COMMUTE TIME IN BRAZIL, 1992-2009: DIFFERENCES BETWEEN METROPOLITAN AREAS, BY INCOME LEVELS AND GENDER

Rafael Henrique Moraes Pereira. Ipea - Institute for Applied Economic Research, Brazil. rafael.pereira@ipea.gov.br

Tim Schwanen. Transport Studies Unit, School of Geography and the Environment, University of Oxford, UK. tim.schwanen@ouce.ox.ac.uk

ABSTRACT

This paper analyzes trends in average commute times in Brazil between 1992 and 2009. It distinguishes between the nine largest metropolitan areas (MAs) plus the Federal District and describes how differences in commute time amongst these areas vary according to income levels and gender. The study is based on the National Household Sample Survey (PNAD), a source of data hitherto little used for transportation studies in Brazil. The PNAD data is not conceived strictly for transport planning but is the only large-scale survey in Brazil with annual information since 1992 on commute time at national and subnational levels. Five main findings are evident. First, commute time is 31% longer in São Paulo and Rio de Janeiro, the two largest MAs in the country, than the in the other MAs. Second, workers in the poorest population segment (1st income decile) spend on average 20% more time to get to work than the wealthiest decile. Third, this gap between rich and poor is spatially contingent; it is much larger in some MAs and almost non-existent in others. Fourth, the data reveal worsening transportation conditions since 1992 as reflected in longer commuting times. However, these trends have been more pronounced in the 1st and especially in 7th-10th income deciles. As a result, overall differences across income groups have actually weakened during the period 1992-2009. Finally, the gender gap in average commuting times has been reduced considerably over the period considered. The study highlights that trends in average commute times in emerging economies, such as Brazil, need not follow the same trajectories as in the Global North. It also shows the importance of not focusing on national trends only, as this obscures important differences between urban regions. From a policy perspective, the paper shows the usefulness of PNAD data for monitoring urban mobility conditions in Brazilian major MAs.

Keywords: Brazil, Commute time, Inequality, Metropolitan Areas, Income, Gender

INTRODUCTION

Urban transportation features prominently in current debates about urban development in Brazil. Given the high urbanization rate and current motorization trends in Brazil, concerns relating to traffic congestion and the time people spend travelling to work have received increased attention from transportation experts across the country (Strambi and Van de Bilt, 2002; Vasconcellos et al, 2011; Silva, 2012). Nonetheless, there is little data available in the country that would enable robust empirical analysis about such matters at the national level or comparisons in travel behavior and transport conditions at subnational levels.

The purpose of this study is to analyze yearly records of commute time in Brazil between 1992 and 2009, in an attempt to capture the main trends that have occurred in the country during this period. This paper describes differences in commuting amongst the nine largest metropolitan areas plus the Federal District of Brasília and highlights differences according to workers' income levels and gender. The data in use is based on the National Household Sample Survey (PNAD) carried out by the Brazilian Institute of Geography and Statistics (IBGE). This data has so far been used only infrequently for transport studies in Brazil. PNAD data is different from traditional Origin/Destination Surveys, since it is not conceived strictly for transport statistics and planning. However, it is the only large-scale survey in Brazil with annual information since 1992 on commute times at national and subnational levels (states and metropolitan areas).

After a brief overview of the literature on commute times, we describe the PNAD survey and the methodological procedures used to overcome some of its limitations for transport research. The two following sections present the yearly records of commute time in Brazil, comparing ten urban agglomerations and differentiating the analysis on the basis of workers' income level and gender. We also put forward a number of tentative explanations for the observed patterns and trends. The conclusion section summarizes our main findings, discusses some implications for further research and reflects on other transport-related issues in Brazil that could be studied using PNAD data.

ANALYSING COMMUTE TIMES

Travel time is one of the dimensions of people's travel behavior that has been studied most extensively and, in particular, the concept of travel time budget has long been discussed in the literature (Zahavi, 1974; Roth and Zahavi, 1982; Schafer and Victor, 2000; Mokhtarian and Chen, 2004). This concept captures the apparent regularity that people in different spaces, times and cultures travel around 70 minutes per person per day and is based on the principle that individuals face a time availability constraint when deciding to allocate daily time to activities and travel. The idea is contested, however, and discussions in the literature revolve around the question whether or not the average amount of time allocated to travel is stable over time and across space at different levels of spatial aggregation – e.g. national, metropolitan and individual levels (Mokhtarian and Chen, 2004).

