NEREUS

Núcleo de Economia Regional e Urbana
da Universidade de São Paulo

The University of São Paulo
Regional and Urban Economics Lab

Lecture 14: Urban Infrastructure

Prof. Eduardo A. Haddad

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Brazil's GDP loses R$156.2 billion, owing to traffic congestion in São Paulo

October 21, 2015

Most cars are licensed in São Paulo City, where the average is 1 car for just under every 2.2 inhabitants (*photo: Léo Ramos/FAPESP*)

By José Tadeu Arantes

Agência FAPESP – How much does it cost you to be stuck in traffic in São Paulo? This question has now been answered with precision. "People who commute by car are spending 100 minutes per day on average in the city's traffic between home and work," says economist Eduardo Haddad, Full Professor of Economics at the University of São Paulo's School of Economics, Administration & Accounting (FEA-USP). "Considering the structural characteristics of metropolitan São Paulo and the mobility patterns found in other Brazilian cities, this commute could be shortened by 30 minutes."

"The resulting productivity gain would add 2.83% to Brazil's gross domestic product (GDP), which reached R$5.5 trillion in 2014. In other words, it would add R$156.2 billion to our collective output, and this could translate into extra consumption, corresponding to R$97.6 billion, by the Brazilian population." Haddad coordinated a research project entitled "**Mobility, accessibility and**

Brazil's GDP loses R$156.2 billion, owing to traffic congestion in São Paulo

Residents in São Paulo Metropolitan Region (RMSP) spend on average half an hour more in commuting time than expected.

If such excessive mobility friction were eliminated, national GDP could be 2.83% higher.

The City of São Paulo would absorb 50% of the potential benefit.

How much does it cost to be stuck in traffic in São Paulo?

Haddad, E. A., Hewings, G. J. D, Porsse, A. P., Van Leeuwen, E. S. e. Vieira, R. S. (2015). The Underground Economy: Tracking the Higher-order Economic Impacts of the São Paulo Subway System. ***Transportation Research Part A: Policy and Practice***, v. 73, pp. 18–30.

Haddad, E. A. e Vieira, R. S. (2015). Mobilidade, Acessibilidade e Produtividade: Nota sobre a Valoração Econômica do Tempo de Viagem na Região Metropolitana de São Paulo. ***Revista de Economia Contemporânea***, v. 19, n. 3, pp. 343-365.

"Mobility in Cities – Distributional Impact Analysis of Transportation Improvement in Metropolitan Region São Paulo", ***World Bank***

FAPESP, CNPq, World Bank

São Paulo Metropolitan Region is the financial and economic center of Brazil

Largest urban agglomeration in the country

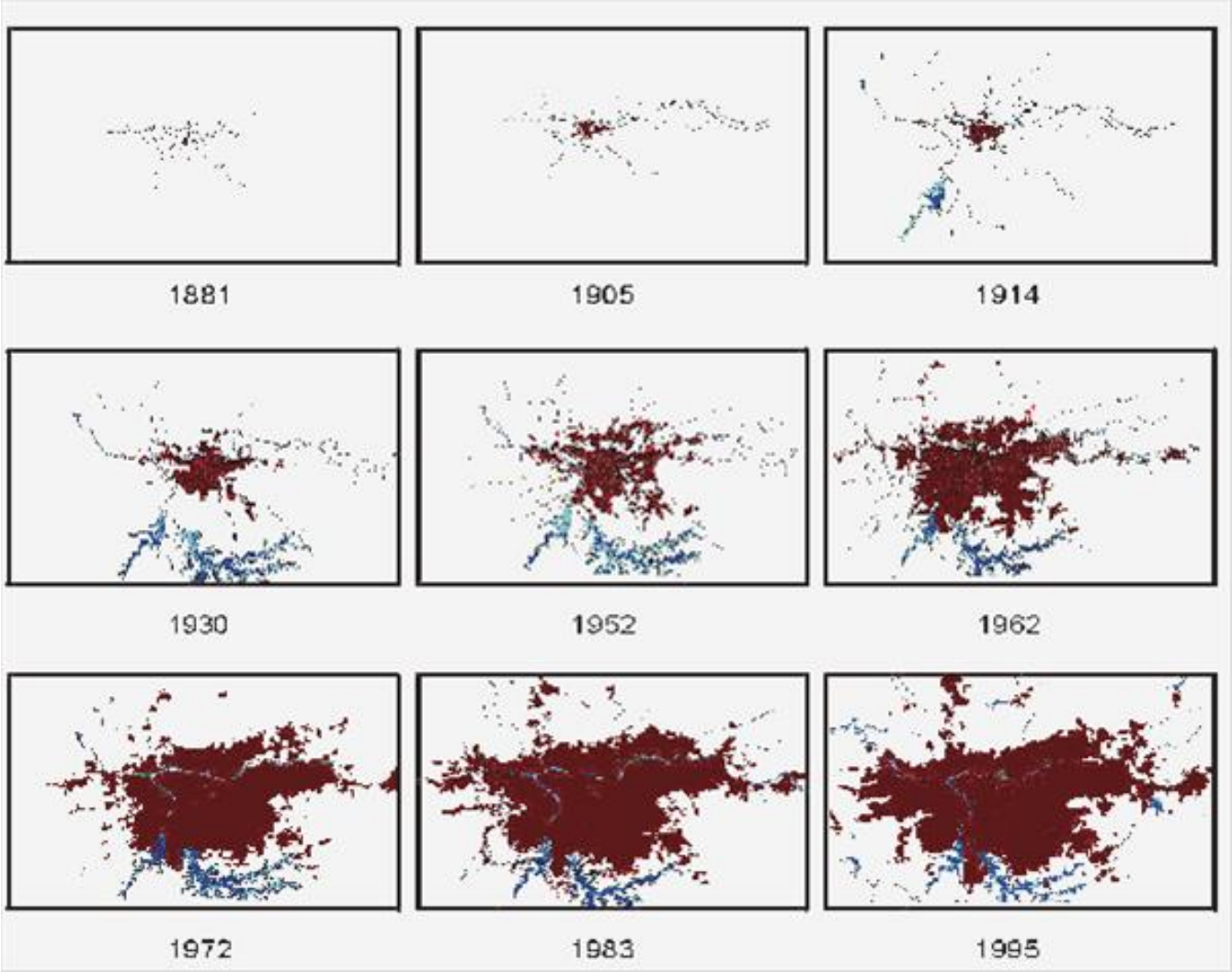
- ✓ 10.3 % of national population (2010)
- ✓ 18.9 % of Brazilian GDP (2009)

The city of São Paulo is the core of the metropolitan area

- ✓ 5.9 % of national population (2010)
- ✓ 12.0 % of Brazilian GDP (2009)

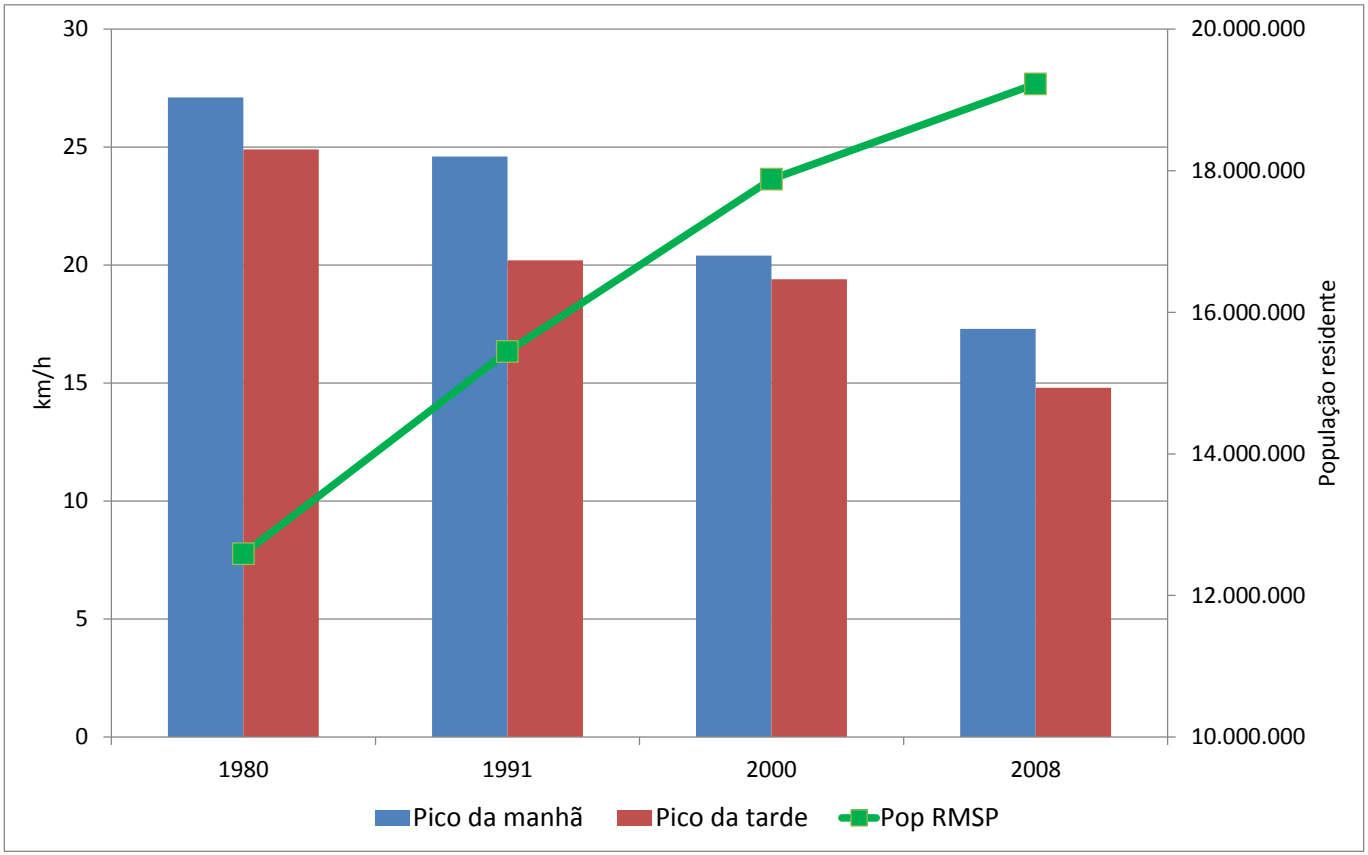
	Area (000 km^2)	*Population (000 000)*	*GDP (USD billion)*	*Per capita GDP (USD)*	*HDI 2000*
São Paulo	1.5	11.3	194	17,221	0.841
SPMR	7.9	19.7	306	15,558	0.813
Brazil	8,514.9	190.8	1,619	8,486	0.665

The rapid process of urban expansion around São Paulo's CBD…



… was not followed by the implementation of adequate public transport infrastructure

Average speed by motorized vehicles in the City of São Paulo during peak hours (in km/h) *versus* Population in SPMR



Traditional approach to estimate the direct impacts of urban transportation projects

Estimates of the individual value of travel time

- Empirical evidence from behavioral and non-behavioral models of modal choice suggest that the value of time saved in commuting represents a percentage of the individual hourly wage (10% to 50%)

Information on changes in travel time associated with the project

Parameters of the labor market of reference

What should we take into account in the calculation of the systemic economic effects?

