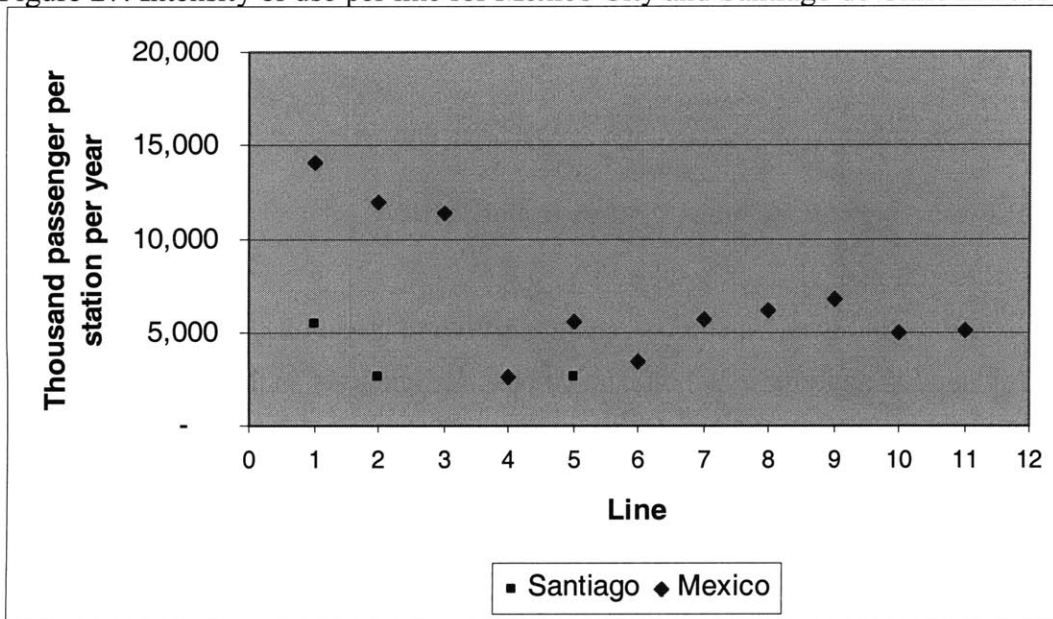
City	Passengers per year (millions)	Passengers per year per station (million)
Mexico	1,344	8.0
Mexico in 1981	987	16.6
Moscow	3,188	20.2
Tokyo	2,090	13.5
Seoul	1,338	11.7
New York	1,093	2.3
Paris	1,029	3.5
Osaka	992	11.7
Hong Kong	813	21.4
London	784	3.0
Sao Paulo	694	16.7

Source: Data taken from Gilat (2002)

In Santiago, the intensity of use increased steadily from the opening of the system in the mid-1970's until 1997, when line 5 was opened. Since then the intensity of use has remained almost constant. The average intensity of use is still higher in Mexico City than in Santiago, but the difference has been reducing in the last two decades.

As we see the difference in intensity of use is not a valid explanation for the apparent higher impact of Santiago's metro on land uses, since the intensity is lower in Santiago than in Mexico City. Nevertheless, we are only considering average intensity. If we look at the intensity of use per line, we can see that there is an enormous difference among them. The following graph shows the intensity of use per line in 2003:

Figure 27: Intensity of use per line for Mexico City and Santiago de Chile in 2003



Source: Passengers, see Appendix 2, number of stations from [www.metrodesantiago.cl](http://www.metrodesantiago.cl) and [www.metro.df.gob.mx](http://www.metro.df.gob.mx). Line 10 refers to Line A, Line 11 refers to Line B

In both cities, the initial lines are the most intensively patronized, and subsequent lines have been less successful. In absolute terms, Line 1 in Chile is similar to most of the low-ridership lines in Mexico City in terms of number of station per station, and lines 2 and 5 from Santiago, are only comparable to line 4 in Mexico.

As we see in this last figure, the intensity of use cannot be the cause of the apparent higher impact of Santiago’s subway on land uses. It can explain though the apparent higher impact of the first three lines on land uses in Mexico City, specifically in the city center, compared to the impact of subsequent lines, particularly the three lines we studied in detail in section 5.3.2. It can also explain the apparent higher impact of Line 1 on land uses in Santiago, compared to lines 2 and 5.

As was said in section 4.4.3, the attractiveness of the areas around stations for retailers depends on the flow of purchasing power around them. What I mean by flow of purchasing power is the flow of people multiplied by their purchasing power. Flows of people are lower around stations in Santiago than in Mexico, but probably the purchasing

power of those people is higher in the Chilean capital. I discuss this point in the following section.

## **7.2 Different average income of riders in both cities**

One of the reasons that may explain the apparent different effect that the metros of Mexico City and Santiago have had on land values and land uses, is the different average income of passengers in both systems. As was said in section 5.2.1, the metro of Mexico City has been planned to serve low-income people, whereas, as was said in section 6.3.1, the one in Santiago de Chile attracts many mid- and high-income people.

There are several reasons why the average income of passengers in the two cities is big, other than the enormous differences in fares. One reason is the level of service of each system. It is a widely recognized fact that during rush hour, lines 1, 2 and 3 are very crowded in Mexico City, whereas in Santiago this situation is less acute. Another plausible reason is the perception of insecurity in the metro, which apparently is high in Mexico City and low in Santiago. An additional reason is related to the status that people associate with riding each system. Whereas Mexico's metro has a stigma of being only for low-income people, the opposite is true in Santiago. The apparently cleaner conditions of cars and stations in Santiago may be another reason why this subway seems to be more attractive to high- and mid-income people than Mexico's.

Some other reasons are less plausible. The design of the cars is not a viable explanation since until the mid-1990's all the cars in Santiago were the original model of Alstom cars bought in the 1970's, which were also used by Mexico City's subway. None of the metros' cars have air-conditioned, and the weather in both cities is not significantly different.

In this section, I try to probe the hypothesis that the metro in Mexico City has become an inferior good, i.e. one which is less consumed as people's income grow, contrary to

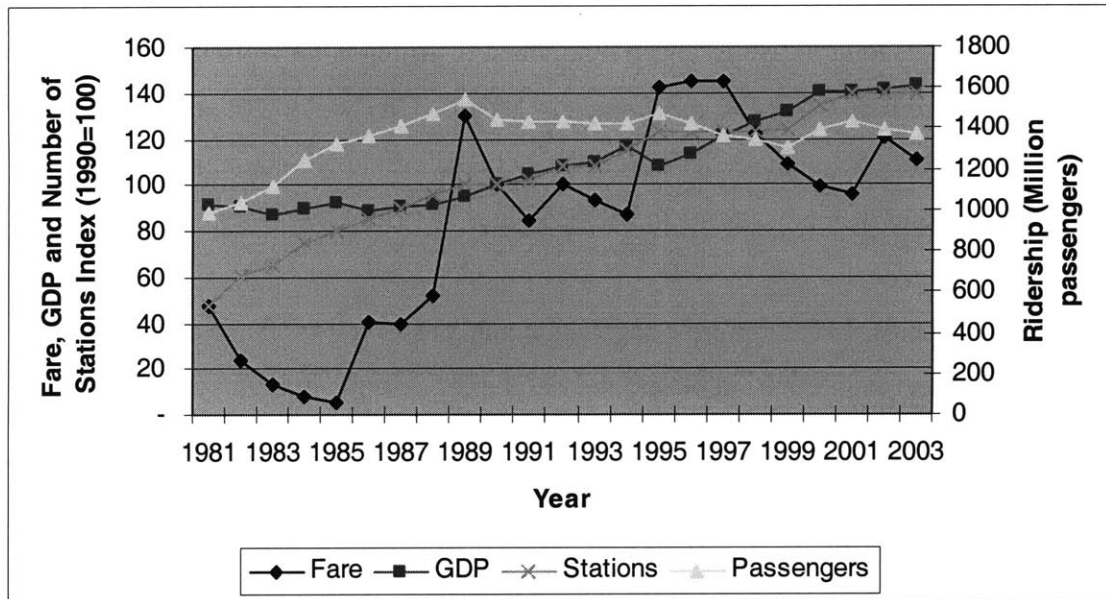
Santiago's metro. The reduction in metro usage in Mexico would be explained by people's switch to cars as soon as they can afford it. Given the fact that low-income people in both cities tend to live in cheap land, most of which is far from the city center and from the metro network, most passengers in Mexico City would connect from their homes to the network through feeder buses. This characteristic would explain the little changes on land uses around stations in Mexico City.

To test the hypothesis, I used multiple regression analysis to relate changes in metro ridership with changes in GDP, fares and the number of stations in both systems. The values of all these variables are presented in Appendix 2. Unfortunately, I did not have access to a reliable estimation of bus fares or estimations of the cost to operate a car in both cities at different times. These variables could have improved the models I developed in the following two sections.

### **7.2.1 An analysis of ridership in Mexico City**

The following graph shows the evolution of GDP, fares, number of stations and ridership from 1981 to 2003 in Mexico City. GDP, fares and the number of stations are expressed as a percentage of 1990's values. GDP and fares are in constant pesos. I chose to start my analysis in 1981, because that year was the first one in which lines 1 and 2 were completed, and line 3 had 16 of its 21 stations. As can be seen in Figure 11, these three lines are the core of the system, concentrating 59% of the boardings in 2003. Therefore I expect that after 1981 a more stable base of riders had been established, and that changes in GDP, fares (adjusted for inflation) and number of stations had a more stable effect on demand.

Figure 28: Ridership, GDP, average fare (adjusted for inflation) and number of stations in Mexico City's metro



Source: See Appendix 2 for details and assumptions.

In this graph we see that during the 1980's, when GDP was stable, the number of passengers moved in tandem with the number of stations, in spite of a tremendous growth in fares. This increase in the number of passengers suggests that fares had a modest impact on ridership in this period. In 1995, there was an important increase in ridership, in spite of another rise in fares, and at the same time of a major economic crisis. This high ridership and its subsequent decrease in the following two years, when GDP was the only of the three explaining variables to change significantly (it increased), suggest a negative correlation between ridership and GDP.

Other reasons can also explain the decrease in the number of passengers in the last decade. Some of them are the following:

- The earthquake of 1986 may have caused a decrease in the number of residents in the central area of the city, which is the largest trip generator and attractor in the metro network. The explanation seems reasonable, since the decrease in the number of passengers roughly coincides with the earthquake. There was indeed a decrease in the number of residents in the central areas, since many of the buildings became

inhabitable<sup>191</sup>. Moreover, the ridership decrease was especially intense in lines 1, 2 and 3, the lines that served the central area directly

- An inadequate maintenance and investment policy in the first three lines made the level of service decrease after 20 years of operation, reducing the level of service of the metro, and making it less attractive to the public. The reduction in the level of service of these three lines may have driven the loss in ridership in the other lines, since most passengers' trips include segments in at least one of the three lines. This theory is not very credible, since Mexico City's metro has a good operational performance compared to other metros in the COMET group<sup>192</sup>
- The fragmentation of the bus system in the late 1980's may have affected the metro, since buses may have feed it with passengers. This is also a plausible explanation. Although there was not a free transfer program in Mexico City, except for the 1986-1997 period, people may have used buses to access the metro
- The original plan of the subway only considered three lines. Subsequent lines have suffered from the lack of planning for their connection to these core lines. It is not unusual to have very long walks to connect from one line to the other
- Rather than stimulating more demand in the other lines, new lines may have diverted passengers. This is a plausible explanation for the decrease in the number of passengers in Line 1 after the opening of Line 9, which was designed precisely to relieve congestion in Line 1
- The low ridership of the lines opened in the 1980's and 1990's can also be explained by the fact that they essentially by-pass the downtown area, which still is the main attractor and generator of trips in the metropolitan area. This theory and the previous two do not explain the loss in ridership in the entire system

I could not test the hypothesis of the effect of the deterioration of the bus system on Metro's ridership, because I did not have access to any reliable indicator of the quality of the service it provided in the period of the analysis.

---

<sup>191</sup> According to Ward (1998), buildings in the central area were already in bad conditions before the earthquake, because of disinvestments caused by rent controls.

<sup>192</sup> Gilat (2002) The COMET group is a benchmarking group formed by the nine largest subways in the world, including Mexico City's.

Given the small number of years we are considering, it is better to use a limited number of variables. The inclusion of more variables would have made it extremely difficult to find coefficients that are significantly different to zero, given their likely correlation with the other variables being used. As was said before, the variables that are going to be tested are GDP, fares (adjusted for inflation) and number of stations. To test the relation of these variables, I ran several regressions, with different specifications. The first specification is linear, and has the following formula:

$$R = \beta_1 + \beta_2 GDP + \beta_3 Fare + \beta_4 Num\_stations + \varepsilon \quad \text{Equation 5}$$

Where R is the number of riders in a year.

The following table shows the results of this model, which I dubbed Model 1:

Table 31: Results of regression with Model 1 for Mexico City

<b>Adjusted R<sup>2</sup> = 0.866</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	1389.9	20.55
$\beta_2$	-0.0012	-8.35
$\beta_3$	-19.700	-0.81
$\beta_4$	8.6291	9.45

Source: Developed by the author

As we see in Table 31, the model has a very high adjusted-R square. The coefficients have all the signs we expected. The coefficient of the fare, although having the expected sign, negative, is not significant at a 95% confidence level.

To improve the results of the previous model, I discarded *Fare* from the equation, obtaining the following results:

Table 32: Results of regression with Model 2 for Mexico City

<b>Adjusted R<sup>2</sup> = 0.869</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	1401.2	21.35
$\beta_2$	-0.0012	-8.42
$\beta_3$	-	-
$\beta_4$	8.1722	11.47

Source: Developed by the author

This model produced higher adjusted R<sup>2</sup> than the previous model, and makes all coefficients have the expected sign, and be significant at the 95% confidence level.

The high adjusted-R square of the previous two regressions may be misleading. GDP and the number of passengers may have exponential growth curves, i.e. their growth may be a constant percentage per year, all other affecting variables being equal. To check if this is the case, I ran a regression with the following formula:

$$R = \exp(\beta_1 + \beta_2 \text{Num\_stations} + \beta_3 \text{Fare} + \beta_4 \text{year} + \varepsilon) \quad \text{Equation 6}$$

Where year = 1 for 1981, 2 for 1982, etc.

This equation is equivalent to:

$$\log R = \beta_1 + \beta_2 \text{Num\_stations} + \beta_3 \text{Fare} + \beta_4 \text{year} + \varepsilon \quad \text{Equation 7}$$

The following table shows the results of this model, which I dubbed Model 3:

Table 33: Results of regression with Model 3 for Mexico City

<b>Adjusted R<sup>2</sup> = 0.889</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	6.1578	68.71
$\beta_2$	0.0128	10.48
$\beta_3$	0.0095	0.54
$\beta_4$	-0.0533	-9.18

Source: Developed by the author

The model has a higher adjusted  $R^2$  than the previous models. As in Model 1, the coefficient of *Fare* is not significant at a 95% confidence level, but in this case the coefficient is positive, which is obviously contra-intuitive. Then, I ran the same model, but discarding the variable *Fare*. The result is the following:

Table 34: Results of regression with Model 4 for Mexico City

<b>Adjusted <math>R^2 = 0.893</math></b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	6.1493	70.96885
$\beta_2$	0.0130	11.14
$\beta_3$	-	-
$\beta_4$	-0.0532	-9.34

Source: Developed by the author

Finally, I tested a Cobb-Douglas function, in which there is a constant elasticity of the number of riders with respect to the explaining variables. I did not include the variable *Fare*, giving the previous results:

$$R = \beta_1 * Num\_stations^{\beta_2} * GDP^{\beta_3} * \varepsilon \quad \text{Equation 8}$$

Which is equivalent to:

$$\log R = \log \beta_1 + \beta_2 \log Num\_stations + \beta_3 \log GDP + \log \varepsilon \quad \text{Equation 9}$$

The following table shows the results of this model, which I dubbed Model 5:

Table 35: Results of regression with Model 5 for Mexico City

<b>Adjusted <math>R^2 = 0.904</math></b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	13.141	14.85
$\beta_2$	0.6322	13.46
$\beta_3$	-0.6558	-8.43

Source: Developed by the author

The model is an additional improvement to what we had before. The value of adjusted  $R^2$  is higher than for any other of the models, the coefficients have the expected sign, and they are significant at a 95% confidence level.