Commute trips play an important role in such discussions regarding daily travel time expenditure and has received much attention in the literature. To some extent this reflects data availability (censuses and other non-transport surveys often contain questions about commute times), but there are also more substantive reasons. Because of its regularity and its susceptibility to congestion, commute time corresponds to a significant portion of daily travel time and it can be considered reasonably informative regarding a city's general performance in terms of urban transport. Furthermore, because of its presumed relations with economic wellbeing, commute time has long been central to transport policy. Commute time has also long been considered central to urban form and structure (e.g. Alonso, 1964) and households' decision-making about home and employment locations (Gordon et al., 1991; Levinson and Kumar, 1997). It also provides a good indicator of social inequalities based on income, gender and other social markers (Hanson and Johnston, 1985; Crane, 2007). However, the existing knowledge regarding commute times is almost exclusively based on empirical data from the Western world; only few studies analyzing variations in commute times, or developments therein over time, have been published in academic journals that focus on metropolitan areas or countries outside the Global North.

Even so, the literature from Western contexts might still inform analysis of cross-section variations and development over time in commute times in Brazilian urban areas. Much of that literature has focused on the degree to which the average commute time has been stable over time. Early work suggested that average commute times in the USA were relatively stable over time, which was explained using the co-location or rational locator hypothesis (Gordon and Wong, 1985; Gordon et al., 1991; Levinson and Kumar, 1994, Kim, 2008): commuters periodically change their workplace and/or residential location to reduce commuting times and avoid the effects of traffic congestion, and firms and organizations also relocate periodically to avoid high land prices and traffic congestion. The macro-level outcomes of these behaviors include relative stability in the metropolitan-wide average commute time, as well as suburbanization and urban decentralization.

Other studies criticized this line of reasoning (Cervero and Wu, 1998; Schwanen et al., 2004; Levinson and Wu, 2005; Yang, 2005). For instance, Levinson and Wu (2005) rejected the rational locator hypothesis because US data from the 1980s and 1990 showed average commute times at the metropolitan level to increase and to depend on the metropolitan spatial structure. Earlier Cervero and Wu (1998) had demonstrated that commuting times in the San Francisco Bay Area increased with greater decentralization of employment from the urban core. They had explained this finding by referring to the difficulty of relocation for multi-worker households and the specificities of the Bay Area's land and housing markets: high rents and land prices close to employments concentrations prevent workers – especially those on lower and medium-level incomes – to live close to work. A range of other studies from the USA and elsewhere have also shown commute time to increase over time (Levinson and Wu, 2005, Crane, 2007; Susilo and Maat, 2007; Kirby and LeSage, 2009; Veneri, 2010).

Research in Western countries is also useful in suggesting that variations in commute times at a single point in time are at least to some extent related to differences in the physical structure

of urban areas, employees' socioeconomic status, socio-demographic and employment characteristics (e.g. McLafferty and Preston, 1996; Levinson and Kumar, 1997; Giuliano and Narayan, 2003; Schwanen et al., 2004; Crane, 2007; Maat and Susilo, 2007; Veneri, 2010). Amongst the characteristics of physical structure, population density, the extent to which employment is concentrated in the CBD and the size of the metropolitan area are important factors related to the time workers spend commuting to work; of the personal attributes gender, income and household status have been shown to be especially important (ibid.). There are, however, far fewer studies that have considered how gender and income differences in commute times have evolved over time; the work of McLafferty and Preston (1996), Crane (2009), Crane and Takahashi (2009) and Susilo and Maat (2007) constitute notable exceptions. Studies in the USA have suggested that gender and commuting differences in commuting time have persisted to a considerable extent over the 1980s (McLafferty and Preston, 1996) and that the gender gap has in fact widened over the period 1985-2005 (Crane, 2007). Crane and Takahashi (2009) showed that gender differences over that time were mediated by race/ethnicity and age, which suggests developments over time to be even more complex.

Given current understandings of commute times, we set out to analyze changes over time in the time employees spend traveling to work in Brazil and consider if and how developments over time vary according to income and gender. In so doing, we will pay particular attention to the question if changes in commute time overall and by income vary spatially – i.e. across the country's largest metropolitan areas.