Heterogeneity (individual and spatial)

Mobility *versus* Accessibility

Effects on labor productivity

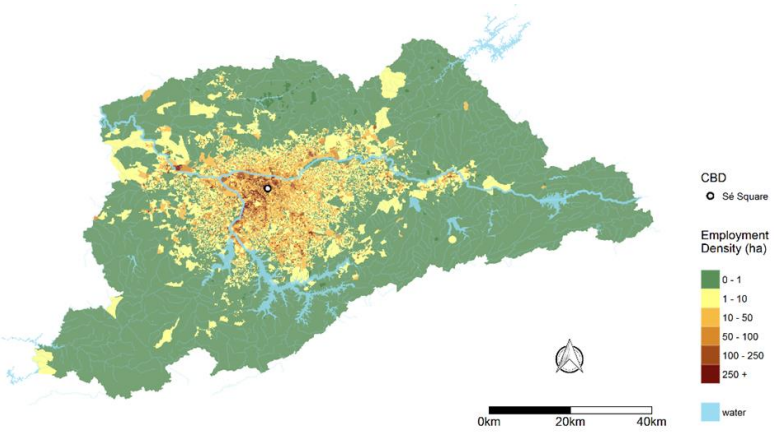
Income flows and trade flow in the context of a metropolitan system

Supply and demand of transportation services

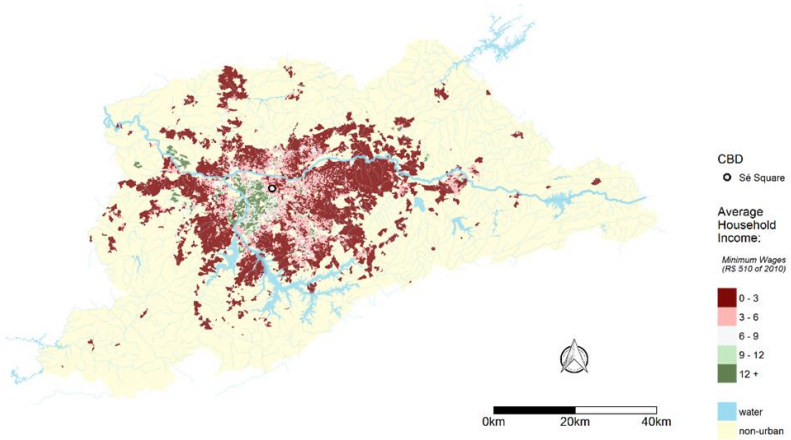
Sound economic theory

São Paulo Metropolitan Region (SPMR)