Finally, I tried a similar model to Model 5, but substituting *GDP* for *Time*. The results are in the following table:

Table 36: Results of regression with Model 6 for Mexico City

<b>Adjusted <math>R^2 = 0.593</math></b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	8.4934	3.72
$\beta_2$	-0.3765	-0.69
$\beta_3$	0.2376	1.21

Source: Developed by the author

This model yielded a low adjusted  $R^2$ . Moreover, the coefficient of the number of stations is negative, though not significant at any reasonable confidence level. Finally, the year time coefficient is not significant.

I ran models 1 and 3 again using the proportion of the GDP per capita that 1000 tickets cost for every year, instead of the raw fare. The estimated coefficients for this variable also failed to be significant for Model 1, and had a negative sign for Model 3. I also ran models 1, 2, 4 and 5 including a dummy variable that was 0 up to 1985, and 1 after that year to determine the impact of 1985's earthquake on ridership. In all cases the coefficient for this variable was positive, which in light of the figure on page 76 is clearly wrong<sup>193</sup>.

---

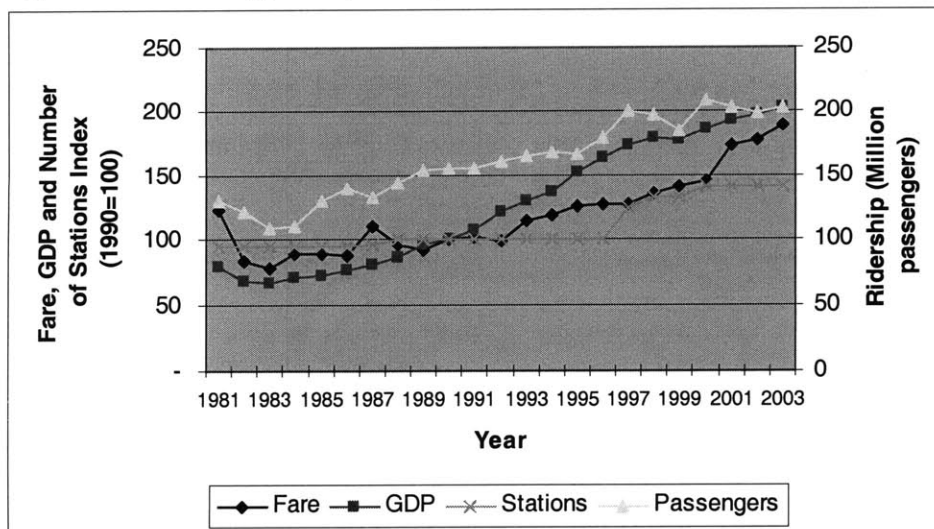
<sup>193</sup> This result may be a consequence of the small number of years included in the analysis, and the correlation of this dummy variable with the other explanatory variables: 0.76 with fares, 0.79 with the number of stations 0.54 with GDP and 0.72 with year.

Several conclusions can be made from this analysis. First, the best model to explain the variations of ridership in Mexico City's metro is Model 5. Apparently increases in GDP cause decrease in the number of passengers, or at least both variables are correlated. People may switch from Metro to other modes in periods of economic growth. This mode switch is even stronger than the growth of trips in all modes associated with economic growth. Ridership does not seem to be affected by changes in fares, probably because fares in Mexico City are very low (currently around 20 cents of a dollar for a single trip). Ridership increases as a response to the increase in the number of station, but this effect has not impeded a decrease in the number of passengers in the last few years.

### 7.2.2 An analysis of ridership in Santiago de Chile

The same variables shown in the figure on page 146 for Mexico City are shown in the following graph for Santiago. As in the case of Mexico City, GDP, fares (adjusted for inflation) and number of stations are expressed as a percentage of 1990's values. GDP and fares are in constant Chilean pesos. Similar to the case of Mexico, I chose to start my analysis in 1981. I chose this year because that was the first year line 1 was opened in its full extension for the entire year. This line in 2003, and as we saw in Figure 23, this line is the core of Santiago's subway, concentrating 64% of the boardings.

Figure 29: Ridership, GDP, average fare and number of stations in Santiago's metro



Source: See Appendix 2 for details and assumptions.

As can be seen in this graph, in the period 1981-1983 there was a decrease in the number of passengers, despite the decrease in average fares (adjusted for inflation), and a fixed number of stations. GDP, which decreased in this period, is the only explanatory variable included in the graph that can explain the decrease in the number of passengers. The subsequent growth in ridership in 1984-1986 when fares increased and stations remained fixed, while GDP grew, reinforce the idea of a positive correlation between GDP and ridership. The theory is further reinforced by the decrease of ridership in 1999, the first year of economic contraction since 1983. The relation is positive, contrasting with the negative relation we found for Mexico City.

The decrease in ridership in 1987, in a year of economic growth, increase in the number of passengers and sharp increase in fares, suggests the existence of a high elasticity of demand with respect to fares. This high elasticity is reinforced by the decrease of ridership in 2001, though in this case the elasticity seems to be lower than in 1987.

The opening of Line 5 in 1997, and its extension in 2000 seem to have produced a permanent increase in ridership.

Other variables can also explain the reduction in the growth of ridership since 1997. One of them is the increasing congestion of the system at rush hour, which may be making people choose other modes. This explanation is valid for the stagnation in the number of people traveling at rush hour (see footnote 166). Unfortunately no index of congestion was available to test the effect of this variable on demand.

To test the relation of ridership with GDP, fares and the number of stations I tested several models with different specifications for ridership, all of which were estimated using linear regressions. The first model is similar to Model 1 for Mexico, so it considers the following formula for the number of riders:

$$R = \beta_1 + \beta_2 GDP + \beta_3 Fare + \beta_4 Num\_stations + \varepsilon \quad \text{Equation 10}$$

Where R is the number of riders in a year.

The following table shows the results of this model, which I dubbed Model 1:

Table 37: Results of regression with Model 1 for Santiago de Chile

<b>Adjusted R<sup>2</sup> = 0.9327</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	7.4000	5.43
$\beta_2$	3.84E-06	7.12
$\beta_3$	-0.1227	-1.34
$\beta_4$	0.5708	0.96

Source: Developed by the author

This model seems to fit the data very well. The adjusted R<sup>2</sup> is very high, and the signs of the coefficients are the ones we expected. The coefficient of GDP is significant at a 95% confidence level. Considering that the distribution of the estimated coefficient is Student's t with 19 degrees of freedom, and using a one-sided percentile, since we know for sure that the coefficients of fare and number of stations are negative and positive respectively, we can obtain the significance level of these coefficients. The coefficient of *Fare* is significant at more than 90% confidence level, and the one for *Num-stations* is significant at more than 82% confidence level.

I tested a new model, where instead of using fares, I used a measure of the ration between fares and GDP per capita<sup>194</sup>. It makes sense that people's response to changes in fares depends on their income. As the economy of Chile grew 155% between 1981 and 2003, the difference between using fares or fares/GDP per capita should be significant. In this new model, ridership was estimated with the following equation:

$$R = \beta_1 + \beta_2 GDP + \beta_3 \frac{Fare * 1\_million}{GDP\_per\_capita} + \beta_4 Num\_stations + \varepsilon \quad \text{Equation 11}$$

<sup>194</sup> The variable was (Fares\*1 million) / (GDP per capita). See Appendix 2 for values.

I called this model for Santiago “Model 2”. The results of the regression are presented in the following table:

Table 38: Results of regression with Model 2 for Santiago de Chile

<b>Adjusted R<sup>2</sup> = 0.9339</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	94.253	5.08
$\beta_2$	2.93E-06	5.18
$\beta_3$	-0.2709	-1.47
$\beta_4$	0.6882	1.12

Source: Developed by the author

This model is better than Model 1. Adjusted R<sup>2</sup> is higher, and so are T-stats of the coefficients of *fare* (in this model it is the coefficient for *Fare\*1 million /GDP per capita*), and of the number of stations. The coefficient of *GDP* continues to be significant well above the 95% confidence level. All the coefficients kept their sign.

Considering again a one-sided percentile of Student’s t distribution with 19 degrees of freedom, in this model the coefficient of *Fare\*1 million /GDP per capita* is significant at more than 92% confidence level, and the one for *Num\_stations*, at more than 86% confidence level. Considering the small number of observations, and the fact that the signs of the coefficients are the ones we expected, these levels of confidence seem high enough for including these two variables in the model.

As in the case of Mexico City, I tested other models. First I checked using an exponential growth of ridership with respect to time, fare and number of stations, using the following equation:

$$R = \exp(\beta_1 + \beta_2 \text{Num\_stations} + \beta_3 \frac{\text{Fare*1\_million}}{\text{GDP\_per\_capita}} + \beta_4 \text{year} + \varepsilon) \quad \text{Equation 12}$$

Where year = 1 for 1981, 2 for 1982, etc.

As was pointed out in the previous section, this equation is equivalent to:

$$\log R = \beta_1 + \beta_2 \text{Num\_stations} + \beta_3 \frac{\text{Fare*1\_million}}{\text{GDP\_per\_capita}} + \beta_4 \text{year} + \varepsilon \quad \text{Equation 13}$$

The following table shows the results of this model, which I dubbed Model 3:

Table 39: Results of regression with Model 3 for Santiago de Chile

<b>Adjusted R<sup>2</sup> = 0.9041</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	4.8072	33.39
$\beta_2$	0.0026	0.60
$\beta_3$	-0.0015	-1.07
$\beta_4$	0.0242	4.86

Source: Developed by the author

As we see in this table, Model 3 has a lower adjusted R<sup>2</sup> than Model 2. Moreover, the coefficients of *Fare\*1 million /GDP per capita* and of *Num-stations* are lower than the equivalent coefficients in Model 2.

I also tested a Cobb-Douglas model, in which ridership has constant elasticity with respect to the explanatory variables, in this case *Fare\*1 million /GDP per capita*, *Num\_stations* and either *GDP* (Model 4) or *Year* (Model 5). In these models ridership is estimated with the following equations:

$$\log R = \log \beta_1 + \beta_2 \log \text{Num\_stations} + \beta_3 \frac{\text{Fare*1\_million}}{\text{GDP\_per\_capita}} + \beta_4 \log \text{GDP} + \log \varepsilon$$

Equation 14, for Model 4.

$$\log R = \log \beta_1 + \beta_2 \log \text{Num\_stations} + \beta_3 \frac{\text{Fare*1\_million}}{\text{GDP\_per\_capita}} + \beta_5 \log \text{Year} + \log \varepsilon$$

Equation 15, for Model 5.

The results of the regressions using each model are presented in the following table:

Table 40: Results of regression with Model 3 for Santiago de Chile

Model Number	4		5	
Adjusted R <sup>2</sup>	0.9283		0.8605	
Variable	Coefficient	T-stat	Coefficient	T-stat
$\beta_1$	-2.1941	-1.85	3.5419	4.61
$\beta_2$	0.1418	0.92	0.6316	4.31
$\beta_3$	-0.0746	-0.63	-0.2304	-1.43
$\beta_4$	0.4204	5.85		
$\beta_5$			0.1008	2.89

Source: Developed by the author

As we see in the table, Model 4 had a higher adjusted R<sup>2</sup> than Model 5, but the former has higher absolute value of t-stats for the coefficients of *Fare\*1 million /GDP per capita* and of *Num-stations*, probably caused by a correlation between these two variables and GDP. Both models are inferior to Model 2 in terms of the goodness of fit, and Model 4 t-stats for *Fare\*1 million /GDP per capita* and of *Num-stations* are much lower than the ones obtained in Model 2.

I also ran a model similar to Model 2 for Chile, but which instead of using *GDP*, includes *Year*. I called this Model 6. Ridership was estimated with the following equation:

$$R = \beta_1 + \beta_2 Year + \beta_3 \frac{Fare * 1\_million}{GDP\_per\_capita} + \beta_4 Num\_stations + \varepsilon \quad \text{Equation 16}$$

The results of the regression are in the following table:

Table 41: Results of regression with Model 6 for Santiago de Chile

<b>Adjusted R<sup>2</sup> = 0.9294</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>T-stat</b>
$\beta_1$	104.16	5.39
$\beta_2$	3.2668	4.89
$\beta_3$	-0.2619	-1.36
$\beta_4$	1.0206	1.74

Source: Developed by the author

This model has the second highest R<sup>2</sup> of the six models we estimated for Chile, only behind Model 2. All the coefficients have the expected sign. Compared to Model 2, Model 6 has lower absolute t-stat for the coefficient of *Fare\*1 million /GDP per capita* and higher for the coefficient of *Num-stations*. Model 2 has an additional advantage over Model 5: a lower intercept, meaning that a larger proportion of ridership is explained by the variables.

Several conclusions can be taken from this analysis for Santiago. First, the best model to explain variations in ridership is Model 2. GDP growth is positively correlated with ridership, and probably there is a causal effect. People may switch from other modes to the Metro in periods of economic growth (most likely from buses), or make more trips in all modes, including the Metro.

Ridership seems to be elastic to fares, but this elasticity has decreased over time as GDP per capita has grown. This reduction in the elasticity of demand with respect to fares is proved by the fact that the ratio between fares and GDP per capita was able to explain more of the variation in ridership than fares by themselves.

Ridership seems to increase after more stations are opened. The most important increase in the number of stations in the period occurred only in the last few years. In these years ridership has been volatile, maybe because of some of the steepest increases in fares and decreases in GDP in the period. This volatility may have impeded us to obtain a more significant coefficient for the variable *Num-stations*.

### 7.2.3 Conclusions from the analyses

In the previous two sections, we have seen the similarities and differences of the effects of GDP, fares and number of stations on ridership both cities. In both cases models using GDP as explanatory variable were better able to explain changes in ridership than models using time. In both cases the increase in the number of stations in the system was positively correlated with ridership.

Whereas in Mexico City ridership had a negative correlation with GDP, the relation was positive in Chile. Whereas ridership was inelastic to fares in Mexico City, it was elastic in Santiago.

These results confirm our hypothesis that the metro in Mexico City has become an inferior good, i.e. one which is less consumed as people's income grow, contrary to Santiago's metro. This idea though is not new in the literature. As was mentioned in sections 6.2.2 and 5.2.1, several studies confirm that there is a significant difference in income of metro passengers in these cities.

There is a spatial mismatch between demand and supply of rapid transit in Mexico City. As we said in section 5.1, densities in the metropolitan area do not vary significantly with respect to the distance to the city center. Additionally, we know land values are in general terms higher in the city center, and that, on average, high-income people live closer to the city center than low-income people (see section 5.1). On the other hand, the densest part of the rail transit network is in the city center. As was pointed out in section 5.2.1, the metro lines follow the corridors used by low-income workers in their commute, not necessary the corridors with high concentration of low-income people's housing, which tend to locate in the periphery of the metropolitan area. Many low-income people travel from the terminal stations to the city center. The terminal stations accounted for 30% of the incoming passengers in labor days in 2000<sup>195</sup>. The area between the terminal stations and the downtown is generally occupied by mid-income people, who are much less

---

<sup>195</sup> Information provided to the author by STC. Considering that a large proportion of these passengers enter to the metro on their way to downtown, we can see that probably more than half of the trips in the metro correspond to people who live beyond the terminal stations.

attracted to the metro than low-income people in the periphery. This spatial distribution of the population determines a situation in which people willing to use the metro cannot afford to live close to the stations, and people that live close to the stations do not want to use the metro.

The situation is the opposite in Santiago. The municipalities served by the metro are more affluent than the average municipality in the metropolitan area, and their land values are higher, as was mentioned in section 6.1. But contrary to Mexico City, metro attracts the people that can afford to live close to the stations. It has been estimated that for trips from and to areas around stations, Santiago's metro captures 52% of the trips<sup>196</sup>. Moreover, except for the morning-peak period where the access mode of 1/3 of Metro's passengers is walking, in all periods more than 58% of the passengers come to the station walking. In the evening peak, more than 50% leave the station walking, and in other periods this figure is higher than 61%<sup>197</sup>. Walking trips are most likely from origins and to destinations located close to the stations. A large portion of metro users is people who live close to the stations. Terminal stations only accounted for 20% of incoming passengers in 2002, much less than in Mexico<sup>198</sup>.

This difference in the location of the passengers with respect to the network is another factor determining the different impacts that subways have had on land uses in these two cities.

---

<sup>196</sup> Metro de Santiago (2000) cited in Zegras (2000), page 56.

<sup>197</sup> Metro de Santiago (2003).

<sup>198</sup> Metro de Santiago (2003).