DATA AND METHODOLOGICAL BACKGROUND

In contrast to other countries, national household travel surveys are not conducted in Brazil. Origin-Destination surveys (ODs) are traditionally the most complete data source on urban transportation in the country, inasmuch as these surveys are designed and conducted to support transport planning within metropolitan areas. However, there are at least four limitations to the usage of ODs if one seeks to analyze urban transportation conditions in Brazil as a whole: (1) Origin-Destination surveys are designed for specific urban areas and therefore fail to cover the majority of the urban population and some metropolitan areas; (2) Methodological differences amongst different ODs might impair accurate comparison between distinct metropolitan areas; (3) In general, these surveys are not conducted regularly, undermining historical comparisons; and (4) Although these surveys are undertaken by public institutions, the datasets are not made publicly available.

The National Household Sample Survey (PNAD) does not have these limitations. It is conducted under the same methodology for the whole country and its sample is statistically representative at the national level, the state level and for the nine largest metropolitan areas plus the Federal District (depicted in Map 1), including urban and rural areas[1].

[1] The nine largest metropolitan areas are: Belém, Fortaleza, Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, Curitiba and Porto Alegre. The PNAD sample for Federal District does not cover 22 municipalities from neighboring states, despite these municipalities being part of the Integrated Development Region of Federal District and Adjacency (RIDE-DF) and making up nearly 1.1 million

Map 1 – The Federal District (FD) and the nine largest Metropolitan Areas in Brazil.

The PNAD has been conducted since 1967 by The Brazilian Institute of Geography and Statistics (IBGE), and it includes questions on the amount of time individuals spend commuting to work since the 1992 edition.[2] However, the survey has not been conceived or designed to address urban transport issues in great depth. It offers no information on non-commute trips undertaken for education, shopping, social life and so forth, and it does not address characteristics of commute trips other than their duration. These limitations explain for a large part why little research has been undertaken using PNAD data to analyze urban transportation conditions in Brazil. Despite its limitations, it is the only large-scale sample survey that allows annual monitoring of how much time people spend commuting to work at the national, state and metropolitan levels. Moreover, PNAD provides an extensive list of variables with information on sociodemographic and economic characteristics of individuals and their households, which, in turn, enables a wide variety of analyses.

For the purpose of this study, certain methodological procedures were taken in the treatment of PNAD data. The available variable on commute time (code V9057) is built as a categorical variable with the following discrete intervals: (a) up to 30 minutes, (b) between 30 minutes and one hour, (c) between one and two hours, (d) two hours and over. Average commute

inhabitants in 2010 (31% of RIDE-DF's population). Rural areas of states in the north region of the country were only included in the sample after 2004.
[2] The PNAD survey was conducted in neither 1994 (for budgetary reasons) nor 2000 (census year).

times were estimated using the midpoint of each intermediate class and the first point of the final open class. It is important to note that in the PNAD questionnaire commute time is only recorded for individuals who have declared to undertake commute trips from home to a workplace. People who work from home or who held a job at the same plot where they lived are excluded from consideration.

Since our focus is on transport conditions in urban areas, people in rural areas are not included in the analysis. Likewise, people employed in agriculture and mining have been excluded from the investigation, as well as those who have declared to work in farms or ranches. We have also excluded from the analysis those people employed at night jobs (starting between 10 pm and 5 am) so as to only consider individuals who are exposed to day-time traffic conditions, congestion levels and availability of public transportation services.

COMMUTE TIME IN BRAZILIAN METROPOLITAN AREAS

Table 1 shows some descriptive statistics for the Brazilian metropolitan areas (MAs) under study, revealing substantial differences in population size, area, population density and wealth across the considered MAs. With regard to population size, for example, São Paulo is more than nine times larger than Belem. Federal District is five times richer than Belem, and São Paulo is almost twelve times denser than Curitiba. In general terms, the MAs to the south of the country (São Paulo, Belo Horizonte, Rio de Janeiro, Curitiba and Porto Alegre) tend to be richer and to present higher population densities and motorization rates than those MAs to the north of the country (Recife Fortaleza, Salvador and Belem). The Federal District is a particular case because it is the seat of federal government of Brazil, which partially explains why it has the highest GDP per capita and motorization rate as well.

Table 1 – Characteristics of major metropolitan areas, Brazil, 2010.