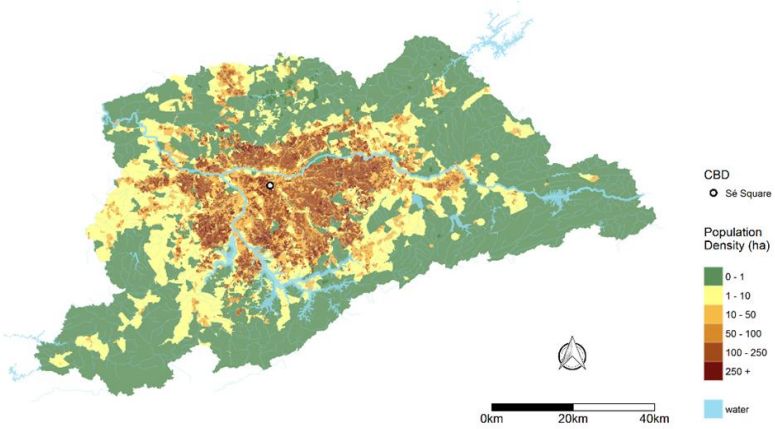
Employment density



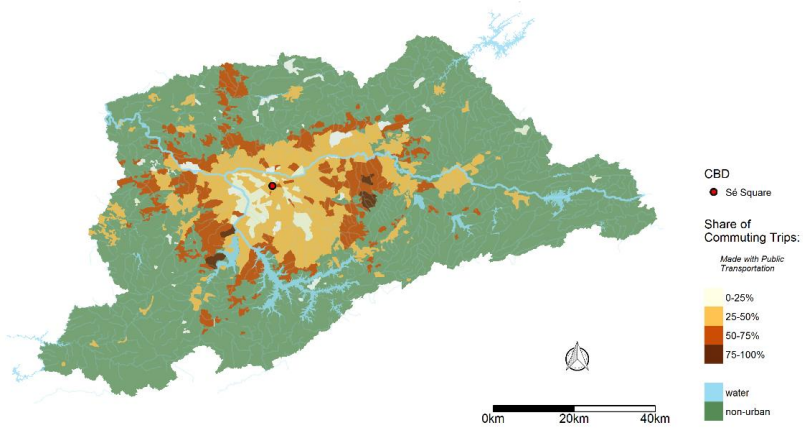
Average household income



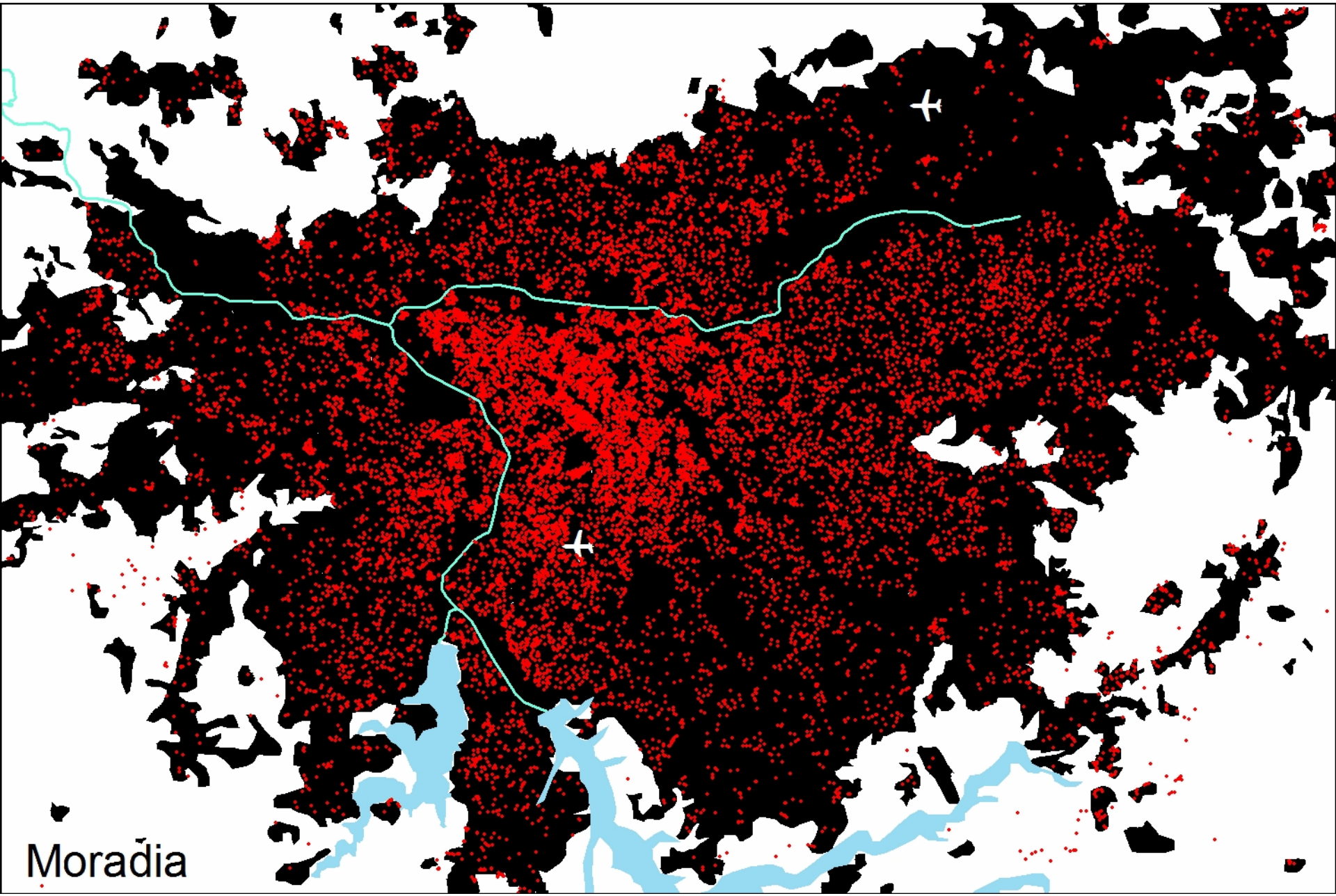
Population density



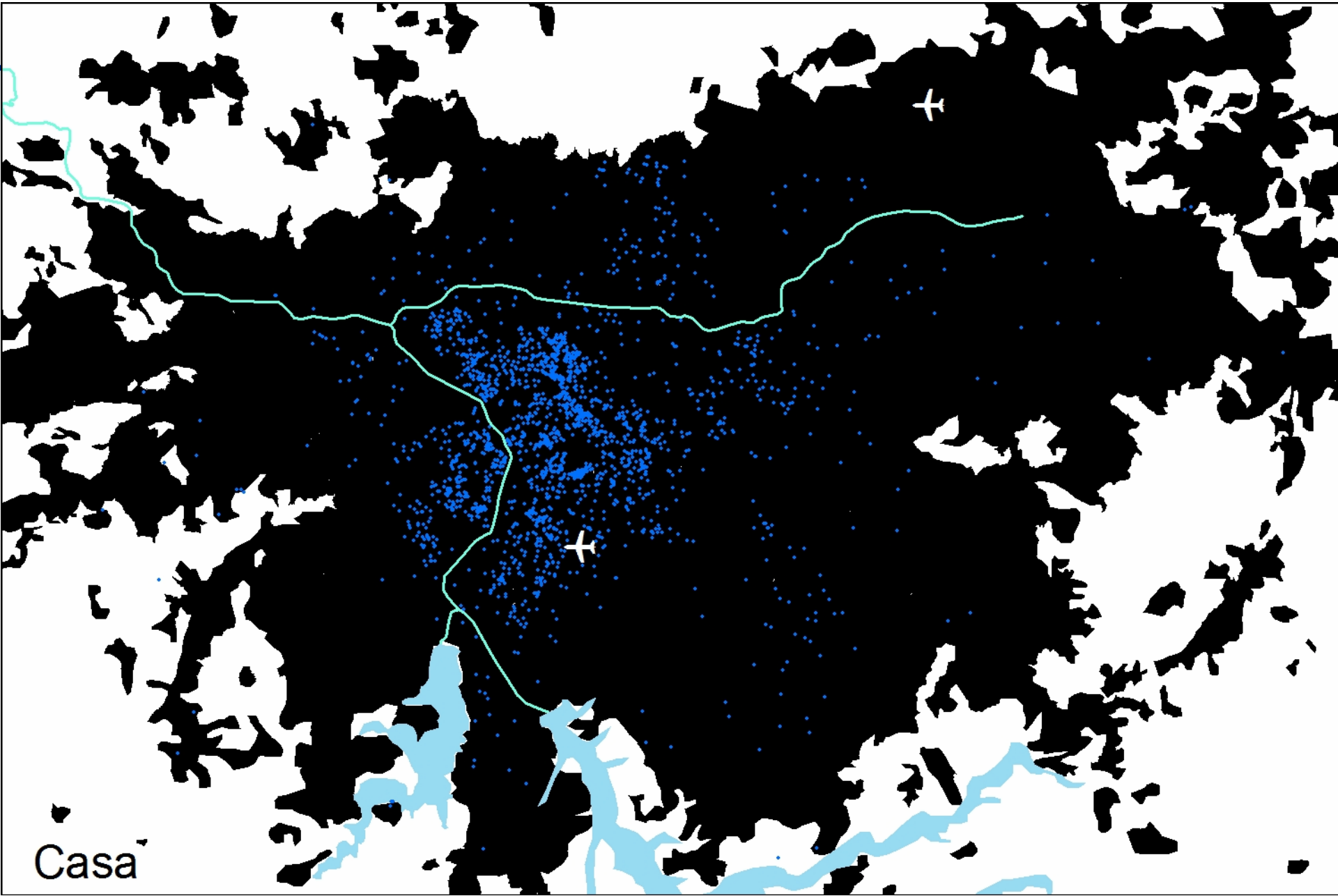
Share of commuting by public transportation



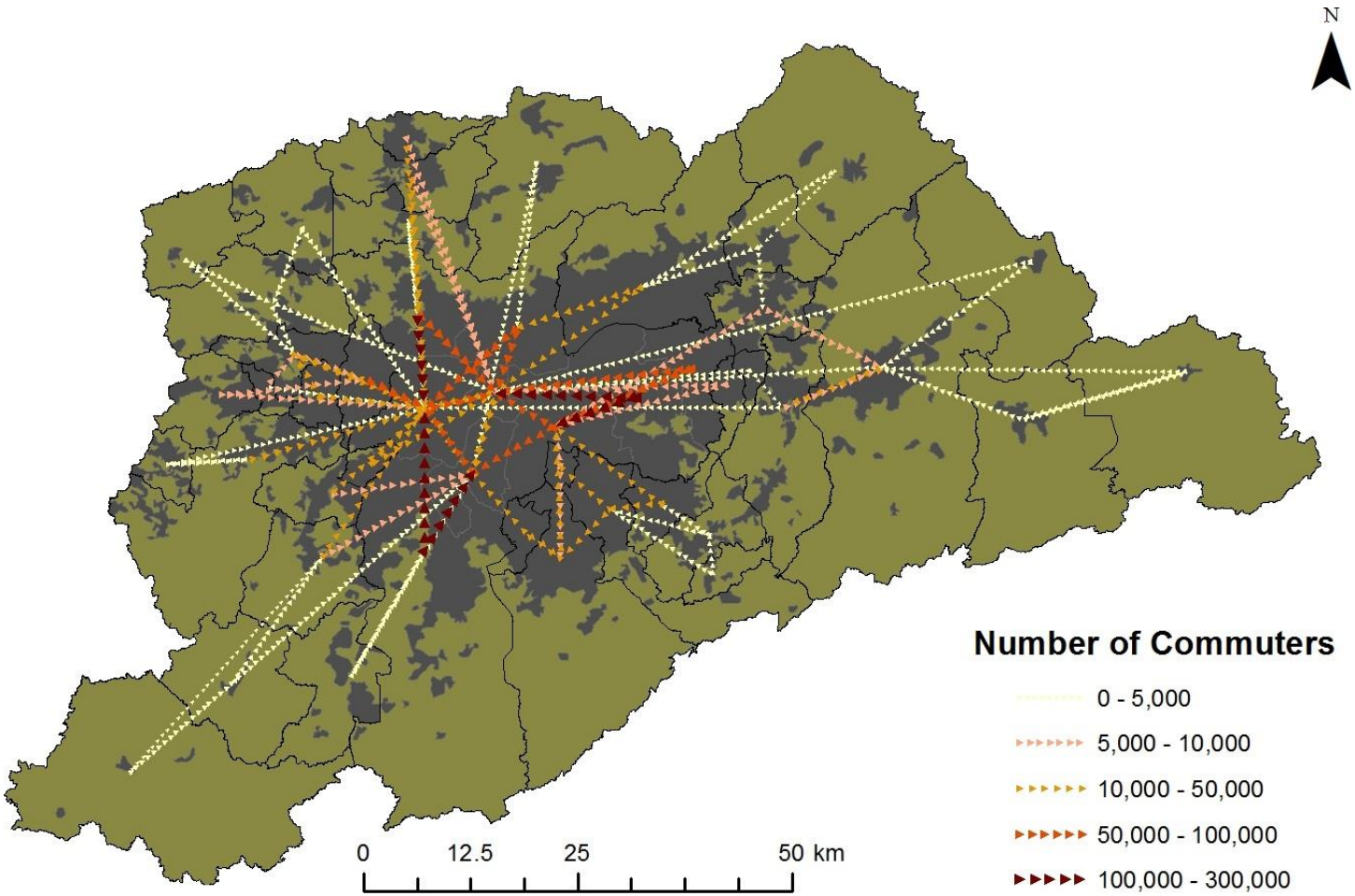
Total workers



Higher wage (>20 SM)



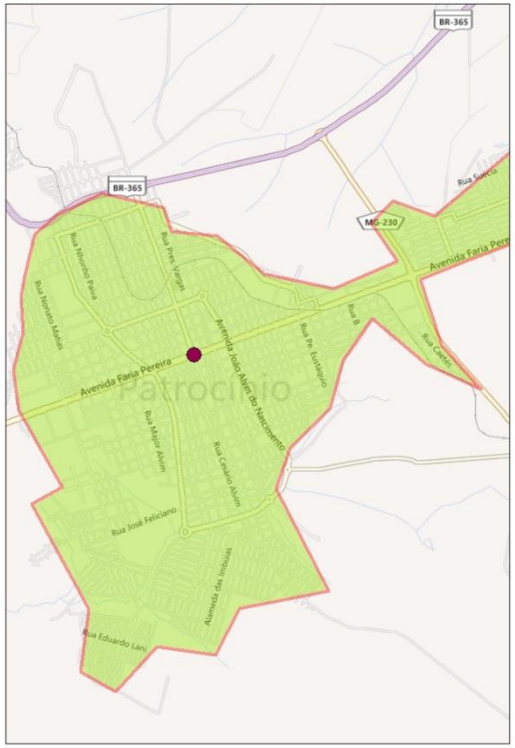
The city of São Paulo receives daily an inflow of almost one million commuters (15.4% of workers in the city)



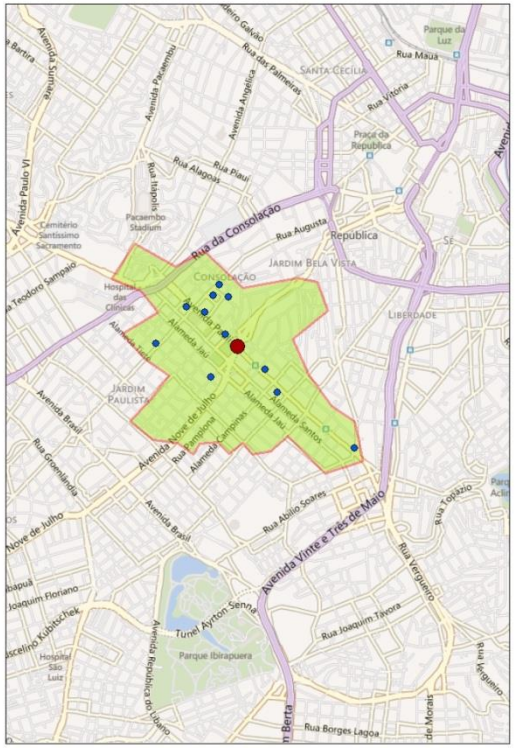
Mobility X Accessibility

"Mobility measures the ability to move from one place to another"

"Accessibility is defined as the potential of opportunities for interaction." (Hansen, 1959)