## **8 Using Land Value Capture to Fund Transit Investment**

This Chapter explains several reasons why land value capture should be used to fund rail transit construction. It also describes how land value capture has been used around the world to fund rail transit construction.

### **8.1 Distortions generated by property taxes**

The property taxes that exist in Mexico and Chile, as in many other jurisdictions around the world, entail two different taxes: one on the land and another on the buildings located on the land. These two taxes have very different effects on the real estate market. While the tax on buildings generates several distortions such as sprawl and land speculation, the tax on land has a neutral effect with respect to these problems.

By taxing buildings, governments promote a reduction in the intensity of use of the land. Private firms and individuals can trade-off land for capital (in the form of buildings). Then, if one of these factors is taxed, the other is used more extensively and their price rises. Therefore, the tax on building promotes sprawl and raises land prices. Cities with low densities are less suitable for transit service and part of their infrastructure is more expensive to build and operate (water, sewage, telephone service, natural gas, etc.).

Taxes on buildings promote the abandonment of land by making the maintenance and improvement of old buildings more expensive<sup>199</sup>. In fact, many property owners end up tearing down these buildings, and replacing them with parking lots to pay lower taxes. Both Mexico City and Santiago have been expanding fast in the last few decades, in spite of the existence of vacant or underutilized land near their city centers. This land is usually in the areas best served by the existing infrastructure. The existence of taxes on buildings may be one of the causes of this problem.

---

<sup>199</sup> Harris (1999).

There are several other reasons to avoid taxes on buildings. These taxes encourage a reduction of the planned durability of them. Charging more for buildings made to last for longer, cause developers to reduce their quality<sup>200</sup>. Taxes on buildings also favor speculation. If there were a tax exclusively on land, the marginal cost of developing the land would be lower than under the current tax structure, so the relative cost of holding land undeveloped would be higher. Having taxes on buildings raises the relative advantage of land uses with lower construction costs. This advantage means that under the current tax structure, activities such as parking lots and gas stations occupy more accessible land than what is socially optimal<sup>201</sup>.

The development of different land plots in the same area of a city is mutually dependent. This dependency means that the abandonment, lack of maintenance or low quality in the development in a site, affects the development of the surrounding sites. Therefore, the negative effects of the tax on buildings are reinforced by this characteristic.

A tax based exclusively on land values would have redistributive benefits. It would keep ownership costs (i.e. the price plus the tax) constant, while reducing land values. As the interest rate paid by people depend on their income or wealth, switching to a property tax only based on the value of land would reduce the relative purchasing power between people of different income. This reduction would allow poor people to live in lower densities, and would force rich people into more dense housing<sup>202</sup>.

Several local jurisdictions have property taxes based exclusively on land values. Many of them are in Australia, New Zealand, Denmark and certain regions on England. In the US, several Philadelphia jurisdictions have lead the way in this direction, by lowering the tax on buildings and increasing the one on land values. These localities have had larger numbers of permits for constructions than comparable communities in the same area.

---

<sup>200</sup> Gaffney (1999).

<sup>201</sup> Gaffney (1999).

<sup>202</sup> Gaffney (1999).

Although no causal relation can be inferred, the results are at least not contradictory with what one would predict<sup>203</sup>.

## **8.2 The case for land value capture**

Value capture, also called benefit-sharing, is a mechanisms in which part of the benefits gained by the beneficiaries of a project are used to fund the required investment. For example, in some cases the construction of transportation infrastructure generates increases in the value of the land served by it. Governments around the world have used land value capture mechanisms to fund these investments. In many cases, this has been the only possible way to finance these projects.

There are many reasons to use value capture. First, value-capture is more just and efficient than using traditional taxes to fund infrastructure. Value capture reduces land speculation, creates a stable source of funding, and it makes governments more accountable for the benefits of their investments<sup>204</sup>. Value-capture mechanisms can fund several transportation projects that, although being cost-effective, are not built because of the shortage of public funds. The revenues generated by value-capture mechanisms are less dependent on political cycles than the funds that come from the government. Therefore, these mechanisms can provide long-term funding, which can reduce the risks associated with funds coming from other sources.

Value-capture mechanisms are inherently different from what people understand by taxes. With value capture the ones who pay for the project are the beneficiaries, not the general public. Value capture is therefore a charge for a service, a good, or a right. The amount of money each of the beneficiaries pay can be proportional to the benefit they obtain, not necessarily to the cost of the project. Used in this way, value capture can also be a source of revenue.

---

<sup>203</sup> See Harris (1999).

<sup>204</sup> Wenzer (1999).

The value of urban land almost never varies as a function of what the owners do on it, but as a function of societies action: the infrastructure that is deployed, the zoning codes, the economic growth of a region, etc.<sup>205</sup>. Contrary to taxes, value-capture mechanisms charge for the impact of investments made by the government or by society, not for what property owners do on it.

Value capture is more efficient than taxes, because it does not create deadweight losses. Urban land is completely inelastic; it cannot be created nor destroyed<sup>206</sup>. Therefore, taxing urban land, or charging for the betterments, does not reduce the total amount of land consumption as it is the case for taxing any other good<sup>207</sup>. Moreover, it does not promote tax-elusion, since urban land is impossible to hide.

Land value capture reduces land speculation. The fact that land values rise as a result of governments' decision regarding transportation investment, makes people speculate with land. The land that is left out of the market for speculation purposes pushes development to the periphery of the city, and leaves resources unutilized for society. Capital gains from speculation are only transfers between individuals; they are not net social gain.

The usage of tax revenues for funding public works makes the general public unaware of the cost/benefit analysis that justify these projects. The implementation of value capture mechanisms would make governments more prone to choose projects with high cost/effectiveness ratio, and citizens more aware of how governments spend their money.

As capital and labor are mobile in the long run, their profits are determined at a regional or national level. But land is a fixed factor, and therefore its value rises as a consequence of an increase in efficiency. The usage of revenue from land value taxes to reduce the

---

<sup>205</sup> One of the few exceptions may be when landowners clean the land that was previously polluted.

<sup>206</sup> We could argue that indeed it can be created, as it proved to be the case with the land reclaiming in Kansai and Hong Kong for their new airport projects, the dam building projects in Holland, and the extension of Manhattan through land filling projects. Nevertheless, these are extremely expensive ways of creating land, and therefore not practical in most cases.

<sup>207</sup> It may be argued though that any tax increase will cause a decline in consumption, given the fact that people's budget is finite.

cost of services to their short-run efficient level would produce gains in efficiency that would more than compensate for the required taxes<sup>208</sup>.

Value capture can help avoid the irreversible damage produced by sprawl. The lack of funds to build public projects forces their postponement. In the case of transit, the lack of investment fosters sprawl and low-density development. Location decisions are almost irreversible, so the damage caused by the lack of good transit lasts for a long time. Redevelopment is very expensive, and therefore city form depends on which mode prevailed at the time of fastest development of a city<sup>209</sup>. The existence of sustainable sources of income such as the ones available with value-capture mechanisms could help governments avoid this risk.

Transit Oriented Development (TOD) has been proposed as a way of dealing with congestion. Although having large popular and political support, TOD has not been implemented extensively, probably due to the inability of government to fund this type of development<sup>210</sup>. Value-capture mechanisms make TOD a viable strategy. In fact, as we will see in the next sections, it has allowed different cities such as Stockholm and Tokyo to orientate development towards public transportation.

### **8.3 Land value capture in the US**

The most common form of land value capture to fund rail transit in the last few years in the US has been joint development. This mechanism consists on transit agencies selling or leasing part of a station area for its development. The developer usually pays for direct connections from the stations to the new buildings.

---

<sup>208</sup> Vickrey (1999).

<sup>209</sup> This idea is explained in Hoyt (1939). Marshall (2000) stresses that city form depends on the prevailing mode, but only if the government allows that mode to prevail. For example, he states that cars prevailed in the US because governments build highways, not the other way around.

<sup>210</sup> Renne and Newman (2002).

A study on all rail-related joint development experiences in the US found that 40% of them include cost sharing, and 20% revenue sharing<sup>211</sup>. Washington D.C. and Atlanta have the most successful cases of station area property and air rights leasing. Joint development has added a premium of \$3 per square foot to office rents, while office vacancy rates have been lower, average building sizes have been bigger and growth has been higher around stations than in the rest of both cities<sup>212</sup>.

WMATA, the transit agency of Washington D.C., has used value capture mechanisms for decades<sup>213</sup>. In 1999 it had a total of 24 completed projects, including 4 million square feet of office space, 1,000 hotel rooms, and 300 residences. These projects generate around \$6 million in annual revenues, and a total of \$60 million have been generated by their first project, Rosslyn, which was completed in 1973. Furthermore, the agency estimates that the projects induce more than 1 million trips per year<sup>214</sup>. In addition to the direct revenue, these projects have helped to pay for the costs of the operation, through passengers' fares.

Two of WMATA most successful projects have been the ones around Ballston station in Arlington, Virginia, and Bethesda station in Maryland. Ballston station is located in an old boulevard. Arlington County designed an incentive program for the redevelopment of the area, where in exchange for paying for the construction of sidewalks and parks, developers were allowed to use higher floor-area ratios<sup>215</sup>. The program tried to avoid the mistakes made in the adjacent Rosslyn station, where low-quality office space was built, reducing the attractiveness of the area. In this case WMATA created class-A office space and multi-familiar housing. The project also included a Hilton Hotel, university facilities and a shopping center<sup>216</sup>.

---

<sup>211</sup> Cervero (1992).

<sup>212</sup> Cervero (1992).

<sup>213</sup> McNeal and Doggett (1999).

<sup>214</sup> McNeal and Doggett (1999).

<sup>215</sup> Personal communication with Robert Brosnan, Arlington County Government, VA, March 26, 2002.

<sup>216</sup> Renne and Newman (2002).

Bethesda Metro Center includes 378,000 square feet of office space, a 380-room Hyatt Hotel and 60,000 square feet of retail space. The project helped revive a once decaying area, and provide WMATA with around \$1.6 million a year in rents.

MARTA has also had successful experiences with joint development. Two examples are Resurgence Plaza at Lenox Station and One Atlantic Center, near Arts Center Station. Both are office buildings, and have provided more than \$1 million a year in leases. They have also helped to increase ridership in the adjacent stations<sup>217</sup>.

MARTA has had a proactive attitude towards development. It has created a standard planning process for the development of the areas around stations. It includes the acquisition of land around existing or proposed stations for value capture purposes, the selection of a developer, and the formation of special districts for making land assembly possible<sup>218</sup>.

Other transit authorities have used other approaches different from joint development. MTA, the transit authority of New York, has used zoning incentives such as density bonuses to encourage developers to renovate subway stations. SEPTA, the transit authority of Philadelphia, leases store areas at lower rates in exchange for developers maintaining and upgrading the areas around their stores. One of the stations of the Santa Clara Light Rail, Moffett Park, was paid by the developer of an adjacent plot, in exchange for a 60% increase in the floor area ratio. The total cost of the station was \$2 million<sup>219</sup>.

The case that most resemble a pure value capture mechanism in the US is Los Angeles' benefit assessment program. In the late 1980's, the City of Los Angeles began to build a metro system. To fund the first section of the first line, two benefit assessment districts were established. Under this system, properties located up to 1/3 of a mile of a station were charged a proportion of the increase in land values expected from the construction

---

<sup>217</sup> Renne and Newman (2002).

<sup>218</sup> Renne and Newman (2002).

<sup>219</sup> Cervero (1992).

of the rail line. The charge was made per area of plot of land, except for retail, hotels and office buildings, which were charged per floor area. Housing and charitable institutions were exempt from the charge. The funds were used to pay the bonds for the metro, and accounted for a 9% of the total estimated costs<sup>220</sup>. The charge had a cap of \$0.42 per square foot, and will be charged from 1985 to 2007<sup>221</sup>.

Under Los Angeles' systems, property owners could petition not to be charged if rail transit did not benefit their property. So far, there have been 25 petitions like that, and only one case where the exemption was granted. The system was not used in subsequent extensions of Los Angeles's metro, partly because Proposition 218 was passed in 1996, which makes it very difficult to form new benefit assessment districts<sup>222</sup>.

#### **8.4 Land value capture in Europe**

In Sweden, the city government has developed a system of satellite cities around Stockholm in the last 50 years. All these cities are served by a rail transit system, which has the highest modal share in all of them.

To develop the satellite cities, the local government has acquired and developed land, and then built new rail lines. The design of the satellite cities has been oriented to transit. There are plazas next to the stations, and around them stores have been built. Near the plazas, high-rise buildings are located, and further away lower densities are allowed. All the areas around stations exhibit high quality pedestrian facilities. The government has tried to balance the flows in the network, so it has promoted the opening of jobs in all these cities. Stockholm has six of these satellite cities now, which account for 1/4 of its total population<sup>223</sup>.

---

<sup>220</sup> Information retrieved from [http://www.mta.net/trans\\_planning/CPD/bad/default.htm](http://www.mta.net/trans_planning/CPD/bad/default.htm).

<sup>221</sup> Ridley and Fawcner (1987).

<sup>222</sup> Personal communication with David Sikes, from the Los Angeles County Metropolitan Transportation Authority, 8/1/2003.

<sup>223</sup> Cervero (1998).

In other European countries, other approaches have been used to capture land value increases:

In Milan, a special tax was charged on properties located up to 500 meters of each station of the subway. The charge was based on the increase in the value of built-up land. The tax was only used for the construction of the first 35 km of the subway system, and has been replaced by a tax on property transfers<sup>224</sup>.

Land value capture was also used to pay part of the cost of light rail to the Docklands in London. The Dockland was a port area, located next to the Central Business Areas. The once thriving area began to be abandoned in the mid 1960's for other ports in southern England such as Felixstowe and Southampton<sup>225</sup>. By the early 1980's, the British government decided to redevelop the area "...with offices, trade centers, housing and light industry"<sup>226</sup>. To trigger this redevelopment, the government funded the construction an 11.7 km light rail. Because of budget limitations, the light rail only got from Tower Gateway to the Docklands, lacking a direct connection to the City of London, and a more convenient connection to the rest of London's Underground<sup>227</sup>. In 1985, a group of investors proposed a £ 1,500 million development project in Canary Wharf, in the Docklands. This development included office space, a shopping center and leisure facilities. To make the project attractive, the investors agreed to pay £ 45 millions of the required £ 130 millions to extend the light rail to Bank Station in the City of London. Eventually, the developers went bankrupt, but the Docklands is now a thriving area, with an easy connection to the rest of London.

After the spectacular rise in land values around the stations of the recently opened Jubilee Line in London<sup>228</sup>, there is a growing interest for using land value capture to fund future extensions of the Underground. The British government has announced that landowners

---

<sup>224</sup> Ridley and Fawkner (1987).

<sup>225</sup> Hall (1996).

<sup>226</sup> Ridley and Fawkner (1987).

<sup>227</sup> The initial alignment connected with London's underground in Shadwell station, but only the East London line serves that station. Bank station, located in the city of London, is served by the Circle, District, Waterloo & City, Central and Northern lines.

<sup>228</sup> See Riley (2001).

will have to give “significant contributions” to the funding of Crossrail, the new line being planned for London<sup>229</sup>.

### 8.5 Land value capture in Asia

In Japan, several private companies have developed satellite cities served by rail transit, whose designs are very similar to Stockholm’s satellites. These firms have purchased land in the outskirts of Tokyo, Osaka and Kobe and have then built suburban trains to downtown, before developing the land. Neither the train nor the developments have received any subsidy from the public sector. Most of these private companies work in conglomerates that include rail operators and department stores. In most of these projects, they have built big stores next to the stations, and high-density housing around them, connected to the rail stations by high quality pedestrian streets<sup>230</sup>. The firms have reaped huge benefits in the land developments, and even make a profit out of the rail operations<sup>231</sup>.

One of the most successful cases in Tokyo has been Tama Denin Toshi, which has been developed by the Tokyu Corporation from the 1960s. The company purchased land before announcing their plan to build the rail line. To avoid hostile reactions by other landowners and given the impossibility to purchase land all along the alignment, they started a joint venture with other landowners. They readjusted land, and shared the land development cost, and the benefits<sup>232</sup>. Tokyu Corporation has used the same *modus operandi* for other satellite city projects<sup>233</sup>. The Japanese government tried to emulate the experience with the construction of Tama New Town, close to Tama Denin Toshi<sup>234</sup>.

---

<sup>229</sup> Norris (2003).

<sup>230</sup> Bernick and Cervero (1997).