Metropolian Area	Population	Total Area (Km²)	Population Density per Km²	GDP per capita (2008)	Motorization Rate*	Average commute time (in minutes)**
São Paulo	19,443,745	7,943.8	2,447.7	30,349.52	38.1	42.8
Rio de Janeiro	11,835,708	5,643.8	2,097.1	19,762.04	20.8	42.6
Belo Horizonte	4,883,970	14,415.9	338.8	19,540.41	29.6	34.4
Porto Alegre	3,978,470	9,800.2	406.0	23,225.00	31.2	27.7
Recife	3,870,004	2,768.5	1,397.9	13,592.95	15.3	34.9
Fortaleza	3,615,767	5,783.6	625.2	11,715.26	14.7	31.7
Salvador	3,573,973	4,375.1	816.9	17,721.18	16.0	33.9
Curitiba	3,223,836	15,418.5	209.1	22,953.67	41.6	32.1
Federal District (DF)	2,570,160	5,801.9	443.0	45,873.47	37.3	34.8
Belém	2,101,883	1,819.3	1,155.3	9,228.27	11.2	31.5

Source: Population Census and National Household Sample Survey (IBGE). National Registry of Motor Vehicles (Renavan/Denatran)
Note : *Automobiles (i.e. cars, pickups, sport utility vehicles, vans and minivans) per 100 persons
**Based on 2009 data

Figure 1 shows the average commute times (one-way trip) in Brazilian metropolitan areas plus the Federal District (FD) and compares them to other selected metropolitan areas around the world with over 2 million inhabitants. In general, commute times tend to be relatively long in Brazilian MAs, especially when their population size is taken into account.

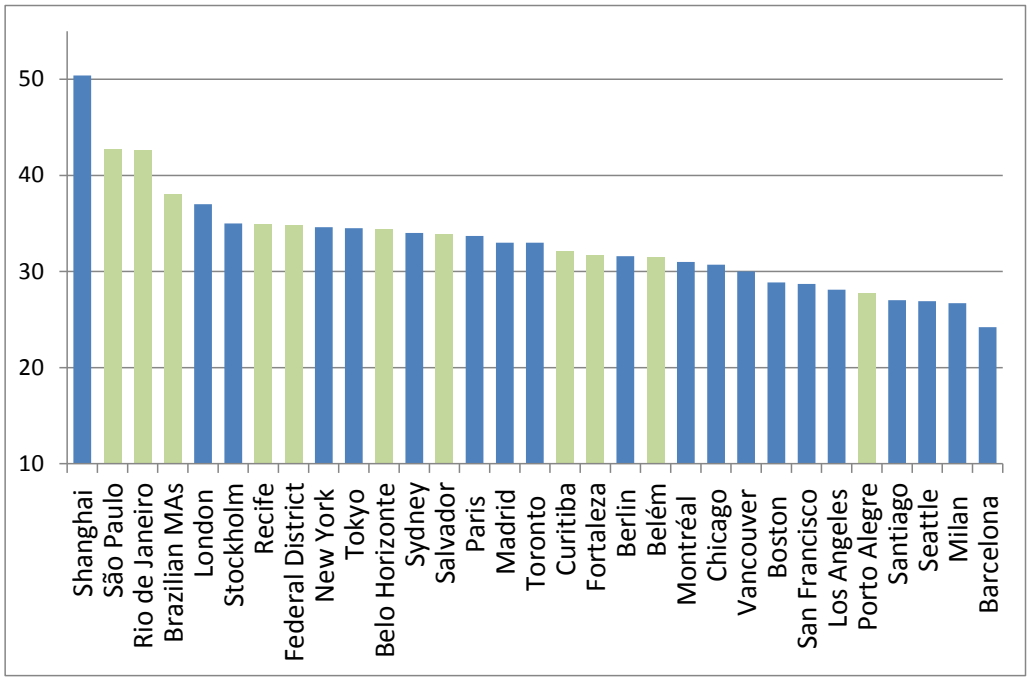

Figure 1 – Average time (in minutes) spent commuting to work in selected metropolitan areas in Brazil and other countries[1],[2]

Source: Brazil - National Household Sample Survey (PNAD/IBGE); Santiago (Chile) – data available at http://www.sectra.gob.cl; data from all other metropolitan areas from Toronto Board of Trade (2012).
Note [1]: Tokyo: 2005; Santiago and Europe: 2006; Brazil: 2009; Australia, Canada, Shanghai and USA: 2010.
[2]: Commute time data from Eurostat is available only at the regional level. However, the delimitation of these boundaries is not strictly defined and may vary greatly across European MAs. Data from the USA is based on Metropolitan Statistical Area.