Patrocínio - MG



São Paulo - SP

Mobility X Accessibility

High levels of mobility can, <u>but do not necessarily</u>, reflect high levels of accessibility…

Hansen's formulation

$$A_{im} = \sum_{j=1}^{n} O_j f(t)$$

j = 460 zones

Oj = Jobs in j

A = Accessibility

t = Commuting time

i = 460 zones

Modes =
1 Private vehicle
2 Public transportation

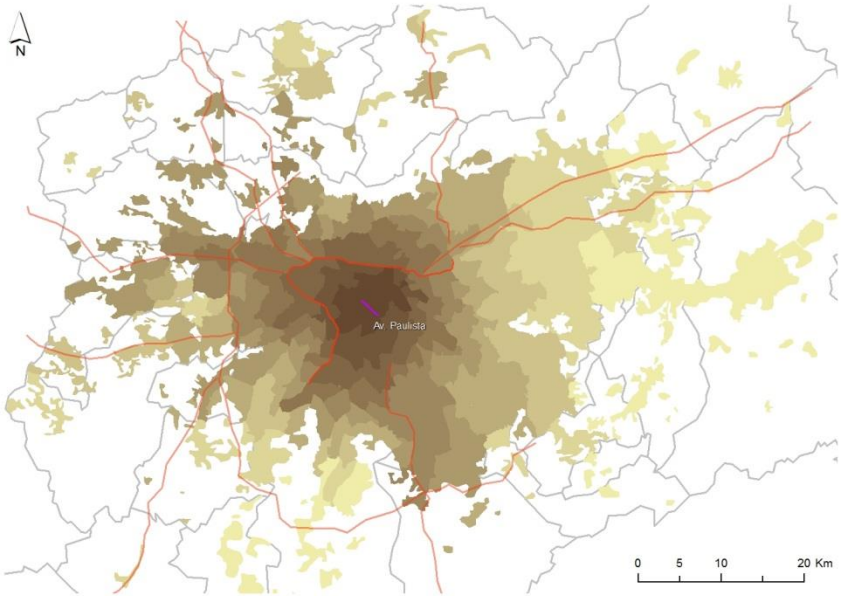
$f(t) = e^{-\alpha t}$

$\alpha = 0{,}01154$

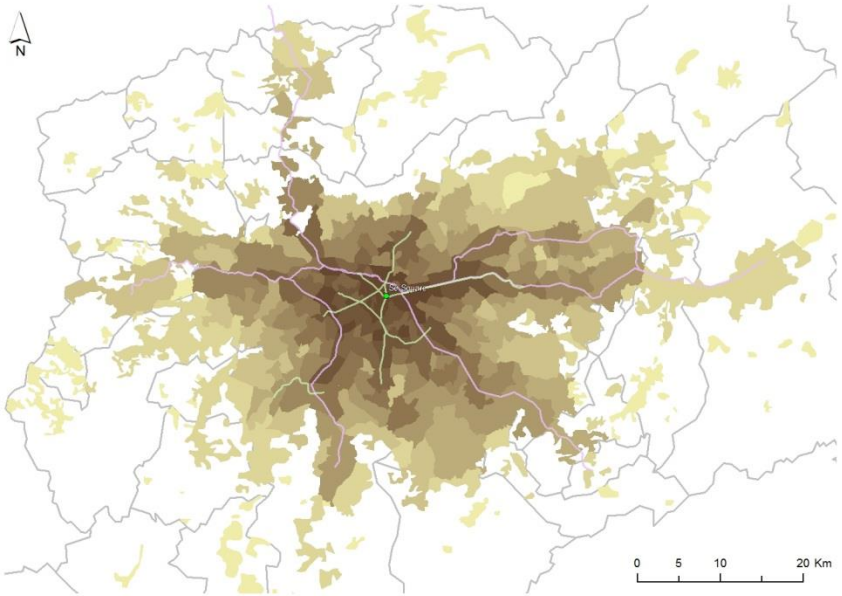
Defined such that f(60) = 0.5

Accessibility to jobs in SPMR

Accessibility by private vehicle

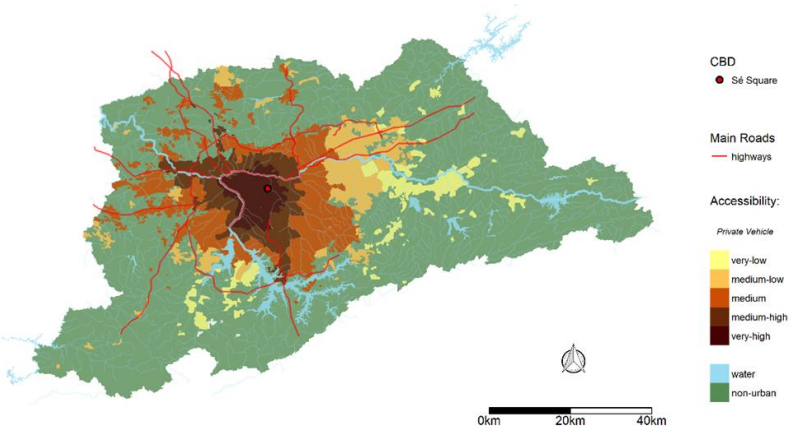


Accessibility by public transportation

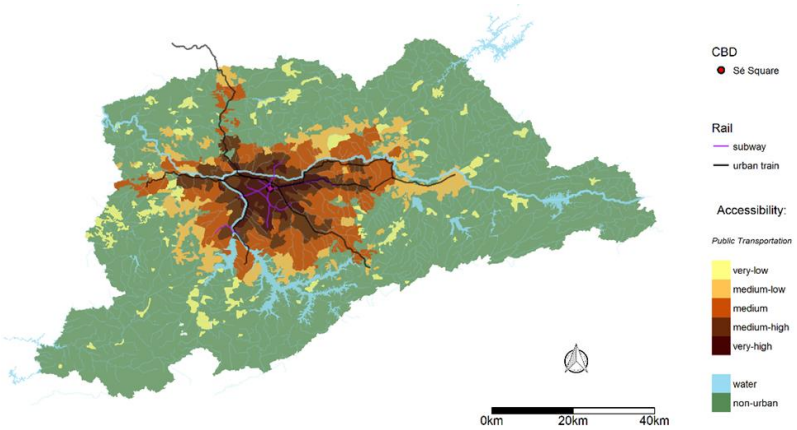


Accessibility to jobs and unemployment in SPMR

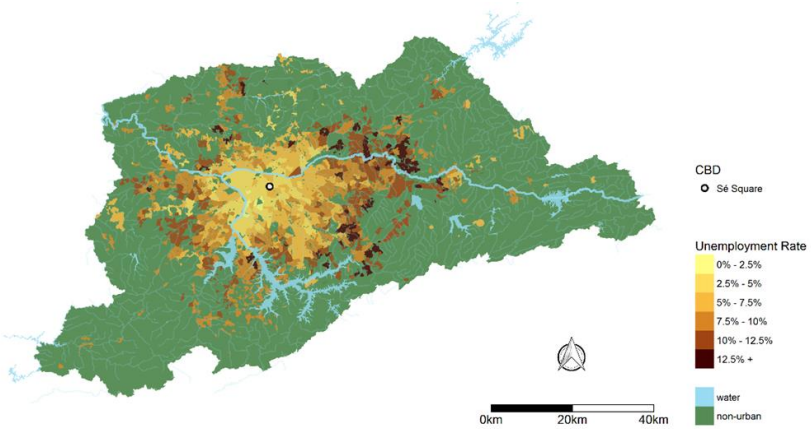
Accessibility by private vehicle



Accessibility by public transportation



Unemployment



Commuting time and productivity

Workers with longer daily commuting are less productive

- Theoretical support (Zenou e Smith, 1995; Zenou, 2002; Brueckner e Zenou, 2003; Ross and Zenou, 2008; Zenou, 2008)
- On-the-job effort is negatively related to commuting time
- Empirical support (Van Ommeren and Gutiérrez-i-Puigarnau, 2009; Porsse et al., 2012)
- Excessive commuting time may induce workers to arrive late or leave early; it also increases the frequency of absenteeism, reducing workers' productivity

Accessibility to jobs and productivity

Workers with better access to available jobs are more productive

- Theoretical support (*"matching"*)
- Effective size of the labor market
  - Efficiency of the transportation system
  - Relative location of jobs and residences
  - Helps explaining workers' productivity
- How many jobs can a worker access in, say, 60 minutes?
- Empirical support

General features of the spatial computable general equilibrium (SCGE) model

Model based on simultaneous optimization of the behavior of individual consumers and firms, subject to resource constraints

Fully specified interregional input-output system (trade flows)