<sup>231</sup> Bernick and Cervero (1997).

<sup>232</sup> Hanayama (1986).

<sup>233</sup> Hanayama (1986).

<sup>234</sup> Bernick and Cervero (1997).

In Hong Kong in the early 1980's, the city government raised HK\$5 billion from the profits obtained from the development of the 13 station areas of the newly extended Island Line. These revenues helped financing the HK\$ 7 billion extension<sup>235</sup>.

## 8.6 Land value capture in Latin America

There are few examples of the usage of land value capture to fund rail transit in Latin America. Sao Paulo's metro has been the one that has used this kind of mechanisms more extensively, but Caracas' metro is planning to use it in the near future. In both cases, the approach the metros have used is joint development. In other two cases, attempts to use tax systems have failed.

Sao Paulo's subway has several joint development projects from which it gains revenue. Around twenty years ago, an intercity bus terminal was built next to Tiete station (Line 1) on land rented to the metro. Two other bus terminals were built under similar arrangements. In 2002, these terminals generated R\$8.7 million (around USD 3 million) in revenue to the metro, not including the fare revenue they generated<sup>236</sup>. The Metro has also promoted the construction of shopping centers in land of its property. Currently three malls operate on land owned by the Metro: *Santa Cruz*, *Itaquera* and *Tatuape*. In 2002, *Santa Cruz*, the only one that was in operation, generated more than R\$1.3 million in rents, plus reductions in operational costs, and fare revenue<sup>237</sup>.

In Caracas, the *Fundación Fondo Andrés Bello* is planning to make a \$688 million development around the station *Zona Rental*, one of the four stations being built in the first phase of Line 4. The metro has agreed to make the station's design oriented towards the future development of the area<sup>238</sup>. The metro will not benefit directly, except from the fare revenue generated by the flows that the project will generate. Nevertheless, the

---

<sup>235</sup> Riley (2001).

<sup>236</sup> Metro SP (2003).

<sup>237</sup> According to Metro SP (2003), in this case the cost of operating an adjacent bus terminal was transferred to the operator of the shopping mall.

<sup>238</sup> Metro Caracas (no date).

foundation is owned by the *Universidad Central de Venezuela*, which is a public university. This way, the national government will capture part of the value added by the new line.

There have also been some failed attempts to use value capture to fund rail transit. In 1987, the municipality of Buenos Aires approved a law that levied a special charge on properties located up to 400 meters from the stations of a new extension of the subway. Property owners would have to pay the total cost of the extensions for up to 15% of the value of their properties in 5 years. For lack of political will this tax was never charged, and some of the extensions were funded through an increase of property taxes all over the city, an increase in metro fares, and an increase in car-registration charges<sup>239</sup>.

In Santiago, the extension of Line 1 to the East was built at the same time as the construction of a new avenue parallel to the main East-West axe of the city, and located one-block from it. Part of the alignment of the metro was along this new avenue, originally called *Nueva Providencia*, and then named “11 de Septiembre” after the date of 1973’s coup. The municipality of *Providencia* presented a plan to charge property owners a special contribution to the cost of building the new avenue and the metro. The charge would be proportional to the distance to the avenue and to the stations. Even though the plan was then rejected by the national government, the consortium formed by the City government of *Providencia* and the national urban renovation agency (CORMU), was able to sell the unused expropriated areas at a higher price than what it paid for it, capturing some of the land value increases produced by the *Nueva Providencia* and the Metro extension<sup>240</sup>. Indirectly, the extension of the Metro was made possible by this value-capture mechanism.

Currently, Santiago’s Metro is considering the usage of value capture mechanisms to finance a new extension of Line 1 to the East. Given the fact that the alignment would cross high-income areas, the national government is not willing to pay all the cost of the

---

<sup>239</sup> Clichevsky (2001).

<sup>240</sup> Cáceres and Sabatini (2001).

investment. The two-station extension is attractive for the metro, since the area is very dense, and the last station would be built next to a shopping mall. The Municipality of *Las Condes* and the Metro are negotiating with the developers of *Nueva Las Condes*, a housing and office project located close to the proposed alignment, to ask them to contribute to the cost of the extension in exchange for an increase in the allowed FARs<sup>241</sup>.

Santiago's metro has had similar negotiations before. In 2002, they negotiated with the owners of the *Costanera Center* the extension of line 4 to that mall, and with the owners of *Ciudad Empresarial*, the extension of line 2 to that office park. In both cases the owners were asked to fund a significant part of the cost, and in both cases no agreement was achieved. In both cases, the developers already had the permits to build at the FARs they wanted, so the municipalities and the metro could not use these permits as trade-coins.

---

<sup>241</sup> Pedro Sabatini, from Metro, personal communication 1/7/2004.

## 9 Proposals

This section discusses several ways to implement land value capture. It then focus on Mexico City and Santiago de Chile to discuss the lessons learned from the previous Chapters, and the ways to implement land value capture mechanisms to fund future extensions of these cities' rail transit systems.

### 9.1 What to do

Mexico City and Santiago de Chile present several advantages for the usage of value-capture mechanisms. Some of these advantages are the following:

- The high proportion of house owners, which reduces the number of people who may be displaced because of the increase in land values (see section 3.5)
- Existing rapid transit networks, which increases the attractiveness of new lines, since new users gain access to an already extensive network
- Probably relatively low land values, which may increase fast as their economies develop
- A relatively segregation of people of different income, which is not good by itself, but allows for market segmentation, i.e. charging more to people that are willing to pay more. This approach can be used to capture land value increases

Many approaches can be taken to implement a system of land value capture to fund rail transit. Some of the mechanisms that are discussed require the passing of laws at the federal level; others can simply be applied at a local level, using existing attributes of local governments.

#### 9.1.1 Using tax increment financing

Tax incremental finance (TIF) is a common mechanism used to fund public investment in the US. It consists on a freeze of the revenue from property tax going to the government of a designated area for a certain time. The incremental gains in property tax, caused by

the increase in property values or the addition of new properties in the area, are earmarked to pay for a public work, which in theory causes land values to increase<sup>242</sup>. Not all the property tax base can become available as in redevelopment districts, but only the incremental revenue, and for a limited time (usually around 20 years).

In the US, tax increment financing has been used to fund several types of infrastructure such as sewage, lightning, and other. Nevertheless, it has not been extensively used to fund transit<sup>243</sup>. In the 1980's, there was a project to build a light rail in Chicago, which considered the usage of TIF. That would have been the first time TIF was used at that scale to fund transit. The project was finally canceled because of political opposition<sup>244</sup>.

Being the average US property tax bellow 2% a year<sup>245</sup>, this mechanism only captures a small part of land value increases. Even worse, in Chile the maximum rate is 1.5% a year, and there are several properties exempt from it. In Mexico it varies from 0.1% to 4.0% but the higher percentages are only in cases where there is an obvious undervaluation of the properties<sup>246</sup>.

Each year the TIF is in place, the incremental tax revenue  $R_t$  is the following:

$$R_t = A * tax \quad \text{Equation 17}$$

Where  $A$  is the change in property value, and  $tax$  is the property tax.

The net present value of the twenty years of tax revenue ( $R$ ) can be calculated with the following equation:

$$R = \sum_{t=1}^{20} \frac{R_t}{(1 + X)^t} \quad \text{Equation 18}$$

---

<sup>242</sup> Park (1999).

<sup>243</sup> Cervero et al (1992) reports that TIF was used to fund part of the cost of BART's downtown stations. I could not find any other case reported in the literature.

<sup>244</sup> Personal communication with Paul Fish, from the Chicago Transportation Authority, 8/13/2002.

<sup>245</sup> The average property tax for the 75 largest US metropolitan area is 1.83% (Information retrieved from <http://www.meyersgroup.com/analysisobjects/affordabilityexist.asp?ProductCategory=HA>).

<sup>246</sup> Perló and Zamorano (2001).

Where  $X$  is the discount rate.

Finally, the proportion of land value increases that is captured ( $Y$ ) is the following:

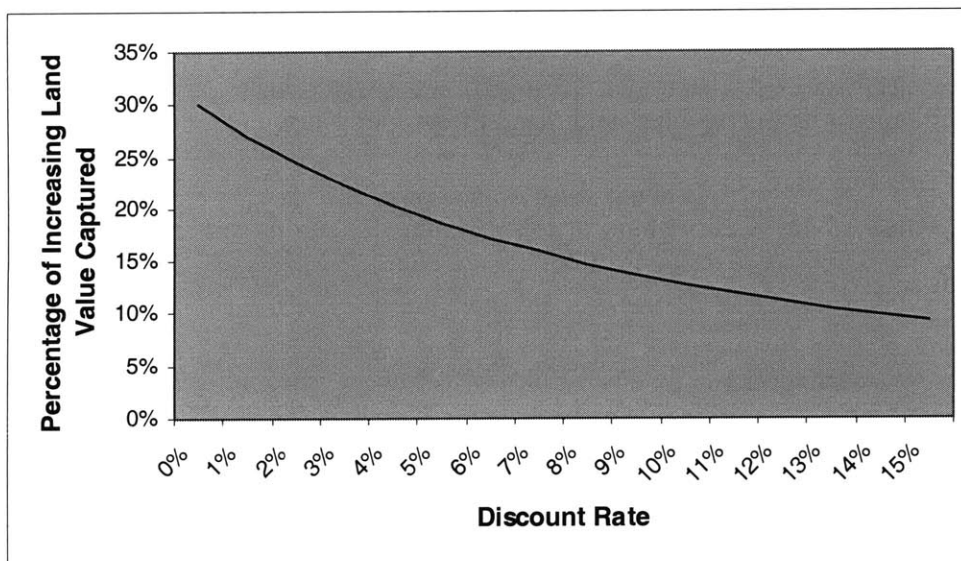
$$Y = \frac{R}{A} \quad \text{Equation 19}$$

Or using the previous equations:

$$Y = \sum_{t=1}^{20} \frac{tax}{(1+X)^t} \quad \text{Equation 20}$$

In Chile, the government does not update property values very often from its records<sup>247</sup>, and anecdotal experience suggests that the assessed property values are well below market prices. This situation is similar in Mexico, except that the tax rate varies in each municipality. The following graph shows the percentage of value captured by property taxes in Chile, assuming a 1.5% rate, and a TIF valid for 20 years:

Figure 30: Percentage of Increasing Land Value Captured by TIF for Chile



Source: Developed by the author. Assumes accurate valuation of the property

<sup>247</sup> According to Arriagada and Simioni (2001), between 1977 and 1995 no new appraisals were made.

Assuming a social discount rate of 10% a year, which is the rate used by the government to evaluate projects<sup>248</sup>, we can see in the case of Chile only around 13% of property value increases could be captured by property taxes.

If we include all the revenue gained by the government after the increase in property value, we will have to include the taxes paid after year 20. In this case, the percentage of property value that the government will gain can be estimated with the following equation:

$$Y = \sum_{t=1}^{\infty} \frac{tax}{(1 + X)^t} \quad \text{Equation 21}$$

Where tax will be 1.5% and X = 10% in this case.

Therefore Y = 15%

So there is a very small difference between the net present value of the revenue generated in the first 20 years, and the one generated if the revenue is permanent. The current rate of property tax in Chile is too low to capture a major portion of land value increases. In the case of Mexico the situation varies from one state to the other, but most likely the mechanism would not work without adequate valuation.

**9.1.2 Direct negotiations**

This approach consist on local governments negotiating with developers, asking for contributions to the cost of the transit infrastructure, in exchange for permitting the project or allowing a higher FAR. This approach has been used extensively in London to fund commuter car parks<sup>249</sup>. It has also been used in Washington D.C. and San Francisco

---

<sup>248</sup> Information retrieved from <http://bip.mideplan.cl/bip-consultas/SEBI/2004/html/PreciosSociales.htm>.

<sup>249</sup> Ridley and Fawkner (1987).

for their joint development programs<sup>250</sup>. As was pointed out in section 8.4, direct negotiations were also used for the extension of the Docklands light rail in London.

Direct negotiations give governments a lot of discretion. This discretion may be dangerous, as it may cause corruption, and even worse, may scare developers away as it creates uncertainty in the developing process. To avoid this problem, transit agencies should make developers know in advance what their interests are, so that uncertainty can be reduced.

Direct negotiations have been in use in Chile in the next few years for the funding of infrastructure to serve suburban housing developments around Santiago. The government negotiates in a case-by-case basis with developers to obtain contributions to pay for the infrastructure, in exchange for building permits<sup>251</sup>.

### **9.1.3 Special benefits assessment**

Special benefit assessment was the mechanism used in Los Angeles to fund metro line. With this mechanism, a special tax is charged on properties located up to a certain distance from the station, in the assumption that rail transit will increase the value of their properties. This approach has been used extensively for other uses in the US. In California, it has also been used to fund "...parking facilities, street lightning, sewers and flood control"<sup>252</sup>.

The difference of this system with Tax Increment Finance (TIF) is that with special benefit assessment property owners face an increase in the money they have to pay. This difference makes Special Benefit Assessment more difficult to implement.

The usage of this system may deter development, as people may want to postpone the investments, and speculate with the land, rather than put it to its best use right away<sup>253</sup>. In

---

<sup>250</sup> Cervero (1987).

<sup>251</sup> See Zegras (2000).

<sup>252</sup> Ridley and Fawkner (1987).

<sup>253</sup> Wetzal (2003).

the case of sites that are already developed, there may be few incentives to agree to pay the tax, since the opportunities for redevelopment, and high land value increases are lower for developed land than for undeveloped land (see section 3.3).

#### **9.1.4 Differentiated pricing, capturing of consumer's surplus**

If charging property owners is not feasible, there are still indirect ways to capture part of the increases in land value. One of them is to use differentiated pricing, to increase the proportion of consumer's surplus captured by the transit agency.

Although it is illegal to charge a different fare to people based solely on their income, transit agencies in Mexico City and Santiago can take advantage of the segregated pattern of their cities, and charge different fares for people in different lines. They can also provide different service attributes to these different segments, based on the characteristics of the potential users in a corridor. This strategy would allow metros to offer value propositions better tailored to potential users, and generate revenue that may be used to build new lines in areas of the city that because of their high average income per capita, are very unlikely to receive large public funds for metro expansions.

The following is an example of how this mechanism would work. Let us suppose a new metro line is built in Santiago from the area around the *Plaza Ñuñoa*, along *Los Leones*, connecting to the station with the same name in Line 1, and continuing along *Vitacura*, up to *Manquehue*. The area around the alignments houses upper-mid and high-income people, so, because of fairness concerns, the government will probably refuse to fund such a line. A differentiated pricing scheme could be implemented. Passengers boarding this line will need to pay 20 cents of a dollar more than the fare of the other lines. Some frills can be added to this line, such as air conditioner in the trains. Passengers could be granted free boarding from this to the other lines, and would have to pay the 20 cents difference in the other way. Charging this connection fare would be easy with the

smartcard being used in Santiago<sup>254</sup>. Given that most likely average income around the alignment is higher than around the rest of the alignment, this scheme would allow for a better alignment of fares and willingness-to-pay of people to board the line.

A similar scheme could be used in Mexico City to extend rail lines into mid- and high-income communities. A different standard of service and fare would reduce the big barriers that mid income people have for using the service. Just as an example, a premium line might be built along *Reforma* Avenue, from *Hidalgo* station (lines 2 and 3), to either *Polanco* or *Lomas*. Maybe in the future such a line could be extended to *Benito Juarez* International Airport. A line like this would serve areas that probably have higher income than average, and that are fairly dense in housing, commercial, office and hotel development.

## 9.2 Proposal for Santiago

There are several barriers to the introduction of land value capture to fund future extensions of Santiago's metro. Some of them are the rejection that people feel for new taxes, the technical difficulty to estimate the time and geographic impact of new lines on land values, and the fear that mechanism like this may make the government choose projects that are able to generate a lot of revenue from this source, but are not the most socially-desirable projects.

The recent attempts to use land value capture to fund for the construction of a new line to *Cerrillos* and to extend Line 1 to the East, make us think that these barriers are not impossible to overcome. Although the construction of a new line to *Cerrillos* is unrepeatably experience (never will the government have such a large piece of land to develop close to the city center), it will test if land value capture makes economic sense in Santiago.

---

<sup>254</sup> From 1982 to February 1993 a similar fare policy existed in Santiago's subway: tickets for Line 2 were cheaper than for Line 1, and a connecting fee was charged only to passengers going from Line 2 to Line 1. There was not smartcard by then.