Focus on SPMR

- 39 municipalities + rest of the State of Sao Paulo + rest of Brazil

56 sectors, 110 commodities

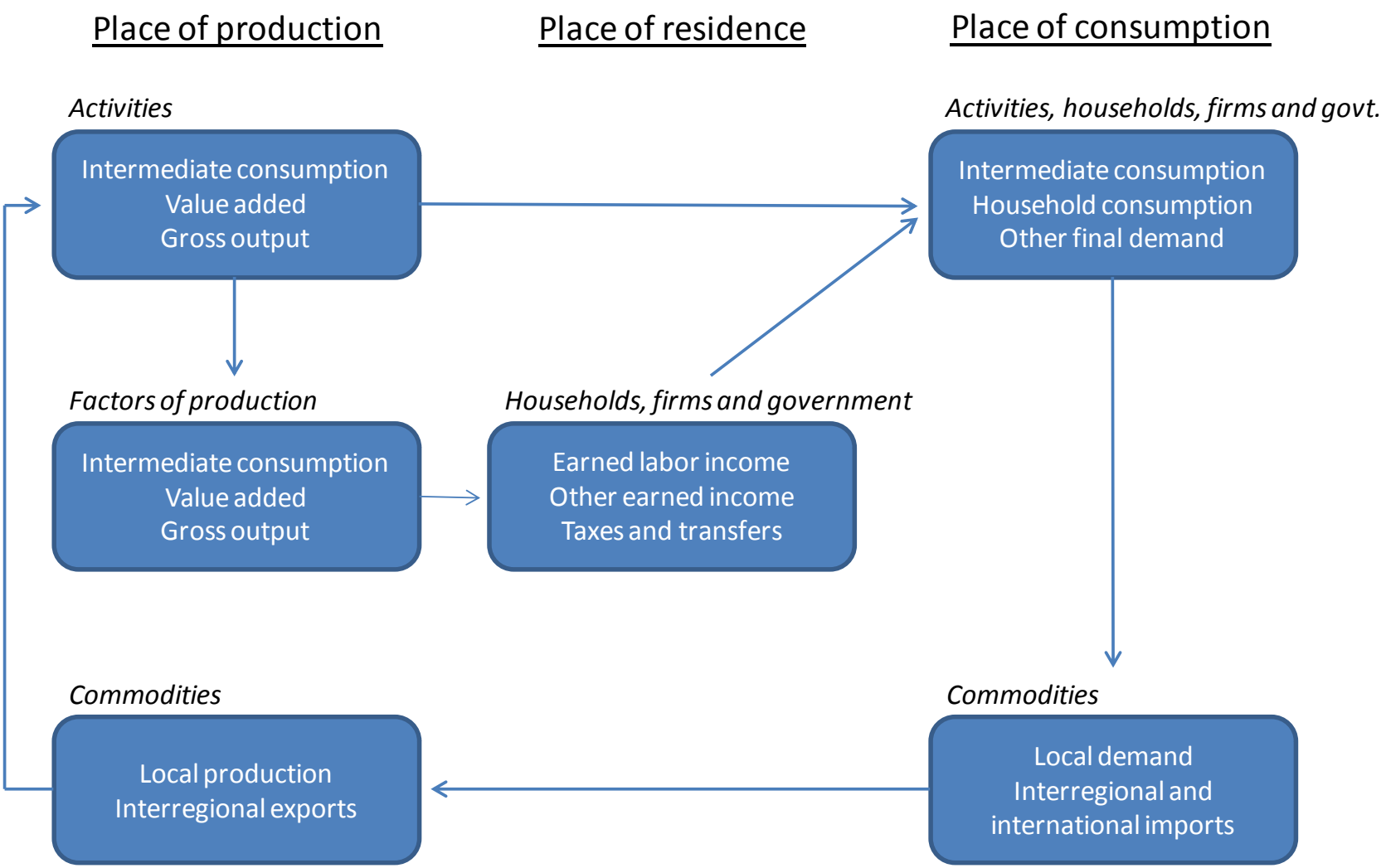
Basic database at the municipality level (2008)

Mapping labor payments from place of work to place or residence

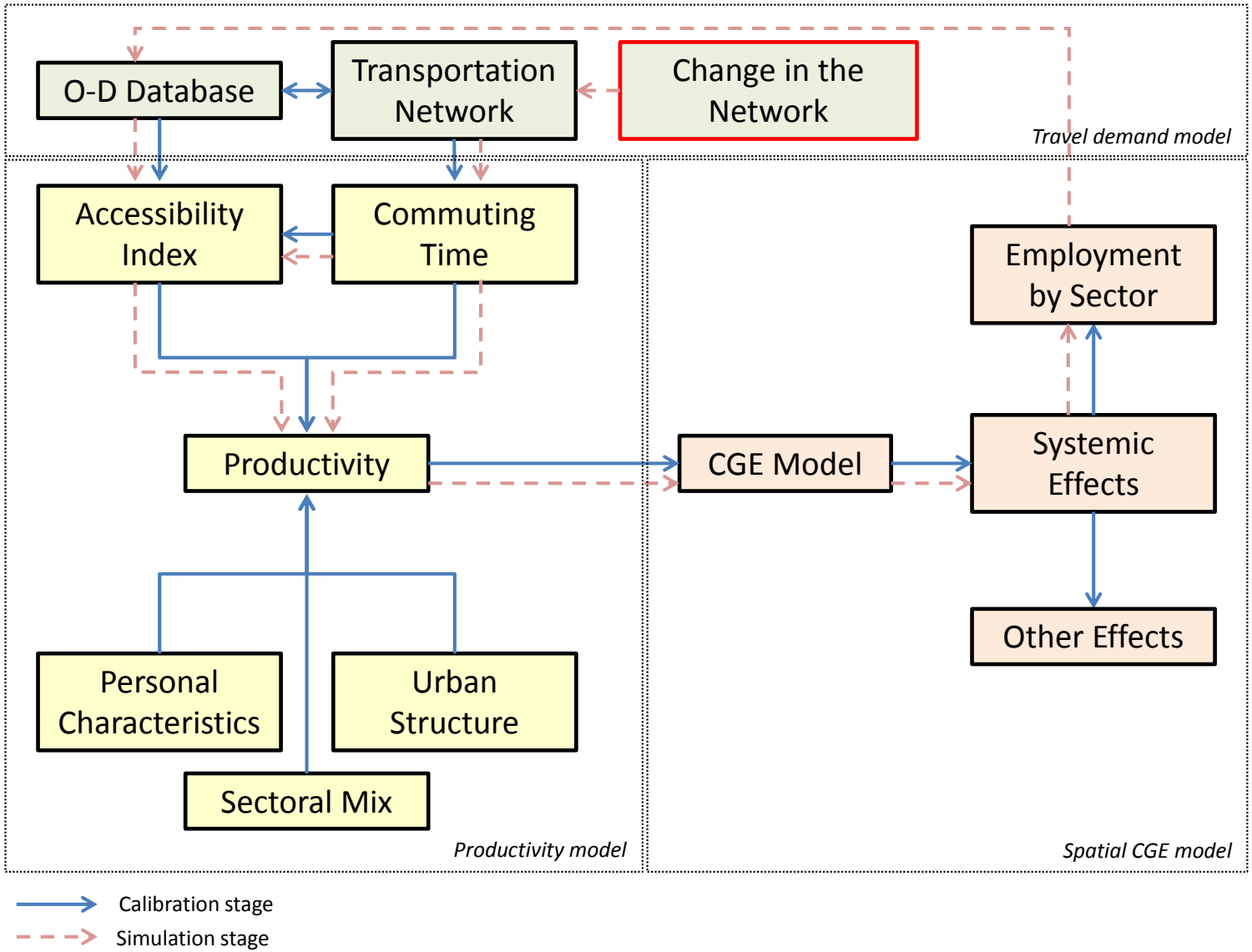
Different patterns of household consumption by place of residence

Reference: Haddad and Hewings (2005)

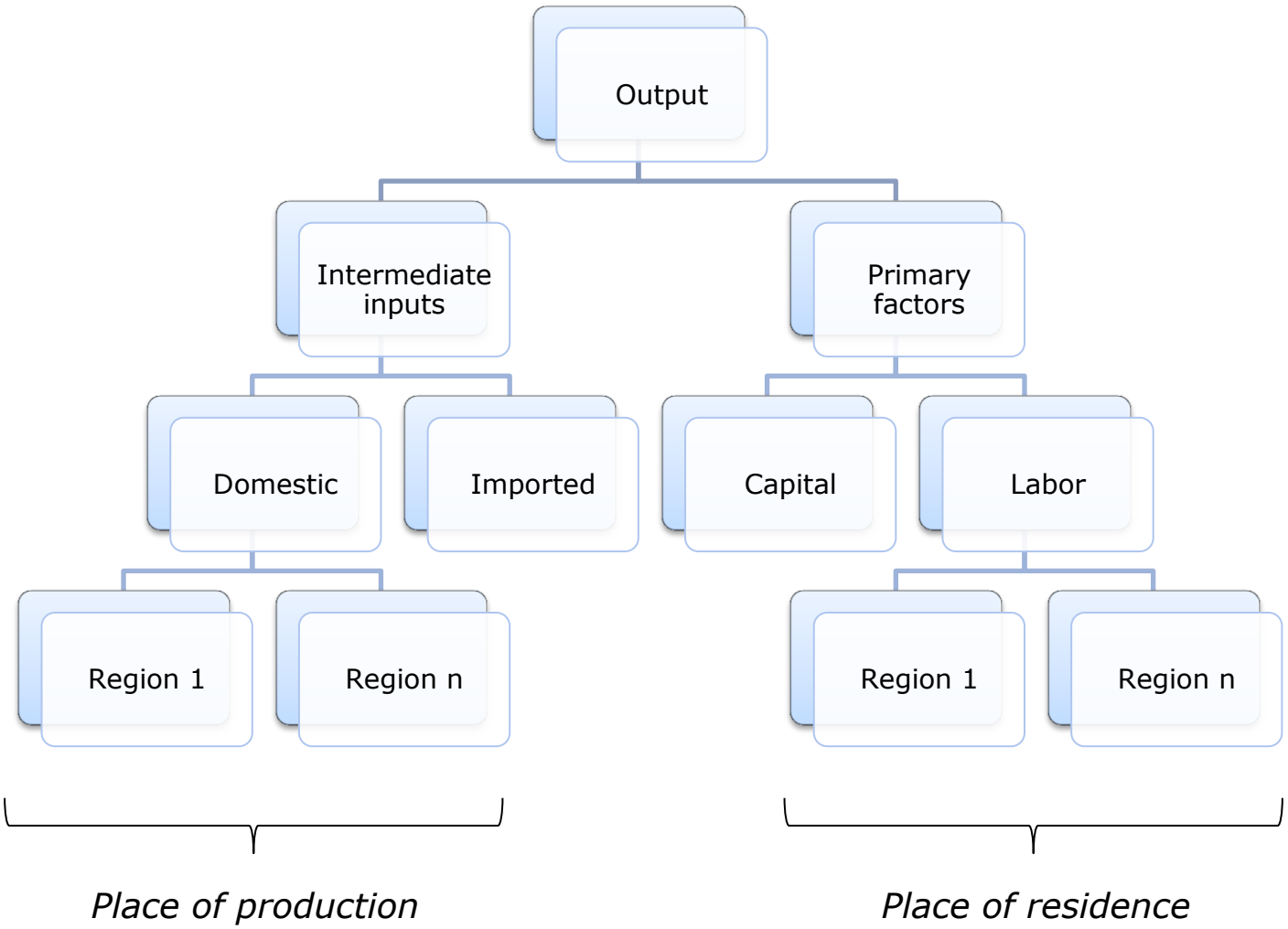
Input-output relations embedded in the SCGE model



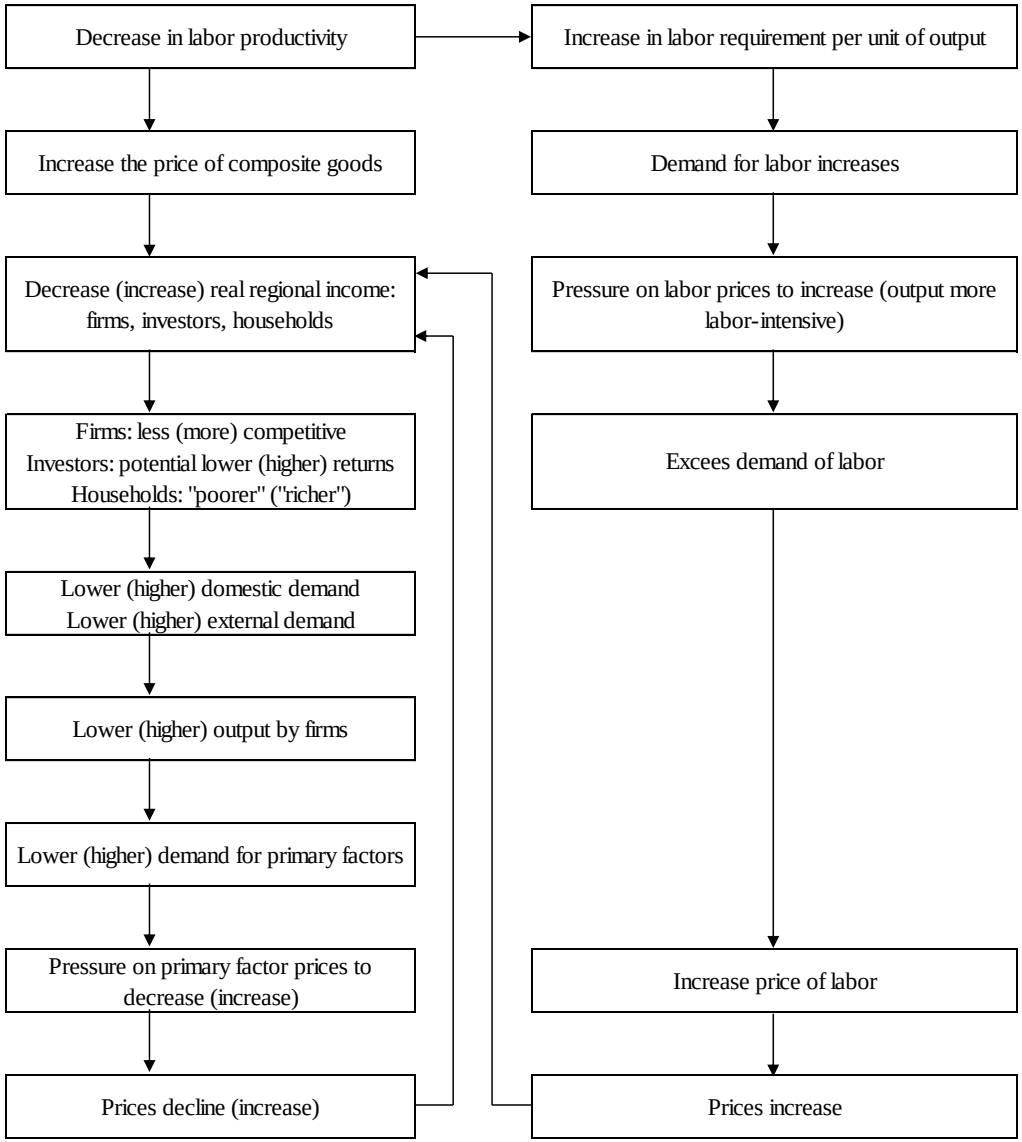
The integrated modeling framework

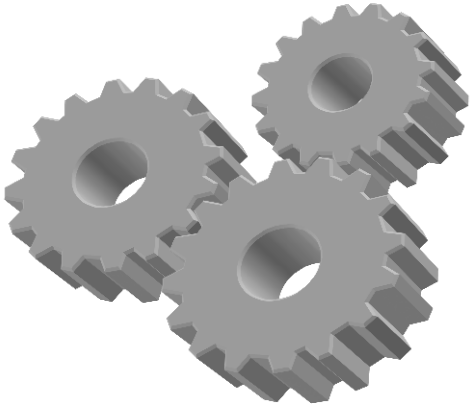


Production function of sector *j* in municipality *r*



Causal relations underlying the system of equations of the SCGE model





What are the distributional impacts of urban mobility policies?

Enhance our understanding of the distributional impacts of mobility improvements in Sao Paulo (***trade-offs***)

1. Infrastructure-related interventions:

- Expansion of the network of mass-transit public transportation

2. Urban mobility policies:

- Monetary disincentives to the use of cars

Simulations – 10 scenarios

Investments Only	*Scenario 1 – Metro and Train developments until year 2020*
	Scenario 2 – Metro, Train and Bus corridor development until year 2020
	Scenario 3 – Metro and Train developments until year 2025
	Scenario 4 – Metro, Train and Bus corridor development until year 2025
Investments + Tax	*Scenario 5 – Metro, Train and Bus corridor development until year 2025, and 30% increase in fuel price*
Changes in policies (fees, toll, tax)	*Scenario 6 – 30% increase of in fuel prices*
	Scenario 7 – Implementation of urban toll (R$5,00)
	Scenario 8 – 50% increase in parking cost in the entire SPMR
	Scenario 9 – 50% increase in parking cost in the extended CBD
	Scenario 10 – 50% increase in parking cost in the core of the CBD

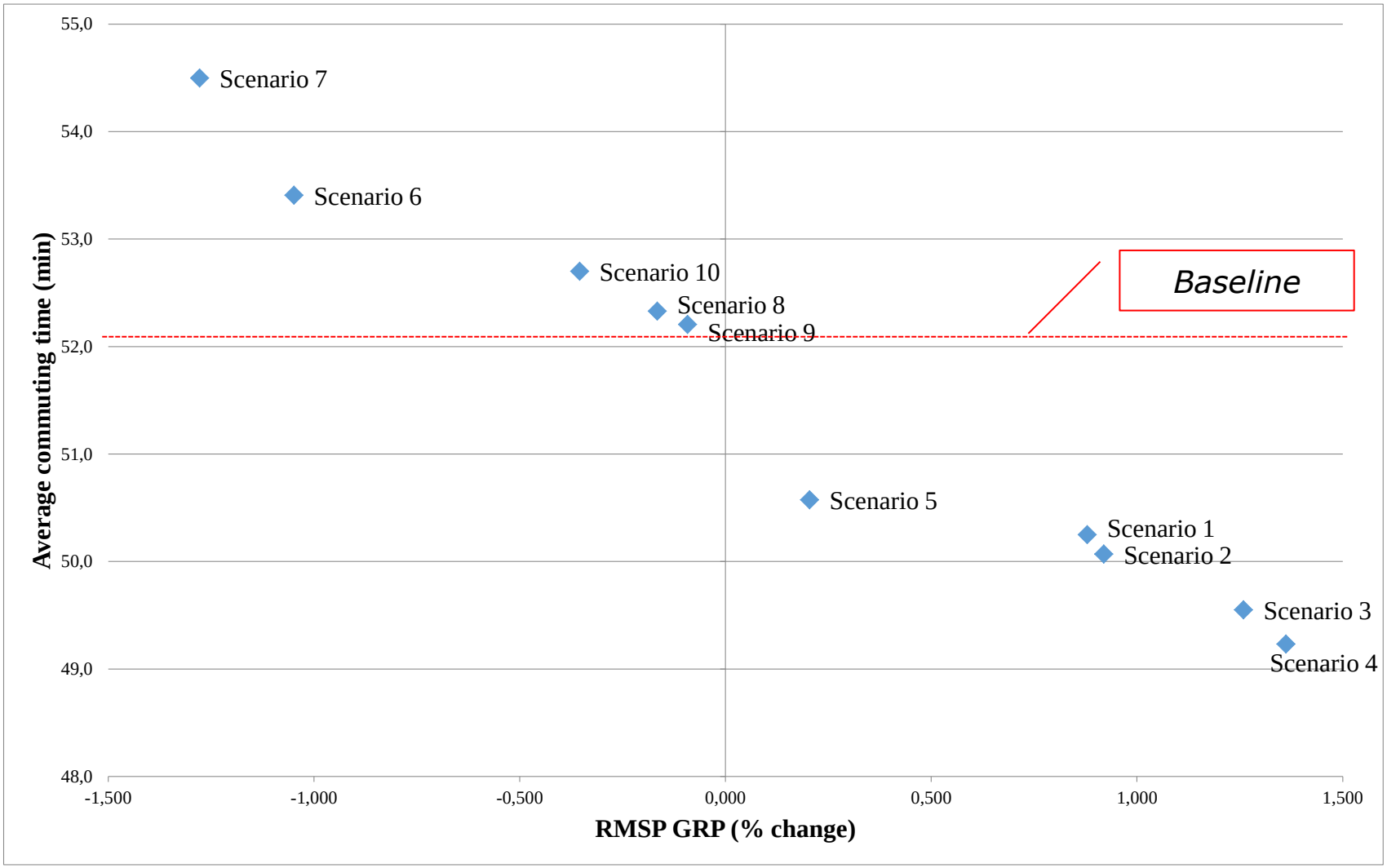
Results – mode shifts

Scenario	Auto generalized costs (min)	Var. (%)	Transit generalized costs (min)	Var. (%)	Auto trips	Transit trips	Percentage of transit trips (%)
Scenario 0	49,393,784	-	51,055,637	-	1,211,347	1,605,276	57.0%
Scenario 1	49,346,714	-0.1%	48,645,136	-4.7%	1,211,951	1,604,674	57.0%
Scenario 2	49,293,780	-0.2%	48,510,714	-5.0%	1,210,189	1,606,436	57.0%
Scenario 3	49,168,278	-0.5%	47,626,573	-6.7%	1,203,601	1,613,022	57.3%
Scenario 4	49,028,855	-0.7%	47,442,580	-7.1%	1,200,579	1,616,044	57.4%
Scenario 5	57,705,139	16.8%	47,174,920	-7.6%	1,097,304	1,719,319	61.0%
Scenario 6	58,351,603	18.1%	50,600,088	-0.9%	1,118,669	1,697,954	60.3%
Scenario 7	58,195,915	17.8%	50,879,975	-0.3%	1,114,858	1,701,766	60.4%
Scenario 8	49,097,676	-0.6%	50,896,886	-0.3%	1,182,994	1,633,630	58.0%
Scenario 9	49,021,173	-0.8%	50,921,652	-0.3%	1,192,138	1,624,486	57.7%
Scenario 10	49,119,771	-0.6%	50,786,838	-0.5%	1,158,818	1,657,807	58.9%