The usage of value-capture mechanisms is the only politically feasible mechanism to allow for any extension of the metro network to the East. As was said in section 6.1, average income in this section of the city is much higher than in the rest of the city, so it is very unlikely that the government will be willing to invest in this area. Land value capture has a high potential to succeed in this area of the city, given the demand for commercial and office space in the eastern part of the city, and the high incomes of its residents.

One way to implement land value capture in Santiago is by reforming property taxes the way I described in section 8.1. This reform would require making property value appraisals more often, and in all the metropolitan area, which is politically and technically very difficult. This approach has more potential in Santiago than in Mexico given the low proportion of informal settlements in Santiago. Depending on the rate the tax could capture a significant part of land value increases, without paying the cost of having special schemes organized for every new project. This approach would require the government to overcome the usual opposition to new taxes<sup>255</sup>.

Special benefit assessment can be more difficult to implement than reforming property taxes, since it requires the passing of a special law each time. Nevertheless, special benefit assessment would only target the beneficiaries of the investment and not all property owners, making it more acceptable for the public than taxes. The fact that the metro is perceived to increase property values in Santiago, and the contrary in Mexico City, makes this approach easier to implement in former than in the latter.

A rough estimation of the potential revenue from a special benefit assessment scheme applied to a metro line like the one described in section 9.1.4 is around 167 million dollars. I assumed a charge exclusively on the land, equivalent to 6% of its value for land located up to 400 meters from the stations, and 3% for land from 400 to 800 meters from

---

<sup>255</sup> The implementation of the tax could be accompanied by a reduction of other taxes to reduce the opposition.

the stations (see Appendix 5 for details). Considering the line would be 10.5 km long, and assuming an average cost of 70 million dollars per km (including rolling stock)<sup>256</sup>, this mechanism alone would be able to pay for almost one fourth of the total cost.

Santiago's Metro should adopt an active approach with respect to urban development around its future station. It should associate with the municipalities, and negotiate development rights with property owners in exchange for funds for expanding the metro to these areas. The metro should also coordinate with the municipalities for the redevelopment of the areas around stations. The plans for redevelopment should include land assembly, the expedition of building permits, and the legalization of the tenure of land. The plans should also consider allowing potential developers to use higher FARs, and other exemptions from previous zoning, in exchange for funds to invest in rail transit. The failure to make big developers pay for the extension of the subways, which I described in section 8.6, serves as a lesson that without building permits to negotiate, it is very unlikely that developers will be interested in funding any significant part of the investment in new extensions<sup>257</sup>.

The high spatial segregation of Santiago provides an excellent opportunity to use differentiated pricing, in the way I described in section 9.1.3. Moreover, the fact that a smart card is already in use, makes this approach even easier to implement.

In future extension, Metro should try to replicate the synergies that have arisen between *Plaza Vespucio* and its metro station. The presence of both a mall and a station has been a strong attractor of dense housing development. Moreover, parking facilities have been shared, providing alternative for people willing to park-and-ride. Metro should consider the extensions of current lines to some of the existing malls in the suburbs.

---

<sup>256</sup> The Chilean government recently announced a 4.3 km extension of line 2 to the north, which will cost 200 million dollars (including rolling stock), i.e. 46.5 million dollars per km, and will be built underground (Information retrieved from <http://www.estrategia.cl/histo/200306/26/ambito/metro.htm>). I am assuming higher costs for the new line.

<sup>257</sup> In both cases the developers had building permits in their hands before starting to negotiate.

### 9.3 Proposal for Mexico

There are no major legal barriers for the implementation of value capture mechanisms in Mexico. There is already a law establishing a tax on property value increases, resulting from the construction of public works. This law though, lacks adequate rules for its usage, and therefore has not generated significant revenue. Moreover, property values are usually outdated, because of lack of resources and political lobby<sup>258</sup>.

There are other problems that make land value capture difficult to apply in Mexico City. Some of them are the following:

- As mentioned in section 6.1, around 40% of properties are not legal, either because they are in squatter settlements, or are not registered
- There is a more common mistrust in the government in Mexico than in other countries. People may fear that value capture would allow for corruption
- As discussed in previous sections, the metro in Mexico City only appeals low-income people, who are the ones with the least capacity to pay for the value added to their properties
- Many people have informal jobs. Their income is presumably less constant in time, making them less able to pay taxes in a periodical way

As said in the previous section, reforming the property system or tax-increment financing are not promising approaches in Mexico City. Special benefit assessment may be easier to implement, particularly if it is used in an area of the city of mid- to high-incomes, which may have a low proportion of the land being occupied informally. Nevertheless, only with a premium service and a different branding than today, could land values increase, and may property owners accept paying part of the investment cost of new lines.

I think there are opportunities to use special benefit assessment to fund suburban trains and new metro lines offering a premium service. As I mentioned in section 5.2, the government is planning to build a commuter line to the Northeast of the Metropolitan

---

<sup>258</sup> Perló and Zamorano (2001).

area. This line would allow for green-field development in the periphery of the city. There is a plan formulated for this train, which considers charging a fare of 9.25 pesos, well above the current 2 pesos fare of the subway<sup>259</sup>. Probably, a train with a fare like this will not attract low-income people.

For this new commuter line, the experience of Tokyo and Stockholm, described in sections 8.4 and 8.5, could serve as an example. A consortium of the DF, the State of Mexico and private companies should be established to acquire land around the proposed alignment, and rail stations should be built in the core of the new housing developments. With this strategy, the consortium would be able to generate a significant portion of the cost of the commuter lines, as it would convert rural land into urban land.

The other case where special benefit assessment may be used is for the funding new premium-service lines, such as the one I described in section 9.1.4. The fact that station would be located in areas of relatively high-income, and presumably without informal settlement, reduce the problem of a lack of registration of the property located around it. Property owners may be required to contribute to a significant part of the cost of the lines. In exchange for the contribution, the city government may allow for an increase in density of future development in the area. As explained in section 3.3, this kind of approaches can generate a high proportion of the cost of the lines when there are redevelopment opportunities around stations.

Differentiated pricing in potential new premium lines also seems to be possible to implement in Mexico City, because of several characteristics of the city. First, there is spatial segregation by income, so it is easy to segment the market by building lines with premium service to the South and the West, maybe along *Reforma* and *Insurgentes* Avenues. Second, there is already an extensive metro network, which may serve potential users of the new premium lines in some cases. Third, the current fares are very low, and there is space for raising fares for premium service without making them completely unaffordable to most people. Finally, there is a high level of congestion in the city, and

---

<sup>259</sup> Gilat (2002), page 94.

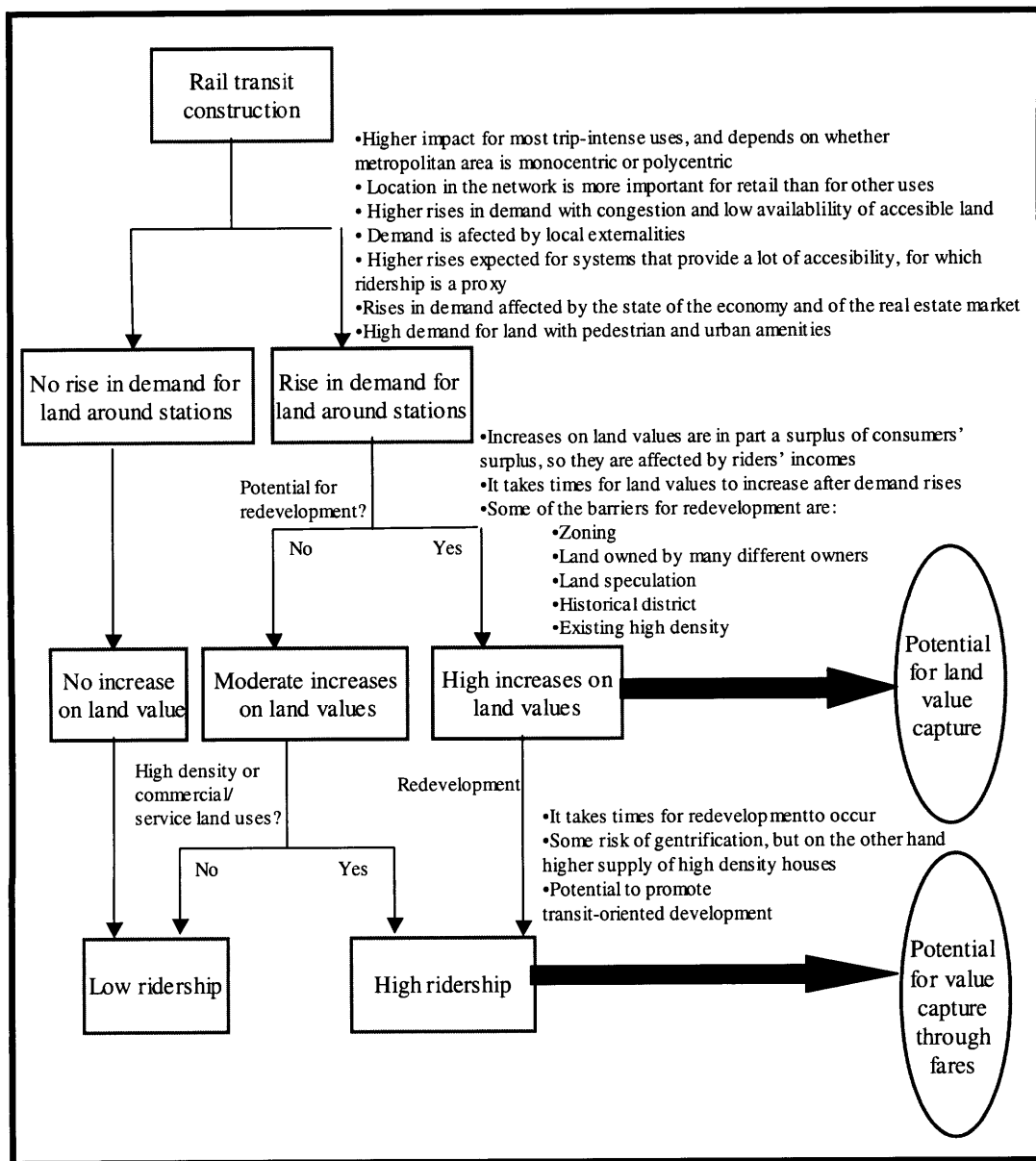
therefore a metro with a higher comfort and safety standard than today can become an interesting value proposition for mid- and high-income Mexicans, and can convert this mode into a viable alternative to the car.

Future implementations of land value capture mechanisms will require a better appraisal of property values, the legalization of illegal squatters, a more developed market for house renting. The governments of the DF and of the State of Mexico should continue their efforts to achieve these goals.

## Conclusions

This report describes the mechanism through which increases in accessibility created by rail transit determine rises of the demand for locating in the land around stations, and increases in land values and redevelopment. The next diagram shows some of the relations of this mechanism.

Figure 31: Diagram of the effect of rail transit on real estate markets, and the potential for value capture



Source: Developed by the author

The effect of the construction of rail transit on the demand for the land located around stations depends on several factors, such as the following:

- It is more intense for land-uses which generate or attract more trips per unit of ground, which in most cases are retail and office space
- Retail is attracted to the area immediately adjacent to the most accessible stations, because is in this area where it benefits from high pedestrian flows
- Access to rail transit benefits office buildings almost regardless of the number of people that use a station, and the relative position of the station in the network, since people are willing to travel farther to work than to go to other activities
- Housing is less attracted to the area immediately next to the station than retail
- The opening of retail space next to the station is an additional factor attracting housing to the area around stations
- The effect of rail transit on office space and housing values is affected by the shape of the metropolitan areas, and of the line: in mono-centric cities, radial rail lines only benefit housing values in the periphery and office space values in the city center. On the other hand, in poly-centric cities, radial lines only benefit housing values regardless of their location, and office space in the city's main center
- The rise in demand is affected by the growth of the economy, which affects the rate of growth in the number of households, and the aggregate demand for housing
- The rise in demand depends on the availability of alternative land in other parts of the city, especially of land with high accessibility
- The rise in demand is especially intense in metropolitan areas with road congestion, which makes rail transit more competitive to other modes
- The demand for locating in the areas around stations is also affected by local externalities, such as the existence of heavy industries
- There are economies of network, so systems that provide high accessibility, e.g. with many different rail lines, generate a higher impact on the demand for land
- The provision of pedestrian and urban amenities raises the attractiveness of the area around stations to housing, and expands the area of influence of the stations, increasing ridership

- The existence of pricing mechanisms to discourage car usage attracts people to the areas next to metro stations
- The demand for the land located next to station is affected by visual intrusion and annoyance generated by the stations

In the cases when there is potential for redevelopment, the rises in demand for locating next to the stations generate the maximum land and property values. Many of the conditions to allow for redevelopment depend on the governments. Some of them are the following:

- Zoning that allows for dense development and mix-uses around stations
- Regulations to discourage sprawl
- Partnership between transit agencies and private developers to promote joint development
- Government's leadership to redevelop station areas, specifically to expedite building permits, assemble land, and secure financing for development projects
- Metropolitan coordination to redevelop the area around the alignment from non-intensive land uses (e.g. industry, single-family housing) to more intensive uses, and to maintain equilibrium of land uses in the alignment (e.g. assure that in every line there is housing and office space to assure balance of flows)

As the increases of land values are in part a capitalization of the consumer's surplus of the riders, the systems whose riders have high purchasing power produce higher increases in land values than those whose riders have low average incomes. The presence of relatively high-income riders also increase the benefit of the stores located close to stations, increasing the attractiveness of the station area for them, and hence land values.

To foster an intensification of land uses around stations, rail transit needs to offer of a value proposition attractive to people that could afford and would want to live in these areas.

In the cases where land values have increased after the construction of rail transit, it has taken time for these increases to materialize, because of the short-term elasticity of the real estate supply with respect to prices, and the cyclical nature of the real estate market.

The redevelopment of the land also takes time to materialize. In this process there are some risks of gentrification to occur. This risk is tempered by the potential of allowing for relatively high-density multi-family housing in the area around stations, which may be an attractive value proposition for low-income people, especially in developed countries. In developing countries, multi-family housing is much less attractive for low-income people. During the redevelopment phase it is possible to promote transit-oriented development.

There is evidence that retail and office space development has followed the migration of housing, and not the opposite. This characteristic suggests that firms and shops are only interested to move close to stations if there is housing nearby, or close to other stations of the system. On the other hand, the sole presence of firms and shops around stations would not attract housing development by itself.

In the cases when land values increase, there is potential for the usage of land value capture mechanisms. In the cases when systems gain a large number of riders, especially when riders are heterogeneous in terms of income or travel patterns, there is potential to use value capture through differentiated fares.

There are several ways in which transit agencies can reap part of the increased value of land to fund the extension of rail transit. These mechanisms have been successfully used in Europe, Asia and less intensively in the United States and Latin America. Some of them are the following:

- Charging a direct fee to land owners to help pay for the infrastructure
- Raising property-taxes
- Negotiating with property owners changes in zoning in exchange for contributions to fund transportation infrastructure

It was proved that most areas around new and existing metro stations in Mexico City had a slower growth of population, income per capita, and commercial and service employment than comparable areas in the rest of the city during the 1990's. It was also proven that in the same decade in Santiago, the areas around stations had a higher growth of population and income per capita than the comparable areas in the city, especially the areas around the lines built before the 1990's.

It was proved that since 1981 the metro in Mexico City has behaved as an inferior good, i.e. one whose consumption has a negative relation with income, whereas the metro in Santiago has behave as a normal good. This finding is congruent with the results of previous surveys about the characteristics of the riders in both systems. It was also proved that since 1981 the demand in Mexico City's metro has been inelastic to changes in fares, whereas in Santiago it has been elastic. This may be a consequence of the large difference in fare between the two metros.

The Metro in Santiago has reinforced the intensification of land uses only around certain parts of its alignment. The Metro was an important factor in the emergence of a secondary employment and retail center in the eastern part of the city, and of the continuation of the growth of *La Florida* in the last few years. There have been lower effects in the areas around the western part of Line 1 and around Line 2, except for a recent significant growth of multi-family building. Finally, Metro has helped stop the decline of the city center and has helped to revitalize residential, office, and retail development in this area.

Three approaches are proposed for implementing value capture in Santiago de Chile: special benefit assessment, joint development and differentiated pricing in corridors serving high-income areas of the city.

The metro in Mexico City has been one of the factors producing the loss in population of the city center, its specialization in tertiary activities, the growth of the metropolitan area, and the reinforcement of previously existing secondary centers.

The fact that the metro in Mexico City is perceived to produce negative impacts on land values makes the usage of land value capture difficult. A plan to use special benefit assessment and differentiated pricing in a new commuter lines, and in new lines is proposed. Value capture is proposed exclusively for premium-service lines, which would need to have differentiated pricing and a distinct branding.

More studies need to be done on the effect of changes in GDP on ridership of rail transit systems. These studies need to include data for shorter periods of time, maybe quarters, and account for demand seasonality. Models might gain precision by considering generation of trips separated from modal choice, so they will need to include data on the cost of alternative modes. The results of those studies will not only be useful for researchers, but also for transit managers.

Empirical studies on the effect of transit on land values in developing countries should also be performed. There are very few studies in this area, and the existing databases on property values are not easy to access for researchers, and may not be accurate.

Finally, more research is needed into the details of the implementation of land value capture mechanism. This thesis has only given general guidelines in this area. A good implementation in demonstration projects may determine the viability of land value capture mechanisms in the future.

## References

- Alonso, W. (1964) *Location and Land Use*. Cambridge: Harvard University Press.
- Anas, A. and Armstrong, R. (1993) *Land Value and Transit Access: Modeling the Relation in the New York Metropolitan Area*. Federal Transit Administration, Washington, D.C.
- APTA (2003) *2003 Public Transportation Fact Book*. American Public Transportation Association, Washington, D.C.
- Arriagada, C. and Simioni, D. (2001) *Dinámica de valorización del suelo en el área metropolitana del Gran Santiago y desafíos del financiamiento urbano*. Serie Medio Ambiente y Desarrollo, CEPAL, Naciones Unidas, Santiago.
- ATI (Alternativa de Transporte Integrado) (2003) <http://www.ati.gobierno.pr/>
- Bajic, V. (1983) The effects of a new subway line on housing prices in *Metropolitan Toronto*. *Urban Studies* 20, 2: 147-58.
- Ben-Akiva, M. and Morikawa, T. (2002) Comparing Ridership Attraction of Rail and Bus. *Transportation Policy* 9, 107-116 (2002)
- Bernick, M. and Cervero, R. (1997) *Transit Villages for the 21<sup>st</sup> Century*. New York: McGraw-Hill.
- Bollinger, C. R.; Ihlanfeldt, K. R. and Bowes, D. R. (1998) Spatial variation in office rents within the Atlanta region, in *Urban Studies*, 35, pp1097-1118.
- Boulding, K. E. (1966) *Economic Analysis*, New York: Harper and Row, 4<sup>th</sup> edition.
- Boyce, D.; Allen, B.; Mudge, R.; Slater, P.; Isserman, A. (1972) *Impacts of rapid transit on suburban residential property values and land development: Analysis of the Philadelphia-Linglewood high speed line*. Philadelphia: University of Pennsylvania, Regional Science Department.
- Bowes, D.R., Ihlanfeldt, K.R. (2000) Identifying the impacts of rail transit stations on residential property values. *Journal of Urban Economics*, 50, 1-25 (2001)
- Braun, J., Braun, M., Briones, I., Díaz, J. (2000) *Economía Chilena 1810-1995. Estadísticas Históricas*. Documento de Trabajo, No. 187, Instituto de Economía, Pontificia Universidad Católica de Chile. Retrieved from [http://www.economia.puc.cl/publicaciones/Doc.Trabajo/DocTrab\\_187.pdf](http://www.economia.puc.cl/publicaciones/Doc.Trabajo/DocTrab_187.pdf).
- BTS (Bureau of Transportation Statistics) Web Site (2002): [http://www.bts.gov/publications/pocket\\_guide\\_to\\_transportation/2002/html/table07\\_per\\_capita\\_passenger\\_travel\\_and\\_freight\\_transportation.html](http://www.bts.gov/publications/pocket_guide_to_transportation/2002/html/table07_per_capita_passenger_travel_and_freight_transportation.html).
- Building Industry Association of Northern California (1993) *Survey of Housing Preferences for Northern California*. San Francisco.
- Burnley, I. H., Murphy, P. A. and Jenner, A. (1997) Selecting suburbia: residential relocation to outer Sydney, in *Urban Studies*, 34, pp1109-1127.
- Cáceres, G. and Sabatini, F. (2001) Santiago de Chile: la recuperación de plusvalías puesta en perspectiva histórica. In: Smolka, M., Furtado, F. (Ed.) *Recuperación de Plusvalías en América Latina*. Pontificia Universidad Católica de Chile, Lincoln Institute of Land Policy.

- Cambridge Systematics, Inc., Cervero, R., and Aschuer, D. (1998) *Economic Impact Analysis of Transit Investments: Guidebook for Practitioners*. National Academy Press, Report 35, Transit Cooperative Research Program, Washington, D.C., 1998.
- Case, K. and Shiller, R. (1988) The Behavior of Home Buyers in Boom and Post-Boom Markets. *New England Economic Review* (November/December 1988) 29-46.
- CdM (Ciudad de México) (1996) *Programa General de Desarrollo Urbano del Distrito Federal*. Secretaría de Desarrollo Urbano y Vivienda. México.
- Cervero, R. (1987) *Alternatives for Producing and Financing Transportation Services and Improvements in California*. Working Paper No. 466, University of California, Berkeley.
- Cervero, R. (1992) *Land Market Impacts of Urban Rail Transit and Joint Development: An Empirical Study of Rail Transit in Washington D.C. and Atlanta*. Working Paper The University of California Transportation Center No. 135.
- Cervero, R. (1996) California's Transit Village Movement. *Journal of Public Transportation*, Vol. 1, No.1, 1996, pp. 103-130.
- Cervero, R. (1997) *Transit-Induced Accessibility and Agglomeration Benefits: A Land Market Evaluation*. Working Paper 691, Institute of Urban and Regional Development, University of California at Berkeley.
- Cervero, R. (1998) *The Transit Metropolis: A Global Inquire*. Washington D.C., Covelo, CA Island Press.
- Cervero, R., Bernick, M., and Gilbert, J. (1994). *Market Opportunities and Barriers to Transit-Based Development in California*. Berkeley, National Transit Access Center, University of California.
- Cervero, R., Duncan, M. (2001) *Rail Transit's Value-Added: Effects of Proximity to Light and Commuter Rail Transit on Commercial Land Values in Santa Clara County, California*. Urban Land Institute, National Association of Realtors, Washington, D.C.
- Cervero, R., Hall, P., Landis, J. (1992) *Transit Joint Development in the US*. University of California at Berkeley, Institute of Urban and Regional Development.
- Cervero, R.; Landis, J. (1997) Twenty years of the Bay Area Rapid Transit System: Land Use and Development Impacts. *Transportation Research A, Vol. 31, No. 4*, 309-333, (1997).
- Chicago Tribune (2001) *Near West Side Boom*. August 11<sup>th</sup>, 2002.
- Chile (1960) Censo Población 1960. Resumen País. Dirección de Estadística y Censo, Santiago, Chile.
- City of Chicago (2003) *The Chicago Zoning Ordinance*. Retrieved from <http://www.cityofchicago.org/Zoning/ordinance/default.html>.
- Clichevsky, N. (2000) Informalidad y segregación urbana en América Latina: una aproximación. *Serie Medio Ambiente y Desarrollo*, No. 28, CEPAL, Santiago de Chile.
- Clichevsky, N. (2001) La Captación de Plusvalías Urbanas en la Argentina: ¿futuro instrumento de equidad social?. In: Smolka, M., Furtado, F. (Ed.) *Recuperación de Plusvalías en América Latina*. Pontificia Universidad Católica de Chile, Lincoln Institute of Land Policy.
- Condon, P. (2000) *Building better compact cities while protecting and restoring green infrastructure*. Retrieved from [www.sustainable-communities.agsci.ubc.ca/newsroom/portland.html](http://www.sustainable-communities.agsci.ubc.ca/newsroom/portland.html).

- Cummings, J. and DiPasquale, D. (2000) The Spatial Implications of Housing Policy in Chile. In: Glaeser, E. and Meyer, J. (Ed.) *Chile. Political Economy of Urban Development*. John F. Kennedy School of Government, Harvard University.
- Damm, D., Lerman, S.R., Lerner-Lam, E., and Young, J. (1980) Response of urban real estate values in anticipation of the Washington Metro. *Journal of Transport Economics and Policy*, 14, 315-336.
- Darbéra R. (1993) Deregulation of urban transport in Chile: what have we learned in the decade 1979-89? *Transport Reviews*, vol. 13 n°1, London, pp. 45-59.
- Darien, T. and Wheaton, W. (2001) Intraurban wage variation, employment location and commuting times. *Journal of Urban Economics*, 50, 2, (September 2001), pp.338-366.
- Davis, J. L. (1965) The Elevated System and the Growth of Northern Chicago. *Studies in Geography*, Number 10, Northwestern University. Evanston, Illinois.
- DCOZ (District of Columbia, Office of Zoning) (2002) *Zoning Regulations*. Retrieved from dcoz.dc.gov.
- De Mattos, C. (1999) Santiago de Chile, globalización y expansión metropolitana: lo que existía sigue existiendo. *Eure*, Vol. 25 No. 76. Pontificia Universidad Católica de Chile, Santiago, Chile.
- De Ramón, A. (1990) La población informal. Poblamiento de la periferia de Santiago de Chile. 1920-1970. *Eure*, Vol. 16, No. 50, pp. 5-17, Pontificia Universidad Católica de Chile.
- DeCorla-Souza, P. (2000) Induced Highway Travel: Transportation Policy Implications for Congested Metropolitan Areas. *Transportation Quarterly*, Vol. 54, No.2.
- Delgado, A., Perló, M. (2000) *El Estado del Conocimiento sobre el Mercados del Suelo Urbano en México*. El Colegio Mexiquense, Lincoln Institute of Land Policy. Zinacantepec, Mexico.
- Delgado, J. (1991) Centro y Periferia en la Estructura Socioespacial de la Ciudad de México. In: Schteingart, M. (Ed.) *Espacio y Vivienda en la Ciudad de México*. El Colegio de México, I Asamblea de Representantes del Distrito Federal, México City.
- Deweese, D. (1976) The effect of a subway on residential property values in Toronto, *Journal of Urban Economics* 3, 4: 357-69.
- DGP (1982) Sistema de Planificación Urbana del Distrito Federal. Dirección General de Planificación, México City.
- Diamond, H. L. and Noonan, P. F. (1996) *Land Use in America*. Lincoln Institute of Land Policy. Washington, D.C.: Island Press.
- DICTUC (2003) Encuesta Origen Destino de Viaje 2001. Santiago, Chile.
- DII-UCh (Departamento de Ingeniería Industrial – Universidad de Chile) (2000) *Estudio, Análisis y Evaluación del Sistema de Transporte de la Provincia de Chacabuco: Informe Final*. Report for the Ministerio de Obras Públicas de Chile.
- DiPasquale, D. and Wheaton, W. (1996) *Urban Economics and Real Estate Markets*. Prentice Hall, Englewood Cliffs, NJ.
- Downs, A. (1992) *Stuck In Traffic: Coping with Peak-Hour Congestion*. The Brookings Institution, Washington, D.C.

Ducci, M. E. (2000) Santiago: territorios, anhelos y temores. Efectos sociales y espaciales de la expansión urbana. *Eure*, Vol. 26 No. 79. Pontificia Universidad Católica de Chile, Santiago, Chile.

Duhau, E. (1991) Urbanización Popular y Políticas de Suelo en la Ciudad de México. In: Schteingart, M. (Ed.) *Espacio y Vivienda en la Ciudad de México*. El Colegio de México, I Asamblea de Representantes del Distrito Federal, México City.

Edwards, G. (XX) El Suelo Urbano y el Mercado de Activos. Pontificia Universidad Católica de Chile.

EIA (Energy Information Administration) (2003) *Commercial Buildings Energy Consumption Survey*. Retrieved from <http://www.eia.doe.gov/emeu/consumptionbriefs/cbecs/pbawebbsite/contents.htm>.

Enríquez, F. J. (2000) Challenges and perspectives of urban transportation for passengers in Mexico City. In: *Urban Transportation and Environment, Proceeding of the International Conference Codatu IX*, Mexico City.

Ewing, R. (1997) *Transportation and Land Use Innovations. When you can't pave your way out of congestion*. Planner Press, American Planning Association.

Falcke, C. (1978) *Study of BART's Effects on Property Prices and Rents*. Washington, D.C.: Urban Mass Transportation Administration, U.S. Department of Transportation.

Figuerola, Oscar (1987) La politique de déréglementation du transport collectif à Santiago du Chile. *Les entreprises de transport collectif et la dereglementation*, INRETS, Arcueil.

Figuerola, Oscar (1990) *Santiago Metro: Integration and Public Transport*. In: Rail Mass Transit for Developing Countries. London, Thomas Telford.

Figuerola, O. (1990b) La desregulación del Transporte Colectivo en Santiago: Balance de Diez Años. *Eure*, Vol. 16, No. 49, pp. 23-32, Pontificia Universidad Católica de Chile, Santiago.

Gaffney, M. (1999) Tax Reform to Release Land. In: Wenzer, K. (1999) *Land Value Taxation: The Equitable and Efficient Source of Public Finance*. Armonk, N.Y.: M.E. Sharpe; London: Shephard-Walwyn, c1999.

Gakenheimer, R. (2002) *Mobility Issues in the Developing World*. International Motor Vehicle Program, MIT.

Gakenheimer, R., Molina, Luisa T., Sussman, J., Zegras, C., Howitt, A., Makler, J., Lacy, R., Slott, R. and Villegas, A. (2002) The MCMA Transportation System: Mobility and Air Pollution. In: Molina, Luisa and Molina, Mario (Ed.) *Air Quality in the México Megacity. An Integrated Assessment*. Kluwer Academic Publishers.

Galilea, S., Hurtado, J. (1988) Efectos del Metro en la Estructura Urbana de Santiago. In: *Eure*, Vol. XIV, num. 42, pp. 43-62. Pontificia Universidad Católica de Chile, Santiago, Chile.

Garreau, J. (1991) *Edge City: Life in the New Frontier*. Doubleday, New York, NY.

Garza, G. and Damián, A. (1991) Ciudad de México. Etapas de Crecimiento, Infraestructura y Equipamiento. In: Schteingart, M. (Ed.) *Espacio y Vivienda en la Ciudad de México*. El Colegio de México, I Asamblea de Representantes del Distrito Federal, Mexico City.

Gatzlaff, D. and Smith, M. (1993). The Impact of Miami Metrorail on the Value of Residences Near Station Locations. *Land Economics*, Vol. 69, No. 1, pp. 54-66.