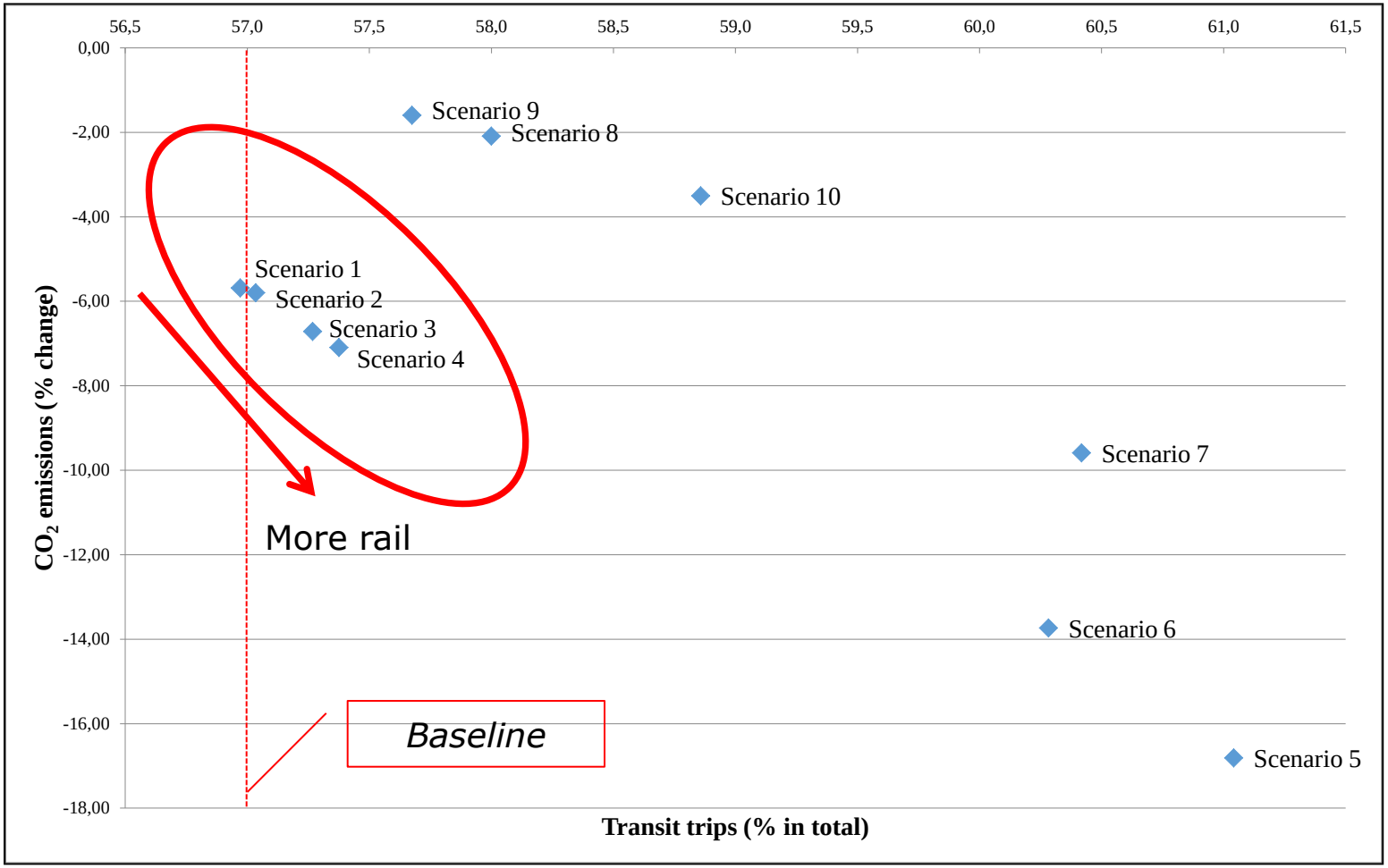
Summary of long run impacts

	Baseline	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*	*Scenario 9*	*Scenario 10*
Travel Demand											
Transit trips (% in total)	56.99	56.97	57.03	57.27	57.38	61.04	60.28	60.42	58.00	57.67	58.86
Generalized cost of private vehicle trips (in % change)	-	-0.095	-0.202	-0.457	-0.739	16.827	18.136	17.820	-0.599	-0.754	-0.555
Generalized cost of transit trips (in % change)	-	-4.721	-4.985	-6.716	-7.077	-7.601	-0.892	-0.344	-0.311	-0.262	-0.526
Gini											
Wage	0.6006	0.5976	0.5970	0.5957	0.5948	0.5847	0.5907	0.5893	0.5982	0.5990	0.5959
Commuting time	0.4120	0.4020	0.4010	0.3990	0.3973	0.3904	0.4044	0.3979	0.4094	0.4104	0.4061
p 90 / p 10											
Wage	4.65	4.66	4.65	4.74	4.54	4.25	4.63	4.67	4.65	4.65	4.66
Commuting time	11.00	8.07	8.07	10.93	8.56	9.12	11.00	13.05	10.47	10.81	11.04
Average Indicators											
Wage (BRL)	761.91	783.03	784.41	793.29	796.24	781.85	748.90	746.38	760.91	761.70	759.27
Commuting time (min)	52.14	50.25	50.07	49.55	49.23	50.57	53.41	54.50	52.33	52.20	52.70
RMSP GRP (in % change)	-	0.879	0.919	1.259	1.362	0.205	-1.049	-1.278	-0.166	-0.092	-0.354
Locational Gini											
Equal weights	0.8461	0.8460	0.8460	0.8461	0.8460	0.8457	0.8457	0.8455	0.8460	0.8460	0.8459
Population weight	0.1602	0.1604	0.1604	0.1605	0.1602	0.1581	0.1583	0.1563	0.1595	0.1597	0.1589
CO2 Emissions (kg per type of vehicle)											
Automibiles (in % change)	-	-5.685	-5.801	-6.714	-7.094	-16.811	-13.737	-9.589	-2.090	-1.595	-3.505
Trucks (in % change)	-	-0.042	0.084	0.139	0.042	-0.042	-0.014	-0.097	-0.014	0.125	-0.028
Qualitative indicators											
Political cost	-	Low	Low	Low	Low	High	High	High	High	High	High
Financing cost	-	High	High	High	High	High	Low	Low	Low	Low	Low

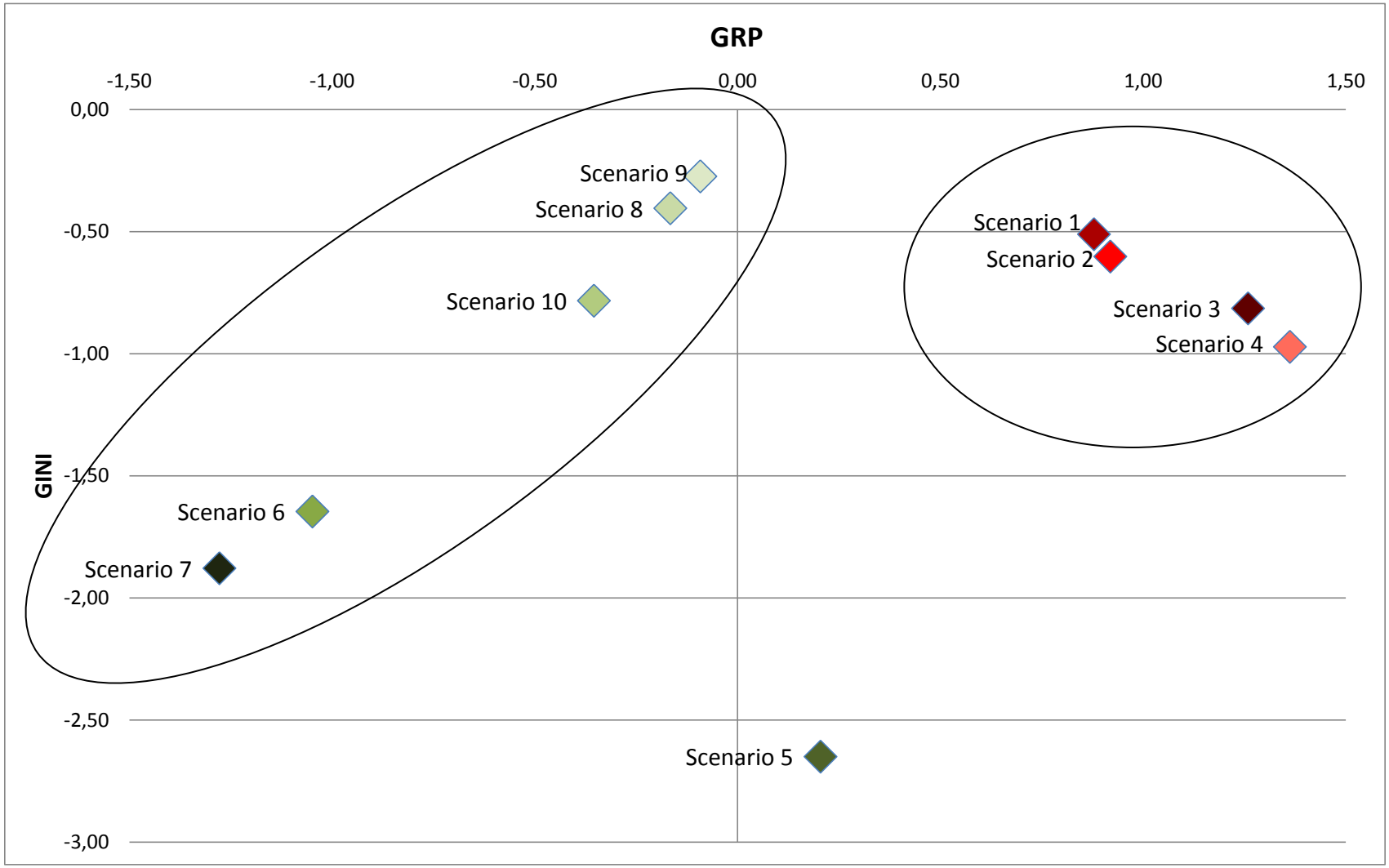
Commuting time and GRP growth



Mode shifts and CO^2 emissions



Summary of impacts on equity and efficiency indicators



Key messages (1)

Need to consider both internal and external interactions of the urban system – **metropolitan issue**

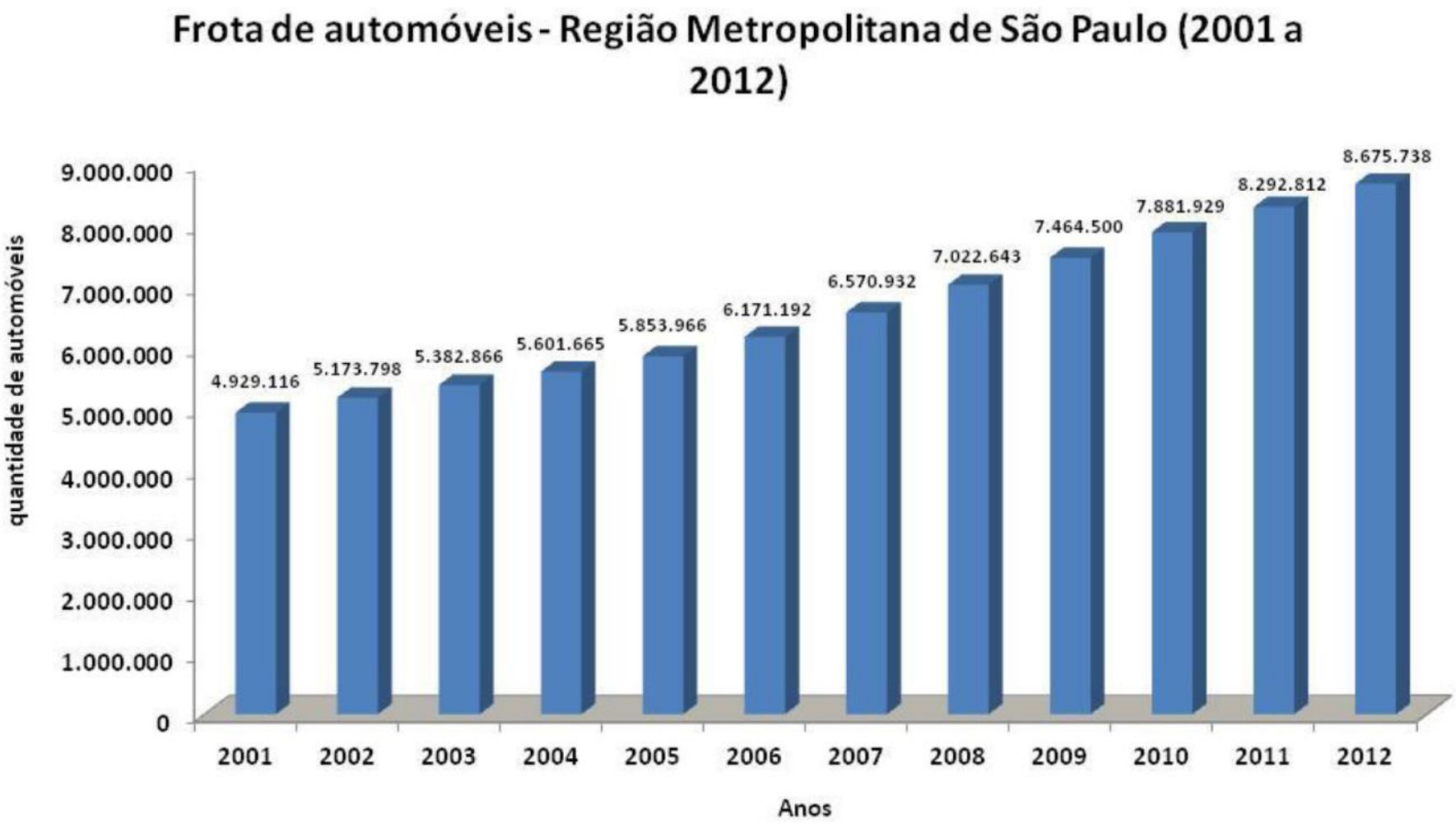
- Network effects: actions by neighbors (e.g. commuting trips) reinforce the consequences of a seemingly local phenomenon
- Economic effects are not only local – economic impacts spread through production and income linkages

Understand potential trade-offs – **multidimensional analysis**

Coordination of investments and national and local policies of urban development – **avoid contradictions**

Financing issues – **who pays the bill?**

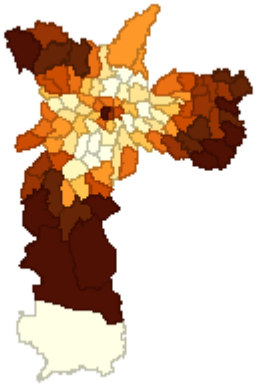
“Food for thought” – Number of cars in SPMR



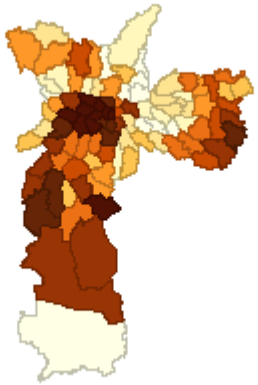
Fonte: Elaborado pelo Observatório das Metrópoles com dados do DENATRAN

“Food for thought” – São Paulo 2016 elections

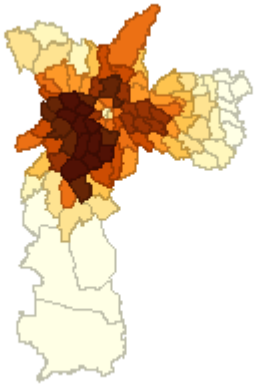
% votes for Haddad 2012



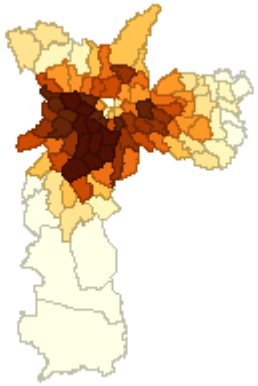
% votes for Haddad 2016



% households with car(s) 2000

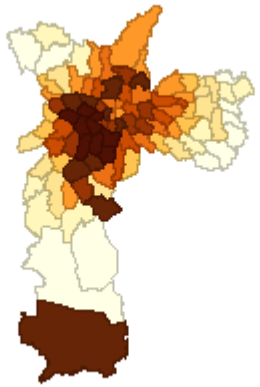


% households with car(s) 2010

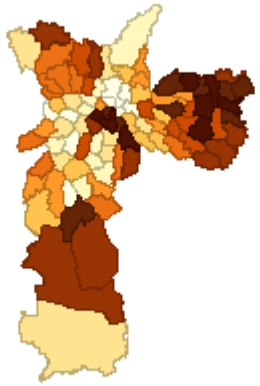


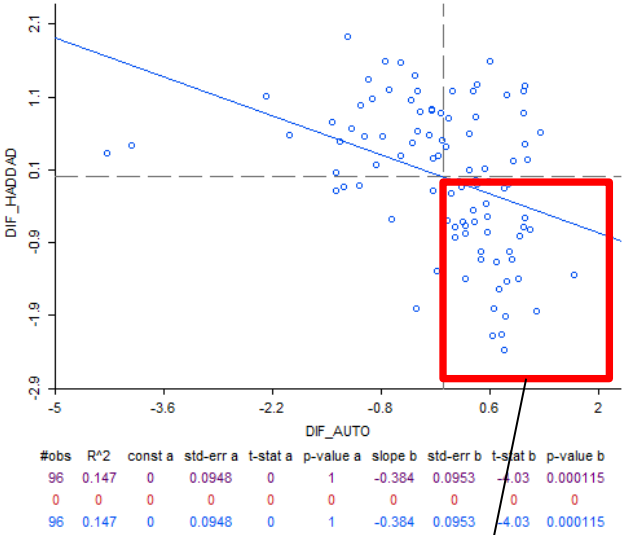
São Paulo 2016 elections

Difference in votes for Haddad 2012-16



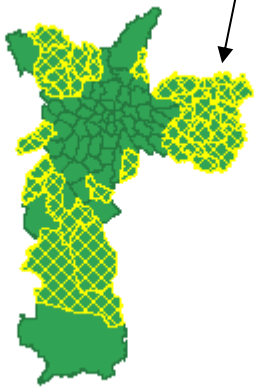
Difference in households with car(s) 2000-10





#obs	R^2	const a	std-err a	t-stat a	p-value a	slope b	std-err b	t-stat b	p-value b
96	0.147	0	0.0948	0	1	-0.384	0.0953	-4.03	0.000115
0	0	0	0	0	0	0	0	0	0
96	0.147	0	0.0948	0	1	-0.384	0.0953	-4.03	0.000115

Chow test for sel/unsel regression subsets: can't compute



Key messages (2)

How to address the commitments undertaken by the City of São Paulo in 2015, in Paris, to reduce GHG emissions?

Composition of the transportation matrix (extensive margin):

- Transit trips > Individual trips
- Rail > Roads
- Active trips (local reach) > > >

Intensity and emission factors (intensive margin):

- Low emission vehicles (alternatives to fossil fuels)
- Renovation of the bus fleet (electric vehicles)

Key messages (3)

“Compact”

- Reduce distance between firms (jobs) and workers (residents)
- Incentives to **co-location** of firms and workers through zoning decisions and planning of land use
- Problems of incentives design!