- Gilat, Michael (2002) *Coordinated transportation and land use planning in the developing world: the case of Mexico City*. Thesis, MIT, Cambridge, MA.
- Gómez-Ibañez, J. A. (1999) Pricing. In: Gómez-Ibañez, J. A., Tye, W. and Winston, C. (ed.) *Essays in Transportation Economic and Policy*. Brookings Institution Press, Washington, D.C.
- González, O. (1988) El Metro de Ciudad de México. In: *Eure*, Vol. XIV, num. 42, pp. 43-62. Pontificia Universidad Católica de Chile, Santiago, Chile.
- Graizbord, B.L., Babcock, E. and Nava, R.L. (1999) Estructura Urbana, Energía, Calidad Ambiental en la ZMCM: Indicadores de Sustentabilidad, mimeo. El Colegio de México, Mexico.
- Gross, P. (1991) Santiago de Chile (1925-1990): Planificación Urbana y Modelos Políticos. *Eure*, Vol. 17, No. 52/53, pp. 27-52, Pontificia Universidad Católica de Chile.
- Gruen, A. (1997) *The Effect Of CTA and Metra Stations on Residential Property Values: Transit Stations Influence Residential Property Values*. Report to the Regional Transportation Authority.
- Haider, M. and Miller, E. (2000) Effects of Transportation Infrastructure and Location on Residential Real Estate Values. *Transportation Research Record 1722*.
- Hall, P. (1996) *Cities of tomorrow: an intellectual history of urban planning and design in the twentieth century*. Oxford, UK; Cambridge, Mass.: Blackwell Publishers.
- Hanayama, Y. (1986) *Land Markets and Land Policy in a Metropolitan Area. A Case Study of Tokyo*. Oelgeschlager, Gunn & Hain, Publishers, Inc. Boston, MA.
- Harris, C. L. (1999) Fundamental and Feasible Improvements of Property Taxation. In: Wenzer, K. (1999) *Land Value Taxation: The Equitable and Efficient Source of Public Finance*. Armonk, N.Y.: M.E. Sharpe; London: Shephard-Walwyn, c1999.
- Hiernaux, D. (1999) Los Frutos Amargos de la globalización: Expansión y Reestructuración Metropolitana de la Ciudad de México. *Eure*, Vol. 25 No. 76. Pontificia Universidad Católica de Chile, Santiago, Chile.
- Hoyt, H. (1939) *The Structure of Growth of Regional Neighborhoods in American Cities*. Washington, D.C.: US Government Printing Office.
- Huang, H. (1996) The Land-Use Impacts of Urban Rail Transit Systems. *Journal of Planning Literature*, Vol. 11, No.1 (August 1996)
- Ibarra, V. (1991) Conformación del Espacio Urbano y su Relación con el Transporte Público. In: Schteingart, M. (Ed.) *Espacio y Vivienda en la Ciudad de México*. El Colegio de México, I Asamblea de Representantes del Distrito Federal, México City.
- Iracheta, Alfonso (1988) Diez años de planificación del suelo en la zona metropolitana de la Ciudad de México. In: Garza, Gustavo (editor) *Una década de planeación urbano-regional en México, 1978-1988*. El Colegio de México, DF, México.
- ITE (Institute of Transportation Engineers) (1997) *Trip generation: trip generation rates, plots, and equations*. Washington, D.C.
- Jacobs, J. (1961) *The Death and Life of Great American Cities*. Random House, New York, NY.
- Kuhn, F. (2002) Bus Rapid or Light Rail Transit for Intermediate Cities? In: Godard, X. and Fatonzoun, I. (ed.) *Urban Mobility for All*. Proceedings of the 10th International Codatu Conference, Held Lome, Togo, November 2002. 2002. pp. 357-65.

Landis, J., Guathakurta, S. and Zhang, M. (1994) *Capitalization of Transportation Investments into Single-Family Home Prices*. Berkeley: Institute of Urban and Regional Development, University of California, Working Paper 619.

Lee, R. W. and Rivasplata, C. R. (2001) Metropolitan Transportation Planning in the 1990's: Comparisons and Contrasts in New Zealand, Chile and California. *Transport Policy* 8 (2001) pp. 47-61.

Lezama, J. L., Favela, R., Galindo, L. M., Ibararán, M. E., Sánchez, S., Molina, Luisa T. (2002) Forces Driving Pollutant Emissions in the MCMA. In: Molina, Luisa and Molina, Mario (Ed.) *Air Quality in the México Megacity. An Integrated Assessment*. Kluwer Academic Publishers.

Litman, T. (2003) *Generated Traffic and Induced Travel Implications for Transport Planning*. Victoria Transport Policy Institute, Victoria, BC, Canada. Retrieved from <http://www.vtppi.org/gentraf.pdf>.

López, Eduardo and Ibarra, Xóchitl (1997) Barrios, colonias y fraccionamientos -historia de la evolución de una familia temática de palabras que designa una fracción del espacio urbano - México. Cahiers "Les mots de la ville". Retrieved from <http://www.unesco.org/most/p2wpfr2.htm>.

Makler, Jonathan (2000) Regional Architectures and Environmentally-Based Transportation Planning: An Institutional Analysis of Planning in the Mexico City Metropolitan Area. Thesis, CE, MIT.

Mar-Juárez (2000) Análisis del uso de colectivos en la Ciudad de México. In: *Urban Transportation and Environment, Proceeding of the International Conference Codatu IX*, Mexico City.

Marshall, A. (2000) *How cities work: suburbs, sprawl, and the roads not taken*. Austin: University of Texas Press.

McDonald, J. F., Osuji, C. (1995) The effect of anticipated transportation improvement on residential land values. *Regional Science and Urban Economics* 25, 261-278.

McNeal, A. and Doggett, R. (1999) Metro Makes its Mark. *Urban Land*, September, pp. 78-81, 118.

Metro Caracas (no date) *Infometro*. Available at <http://www.metrodecaracas.com.ve/culpublicaciones/pdf/INFORMETRO.pdf>

Metro de Santiago (2000) Memoria Anual 1999.

Metro de Santiago (2003) Memoria Anual y Anexo Estadístico 2002. Available at <http://www.metrodecaracas.com.ve/culpublicaciones/pdf/INFORMETRO.pdf> and <http://www.metrodecaracas.com.ve/culpublicaciones/pdf/INFORMETRO.pdf>

Metro SP (2003) *2002 Annual Report*. Metro de Sao Paulo. Available at <http://www.metrodecaracas.com.ve/culpublicaciones/pdf/INFORMETRO.pdf>

Molina, L.T. and M.J. Molina, eds. (2002). *Air Quality in the Mexico Megacity: An Integrated Assessment*, Kluwer Academic Publishers, Dordrecht, the Netherlands, 406 pages.

Molinero (2000) Lo que se debe y lo que no se debe de hacer: La Ciudad de México. In: *Urban Transportation and Environment, Proceeding of the International Conference Codatu IX*, Mexico City.

Moore, T. and Thorsnes, P. (1994) The Transportation/Land Use connection: a framework for practical policy. American Planning Association, Planning Advisory Service, Chicago, IL.

Morales, S. (1988) El Metro de Santiago. In: *Eure*, Vol. XIV, num. 42, pp. 19-42. Pontificia Universidad Católica de Chile, Santiago, Chile.

- Morrison, A. (1992) *The Tramways of Chile 1858-1978*. New York, Bonde Press. Retrieved from <http://www.tramz.com/cl/tto/a.html>.
- Muth, R. (1969) *Cities and Housing*. Chicago: University of Chicago Press.
- Navarro, B. (1990) XX. In: *Rail Mass Transit for Developing Countries*. London, Thomas Telford.
- Navarro, B. (1993) *Ciudad de México. El Metro y sus Usuarios*. Universidad Autónoma Metropolitana, Unidad Xochimilco.
- Navarro, B., González, O. (1989) *Metro, Metrópolis, México*. México : UNAM, Unidad Xochimilco: Instituto de Investigaciones Económicas, 1989.
- Nelson, A. (1992) Effects of elevated heavy-rail transit stations on house prices with respect to neighborhood income. *Transportation Research Record 1359, Planning and Administration: Economics, Finance and Administration*. Transportation Research Board, National Research Council, National Academic Press, Washington D.C.
- Nelson, A. (1999) Transit Stations and Commercial Property Values: A Case Study with Policy and Land-Use Implications. *Journal of Public Transportation*, Vol. 2, No. 3, 1999, pp. 77-93.
- Norris, S. (2003) *Fourteen years on, Crossrail celebrations are still premature*. Property Week July 18, 2003.
- Ochoa, Otoniel (no date) *Impacto de los Sistemas Masivos de Transporte sobre el Valor y Uso de Suelo. El Caso de la Línea 3 del Metro Universidad-Indios Verdes en la Ciudad de México*. Not published.
- Orrego, R.R.; Torres, P.A.; Estrada, S.G. (2000) La influencia del “Metro” en el desarrollo urbano de la Ciudad de México. In: *Urban Transportation and Environment, Proceeding of the International Conference Codatu IX, Mexico City*.
- Palerm, A. (no date) *La Elasticidad de la Demanda del Sistema de Transporte Colectivo*. Servicios de Apoyo a la Modernización Industrial.
- Park, M. (1999) *The Role of a Transit Agency in Station Area Development: A Case Study of Tren Urbano, Puerto Rico*. Thesis for the Degree of Master in City Planning. Massachusetts Institute of Technology.
- Perló, M. and Zamorano, Luis R. (2001) ¿Se Justifica la Aplicación del Impuesto a la Plusvalía en México?. In: Smolka, M., Furtado, F. (Ed.) *Recuperación de Plusvalías en América Latina*. Pontificia Universidad Católica de Chile, Lincoln Institute of Land Policy.
- Popenoe, D. (1977) *The Suburban Environment: Sweden and the United States*. Chicago: University of Chicago Press.
- Renne, J. and Newman, P. (2002) Facilitating the Financing and Development of ‘Smart Growth’. *Transportation Quarterly*, Vol. 56, No.2, Spring 2002 (23-32). Eno Transportation Foundation, Inc., Washington, D.C.
- Ridley, T. and Fawcner, J. (1987) *Benefit Sharing: the funding of urban transport through contributions from external beneficiaries*. International Union of Public Transport (47<sup>th</sup> International Congress, Lausanne 1987)
- Riley, D. (2001) *Taken for a Ride. Trains, Taxpayers and the Treasury*. Tedddington, UK: Centre for Land Policy Studies.

- Rodríguez, A., Winchester, L. (2001) Metropolización, globalización, desigualdad. *Eure* 27, No. 80, pp. 121-139. Pontificia Universidad Católica de Chile.
- Sabatini, F. (1990) Precios de suelo y edificación de viviendas (4 conclusiones sobre Santiago relevantes para políticas públicas) *Eure*, Vol. 16, No. 49, pp. 23-32, Pontificia Universidad Católica de Chile, Santiago.
- Sabatini, F. (2000) Reforma de los mercados de suelo en Santiago, Chile: efectos sobre los precios de la tierra y la segregación residencial. *Eure*, Vol. 26 No. 77. Pontificia Universidad Católica de Chile, Santiago, Chile.
- Sabatini, F. and Arenas, F. (2000) Entre el mercado y el Estado: resonancias geográficas y sustentabilidad social en Santiago de Chile. *Eure*, Vol. 26 No. 79. Pontificia Universidad Católica de Chile, Santiago, Chile.
- SACTRA (The Standing Advisory Committee on Trunk Road Assessment) (1994) *Trunk Roads and the Generation of Traffic*. UK Department of Transport and HMSO. London, UK.
- Scheurer, J., Newman, P. and Kenworthy, J. (2000) *Can Rail Pay? Light Rail Transit and Urban Redevelopment with Value Capture Funding and Joint Development Mechanisms*. Perth, Australia.
- Schteingart, M. (1991) Producción Habitacional en la Zona Metropolitana de la Ciudad de México (1960-1987) In: Schteingart, M. (Ed.) *Espacio y Vivienda en la Ciudad de México*. El Colegio de México, I Asamblea de Representantes del Distrito Federal, México City.
- Sectra (1991) Encuesta Origen Destino de Viaje 2001. Santiago, Chile. Available at [www.sectra.cl](http://www.sectra.cl).
- SETRAVI (1996) *Plan Maestro del Metro y Trenes Ligeros. Área Metropolitana de la Ciudad de México*. Secretaría de Transporte y Vialidad, DF. México City.
- Stöveken (2000) Improving urban transportation in Mexico City. In: *Urban Transportation and Environment, Proceeding of the International Conference Codatu IX*, Mexico City.
- Stutsman, J. (2002) Bus Rapid Transit Or Light Rail Transit--How To Decide? Los Angeles Case Study. *Transportation Research Record*. 2002. (1793) pp. 55-61.
- TRB (Transportation Research Board) (1992) *Travel Characteristics at Large Scale Suburban Activity Centers*. Washington, D.C.
- TRB (Transportation Research Board) (2003) *Bus Rapid Transit. Volume 1: Case Studies in Bus Rapid Transit*. TCRP Report 90. Washington, D.C.
- Trivelli, P. (2003) *Mercado del Suelo Urbano, Area Metropolitana de Santiago. Boletín N° 82, Cuarto Trimestre 2002*.
- TTI (2002) *2002 Urban Mobility Study*. Texas Transportation Institute. Retrieved from <http://mobility.tamu.edu/ums/>.
- UITP (2001) *Millennium Cities Database for Sustainable Transport*. Brussels, Belgium.
- US Census Bureau's Web Site: <http://www.census.gov>.
- US Census Bureau (1999) *Characteristics of New Housing*. Retrieved from <http://www.census.gov/prod/2000pubs/c25-99a.pdf>.

US DOT (Department of Transportation) (2002) *2001 National Household Travel Survey*. Retrieved from [http://nhts.ornl.gov/2001/html\\_files/introduction.shtml](http://nhts.ornl.gov/2001/html_files/introduction.shtml).

Vickrey, W. (1999) Proposition Relating to Site-Value Taxation. In: Wenzer, K. (1999) *Land Value Taxation: The Equitable and Efficient Source of Public Finance*. Armonk, N.Y.: M.E. Sharpe; London: Shephard-Walwyn, c1999.

Villegas, Alejandro (2000) Analysis of the air quality-transportation policies in Mexico City. In: *Urban Transportation and Environment, Proceeding of the International Conference Codatu IX*, Mexico City.

Voith, R. (1993) Changing Capitalization of CBD-Oriented Transportation Systems. Evidence from Philadelphia, 1970-1988. *Journal of Urban Economics*, Vol. 33, pp 361-376.

Walker, J. (1998) *Accessibility-Based Evaluation Methods*. Tren Urbano Progress Report. MIT. Not published.

Walmsley, D.A. and Perrett, K.E. (1992) *The Effects of Rapid Transit on Public Transport and Urban Development*. London: HMSO.

Ward, P. (1998) *Mexico City: the production and reproduction of an urban environment*.

Weinstain, B. and Clower, T. (1999) *The Initial Economic Impacts of the DART LRT System*. Denton, Texas: University of North Texas, Center for Economic Development and Research, prepared for the Dallas Area Rapid Transit District.

Wenzer, K. (1999) *Land Value Taxation: The Equitable and Efficient Source of Public Finance*. Armonk, N.Y.: M.E. Sharpe; London: Shephard-Walwyn, c1999.

Wetzel, D. (2003) *Tax landowners, not developers and businesses*. Property Week, May 2, 2003.

Weyrich, P. and Lind, W. (2001) *Twelve Anti-Transit Myths: A Conservative Critique*. The Free Congress Foundation, Washington, D.C.

World Bank (1986) *Urban Transport: A World Bank Policy Study*. World Bank, Washington D.C.

Zegras, Pericles Christopher (2000) *The potential for using urban growth management for transportation system enhancements in Developing countries: the case of the Santiago, Chile Metropolitan Region*. Thesis MIT, Cambridge, MA.

Zhang, T. (2000) Community features and urban sprawl: the case of the Chicago metropolitan region. *Land Use Policy* 18 (2001) 221-232.

## Appendix 1

Some of the people who were interviewed are the following:

- María Teresa Atrián, Seduvi
- Leonardo Martínez, Sigea
- Joel Ahumada, Setravi
- Ricardo Núñez, STC
- José Flores, STC
- Francisco Sabatini, Metro de Santiago
- Robert Brosnan, Arlington County Government
- David Sikes, Los Angeles County Metropolitan Transportation Authority
- Oscar Figueroa, Pontificia Universidad Católica de Chile
- Paul Fish, Chicago Transportation Authority

## Appendix 2

The following is a table with the number of riders, GDP, average fares, and number of stations for the 1981-2003 period in Mexico City:

Table 42: Ridership, GDP, average fare, average fare/GDP per capita and number of stations in Mexico City

Year	Pax	GDP	Fare	Fare*1million/GDP per capita
1981	987.4	758,357	0.78	19.70
1982	1,037.5	754,246	0.39	10.20
1983	1,116.7	722,596	0.22	6.02
1984	1,242.2	748,683	0.14	3.73
1985	1,324.4	768,099	0.08	2.27
1986	1,361.9	739,265	0.68	19.49
1987	1,414.1	752,068	0.65	18.86
1988	1,476.1	761,163	0.86	25.03
1989	1,542.9	793,119	2.16	59.44
1990	1,447.7	833,317	1.66	44.38
1991	1,433.6	868,501	1.40	36.52
1992	1,436.1	900,016	1.66	42.76
1993	1,421.6	917,571	1.54	39.55
1994	1,422.7	972,693	1.44	35.48
1995	1,474.0	899,000	2.37	63.81
1996	1,425.3	945,328	2.41	63.29
1997	1,361.5	1,009,345	2.40	60.10
1998	1,344.0	1,060,119	2.03	49.04
1999	1,301.1	1,098,525	1.80	42.81
2000	1,394.2	1,171,438	1.66	37.42
2001	1,433.7	1,170,267	1.59	36.43
2002	1,396.4	1,178,458	2.00	46.33
2003	1,375.1	1,193,778	1.84	42.75

The sources of information are the following:

- Ridership is from STC, direct communication with the author
- GDP 1981-2000 from <http://oxlad.qeh.ox.ac.uk/search.php>
- GDP 2001-2003 from INEGI, [www.inegi.gob.mx](http://www.inegi.gob.mx)

- Fares from Palerm, A.(no date), and brought to constant pesos, using the CPI, reported by Banco de Mexico's web site (<http://www.banxico.org.mx>)
- Number of stations from [www.urbanrail.net](http://www.urbanrail.net).
- For the number of stations I rounded the day of inauguration of the station to the nearest month
- Population 1981-2000 from <http://oxlad.qeh.ox.ac.uk/search.php>
- Population 2001-2003 projected using the linear projection in percentage of growth in population between 1999 and 2000

The following is the same table for Santiago:

Table 43: Ridership, GDP, average fare, average fare/GDP per capita and number of stations in Santiago

Year	GDP (million CHP of 1995)	Fare (CHP of 2002)	Fare*1million/GDP per capita	numb_stat
1981	13,585,241	187	116.7	35
1982	11,739,268	129	94.5	35
1983	11,410,329	118	90.9	35
1984	12,081,876	136	100.7	35
1985	12,319,699	136	100.5	35
1986	13,009,137	134	95.4	35
1987	13,866,995	167	113.3	36
1988	14,880,851	147	94.1	37
1989	16,452,304	140	82.7	37
1990	17,060,640	153	87.7	37
1991	18,420,357	156	84.2	37
1992	20,682,012	152	74.6	37
1993	22,126,912	175	81.3	37
1994	23,389,943	181	80.9	37
1995	25,875,727	191	78.6	37
1996	27,794,001	193	75.0	37
1997	29,629,956	195	72.0	46
1998	30,587,263	207	74.9	49
1999	30,354,539	215	79.8	49
2000	31,717,177	221	79.2	52
2001	32,792,398	264	92.7	52
2002	33,517,771	270	94.1	52
2003	34,612,438	288	98.1	52

The sources of information are the following:

- Ridership 1981-2002 from Metro de Santiago (2003)
- Ridership 2003 from [www.ine.cl](http://www.ine.cl)
- GDP 1980-1995 from Braun et al (2000)
- GDP 1996 from <http://oxlad.qeh.ox.ac.uk/search.php>
- GDP 1997-2003 from [www.bcentral.cl](http://www.bcentral.cl)
- Operational Income 1981-1984 from Morales (1988)
- Fares 1985-2002 from Metro de Santiago (2003)
- Fares 2003 from [www.metrodesantiago.cl](http://www.metrodesantiago.cl)
- Number of stations from Metro de Santiago (2003)
- Population 1981-2000 of Chile from <http://oxlad.qeh.ox.ac.uk/search.php>
- Population 2001-2003 from [www.ine.cl](http://www.ine.cl)

Average fares were estimated the following way:

- For 1981-1984 it was estimated by dividing operational income, reported in Morales (1988) by the number of passengers
- For 1990 it was estimated as the average of the fares for Line 1, for Line 2 and for students, weighted by the number of passengers in each line, and by the proportion of full-fare passengers and students (these proportions were taken from Metro de Santiago, 2003)
- As 1990 was the first year in which free transfer between lines was allowed, and fares in Line 2 rose proportionally more than for Line 1 in that year, I estimated the difference between the resulting average fare, and the one that would have result from a proportional increase in the fare of the two lines. This difference was CHP 5.8
- For the 1985-1989 period, it was estimated as the average of the fares for Line 1 and Line 2, plus the CHP 5.8 I mentioned, which accounts for the revenue from the transfers from Line 2 to Line 1
- For 1991 and 1992, it was estimated using the same formula, but also adding the students' fare, and the proportion of passengers using full-fare and students' fare

- For 1993-2003, it was estimated as the average of the rush hour fare, the regular fare, the students' fare, and the senior citizens' fare, weighted by the proportion of passengers at rush and non-rush hours, and the proportion of people using the other two fares
- The proportion of people paying rush hour fare were estimated for 2002 by making the above-mentioned formula equal to the income from tickets divided by the number of passengers. Both figures were taken from Metro de Santiago (2003)
- For 1996-2001, the proportion of full-fare passengers paying rush-hour fare was estimated multiplying the equivalent proportion for 2002, estimated as mentioned before, by a factor I called "Factor A"
- Factor A is the summation of the average number of passengers at the peak 1-hour between March and December of each year in each line, (obtained from Metro de Santiago, 2003), divided by the same for the year 2002. By construction Factor A equals 1 for 2002
- For 1993-1995 I used the same proportion of rush-hour tickets as in 1996
- For 2003 I used the same proportion of rush-hour tickets as in 2002

### Appendix 3

The following tables show the population, income, distance to city center, and urban area for the 34 municipalities of the Santiago Metropolitan Area.

Table 44: Income per capita, distance to city center, Urban Area for municipalities in the Santiago Metropolitan Area

<b>Comuna</b>	<b>Income per Capita 1998 (CHP/year)</b>	<b>Distance to Downtown (Km)</b>	<b>Urban Area 1992 (Ha)</b>	<b>Current Urban Area (Ha)</b>
Cerrillos	466	8.0	1,200	1,288
Cerro Navia	286	9.1	910	1,110
Conchalí	372	8.4	1,060	1,070
El Bosque	340	13.5	1,390	1,410
Estación Central	394	4.8	1,340	1,340
Huechuraba	410	10.6	640	1,791
Independencia	527	4.6	740	740
La Cisterna	540	9.5	1,000	1,000
La Florida	596	12.5	3,250	3,462
La Granja	361	10.8	1,000	1,010
La Pintana	274	16.0	1,290	3,060
La Reina	1,649	12.5	1,780	2,340
Las Condes	1,671	12.5	3,590	5,105
Lo Barnechea	1,671	20.9	1,540	4,607
Lo Espejo	284	7.6	720	720
Lo Prado	482	6.8	660	670
Macul	567	7.6	1,230	1,290
Maipú	474	13.3	2,770	3,210
Ñuñoa	1,174	5.9	1,630	1,630
Pedro Aguirre Cerda	371	6.5	860	860
Peñalolén	452	12.9	1,560	2,730
Providencia	1,622	5.3	1,440	1,440
Pudahuel	372	10.3	860	1,724
Puente Alto	374	19.0	2,760	3,191
Quilicura	373	12.5	560	1,988
Quinta Normal	385	5.3	1,160	1,160
Recoleta	374	5.9	1,500	1,500
Renca	335	8.4	1,180	2,420
San Bernardo	356	16.3	2,360	3,878
San Joaquín	415	6.3	970	970
San Miguel	615	5.7	950	950
San Ramón	327	10.6	650	650
Santiago	597	0.0	2,240	2,240
Vitacura	1,622	12.2	2,830	2,830

Table 45: Income per capita, distance to city center, Urban Area for municipalities in the Santiago Metropolitan Area

Comuna	Population 1970	Population 1982	Population 1992	Population 2002
Cerrillos	34,903	67,013	72,137	71,906
Cerro Navia	83,755	137,777	154,973	148,312
Conchalí	117,405	157,884	153,089	133,256
El Bosque	89,030	143,717	172,338	175,594
Estación Central	131,157	147,918	142,099	140,000
Huechuraba	22,217	56,313	61,341	74,070
Independencia	95,723	86,724	77,539	65,479
La Cisterna	80,512	95,863	94,732	85,118
La Florida	58,698	191,883	334,366	365,674
La Granja	77,263	109,168	126,038	132,520
La Pintana	37,994	73,932	153,586	190,085
La Reina	55,048	80,452	88,132	96,762
Las Condes	112,590	175,735	197,417	249,893
Lo Barnechea	11,174	24,258	48,615	74,749
Lo Espejo	73,111	124,462	119,899	112,800
Lo Prado	53,365	103,575	110,883	104,316
Macul	89,823	113,100	123,535	112,535
Maipú	44,733	114,117	257,426	468,390
Ñuñoa	149,001	168,919	165,536	163,511
Pedro Aguirre Cerda	141,592	145,207	128,342	114,560
Peñalolén	50,983	137,298	178,728	216,060
Providencia	121,437	115,449	110,954	120,874
Pudahuel	50,959	97,578	136,642	195,653
Puente Alto	76,694	113,211	254,534	492,915
Quilicura	11,397	22,605	40,659	126,518
Quinta Normal	133,187	128,989	115,964	116,000
Recoleta	141,694	164,292	162,964	142,220
Renca	48,343	93,928	129,173	133,518
San Bernardo	79,150	129,127	188,580	246,762
San Joaquín	115,085	123,904	112,353	97,625
San Miguel	93,784	88,764	82,461	78,872
San Ramón	59,033	99,410	101,119	94,906
Santiago	289,877	232,667	202,010	200,792
Vitacura	40,343	72,038	78,010	81,499

The following are the sources of the information:

- The sources of population are the Census of 1970, 1982, 1992 and 2002
- The source for income is [www.ine.cl](http://www.ine.cl).
- The sources of the distance to the city center is Cummings and DiPasquale (2000)
- Inner City: municipality of Santiago
- Intermediate Area: municipalities located up to 6.5 km. from the city center

- Second Ring: municipalities located between 6.6 and 12.9 kilometers from the city center
- Third Ring: All other municipalities
- The source of total area per municipality is [www.ine.cl](http://www.ine.cl)
- The source of urban area in 1992 is Arriagada and Simioni (2001)
- It was assumed that all the area was urban except for municipalities with large undeveloped areas, which are the following:
  - *Cerrillos*: I assumed density remained constant from 1992
  - *Estación Central*: I assumed same urban area as 1992
  - *Huechuraba*: I assumed same density as a La Reina
  - *La Florida*: According to the municipality's web site ([www.laflorida.cl](http://www.laflorida.cl)), 48.9% of the land is urbanized
  - *Las Condes*: I assumed same density as 1992
  - *Maipú*: Urban area retrieved from municipality's web site ([www.maipu.cl](http://www.maipu.cl))
  - *Ñuñoa*: I assumed same urban area as 1992
  - *Peñalolén*: According to municipality's web site ([www.penalolen.cl](http://www.penalolen.cl)), real density is 77.13 residents per hectare
  - *Pudahuel*: I assumed same density as 1992
  - *Puente Alto*: According to the municipality's web site ([www.puentealto.cl](http://www.puentealto.cl)), 48.9% of the land is urbanized
  - *Quilicura*: I assumed same density as San Bernardo
  - *Quinta Normal*: I assumed same urban area as 1992
  - *Recoleta*: I assumed same urban area as 1992
  - *San Bernardo*: Based on the municipality's map at [www.sanbernardo.cl/index\\_01.html](http://www.sanbernardo.cl/index_01.html), I estimated that 25% of the municipality's land is urbanized

## Appendix 4

The following municipalities in the Santiago metropolitan area were included in the analysis of section 6.3.2:

- Estación Central
- La Cisterna
- La Florida
- La Granja
- La Reina
- Las Condes
- Lo Espejo
- Lo Prado
- Macul
- Ñuñoa
- Pedro Aguirre Cerda
- Peñalolén
- Providencia
- Quinta Normal
- San Joaquín
- San Miguel
- San Ramón
- Santiago

The rule was to select all those that included zones located at a relatively same distance to the city center as the zones that gained access to Line 5. *La Reina* and *Las Condes* were included to provide base for comparison with the zones in *Providencia* and *Ñuñoa* located next to the metro. As mentioned in section 6.1, these 4 municipalities, along with *Lo Barnechea* and *Vitacura* form the *Zona Oriente*, the area with the highest income per capita in the metropolitan area by far.

The municipalities of *Maipú*, *Pudahuel* and *Recoleta* were not included, because a high number of the zones of the 2001's survey were not fully contained into a single zone of 1991's survey, making it impossible to compare the changes in population and income per capita in the same area.

## Appendix 5

I assumed a new line would be built along the alignment described in section 9.1.4. This hypothetical line would have twelve stations, which are described in the following table:

Table 46: Hypothetical stations in a new metro line in Santiago

Name	Intersection	Municipality	Distance to next station (meters)
Plaza Ñuñoa	Chile-España / Irrazábal	Ñuñoa	914
Simón Bolívar	Chile-España / Simón Bolívar	Nuñoa	1153
Diagonal Oriente	Los Leones / Diagonal Oriente	Border of Ñuñoa and Providencia	985
Bilbao	Los Leones / Bilbao	Providencia	1116
Eliodoro Yáñez	Los Leones / Bilbao	Providencia	1185
Los Leones (connection to Line 1)	Suecia / Nueva Providencia	Providencia	980
El Bosque	Vitacura / Helvecia	Las Condes	1203
Pérez Zujovic	Vitacura / Nueva Costanera	Vitacura	649
Alonso de Córdova	Vitacura / Alonso de Córdova	Vitacura	753
Américo Vespucio	Vitacura / Américo Vespucio	Vitacura	773
Luis Carrera	Vitacura / Los Gómeros	Vitacura	830
Clínica Alemana	Vitacura / Manquehue	Vitacura	

Source: Created by the author. Distance between stations retrieved from [www.mapcity.com](http://www.mapcity.com)

To have a rough estimation of the potential revenue that could be gained using special benefit assessment, I assumed that the government would charge landowners a special charge equivalent to of 6% of the value of their land (if located up to 400 meters from stations), or 3% (if located between 400 and 800 meters from stations). The charge would be exclusively on land values, not on the value of buildings.

I estimated the potential revenue of such a scheme, based on the average value of land sold in the four municipalities. The following table shows these values for the fourth quarter of 2002, which are assumed to be the same as today's prices. Real estate prices in Chile are quoted in UF, which is an inflation-indexed unity, and is equivalent to approximately 27 US dollars.

Table 47: Average value of land sold in the fourth quarter of 2002 in selected municipalities of the Santiago metropolitan area

Municipality	Average value of land sold (UF/m <sup>2</sup> )	Average value of land sold (USD/m <sup>2</sup> )
Providencia	21.7	586
Vitacura	14.7	397
Ñuñoa	11.2	302
Las Condes	19.9	537

Source: Trivelli (2003), quoted in [http://www.loaguirre.cl/evol/pag\\_18.htm](http://www.loaguirre.cl/evol/pag_18.htm)

The following are some assumptions I made:

- 60% of the land around stations is privately owned (i.e. 40% of the land is used by streets and parks)
- All the stations are in the same line, so the circle whose radius is 400 meters, and the ring whose outer radius is 800 meters and its inner radius is 400 meters can both be divided into one part heading the following station and one part heading the previous station
- Based on the previous assumption, areas where circles and rings of more than one station were placed on top of each other were estimated, to avoid double-counting
- The circles with 800-meter radius located around stations *Pérez Zujovic* and *Américo Vespucio* do not intersect. This was the only case where the circles of stations not located immediately adjacent to each other intersect
- The value of land around station *Diagonal Oriente* is the mean between the average values of land in *Providencia* and *Ñuñoa*
- The scheme would not be used in *Los Leones* station, since there is already a metro station (Line 1). That is why this station was left out of the analysis

The total land located around each of the stations and the potential revenue generated by the special charge are shown on the following table:

Table 48: Total area around stations subject to special charge, and generated revenue

Station name	Private land located at less than 400 meters from station		Private land located at more than 400 meters and less than 800 meters from station	
	Area (m <sup>2</sup> )	Revenue from 6% tax on land values (US dollars)	Area (m <sup>2</sup> )	Revenue from 3% tax on land values (US dollars)
Plaza Ñuñoa	302,000	5,500,000	715,000	6,500,000
Simón Bolívar	302,000	5,500,000	613,000	5,600,000
Diagonal Oriente	302,000	8,000,000	640,000	7,600,000
Bilbao	302,000	10,600,000	628,000	11,000,000
Eliodoro Yáñez	302,000	10,600,000	698,000	12,300,000
Los Leones	-	-	-	-
El Bosque	302,000	9,700,000	655,000	10,600,000
Pérez Zujovic	287,000	6,800,000	533,000	6,300,000
Alonso de Córdova	285,000	6,800,000	366,000	4,400,000
Américo Vespucio	298,000	7,100,000	406,000	4,800,000
Luis Carrera	300,000	7,200,000	435,000	5,200,000
Clínica Alemana	302,000	7,200,000	681,000	8,100,000
<b>Total</b>	<b>3,284,000</b>	<b>85,000,000</b>	<b>6,370,000</b>	<b>82,400,000</b>

Source: Created by the author. Areas and revenues were rounded.

So the total revenue that the government would be able to obtain is 167 million dollars.