COMPARING METROPOLITAN AREAS

In order to analyze how commute times have changed over the last two decades in Brazil, Figure 2 depicts the average time people spent commuting to work in the country and its largest metropolitan areas plus the Federal District (FD) between 1992 and 2009. Figure 2A draws attention to the stark differences between metropolitan areas (MAs) and non-metropolitan areas. In the year 2009, for instance, the average commute in the analyzed MAs took 63% longer than in non-metropolitan areas: 38 minutes against 23.3 minutes. This difference has been fairly stable over time. This reflects amongst others that the average commute time has gradually increased in both metropolitan and non-metropolitan areas over the period 2000-2008, following the national trend. The dip in the average commute time in 2008-2009 has also occurred in both types of area. This dip may be a related to the global economic crisis but caution is required: the recession has had only limited immediate effects

on the Brazilian labor market. Further analysis with data from the 2010 population census and 2011 PNAD would be required to verify any link with economic developments.

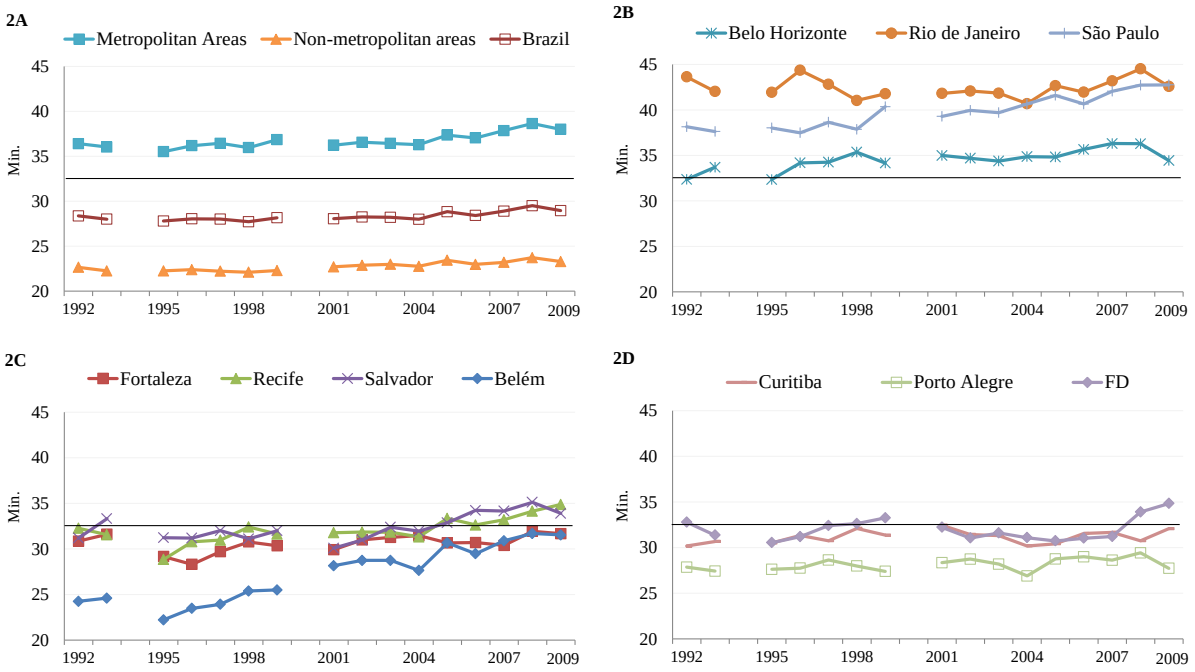

Figure 2 – Average time (in minutes) spent commuting to work, Brazil and Metropolitan Areas, 1992-2009

Source: National Household Sample Survey (PNAD/IBGE).

In terms of differences amongst MAs it is clear that the southeastern areas face the longest commute times (Figure 2B). The most critical situations are found in São Paulo and Rio de Janeiro, the two largest MAs in the country, where travel to work trips are almost 31% longer than in the other MAs. Trends over time vary considerably over time across the ten cities considered. The three metropolitan areas in the Northeast region plus Belém – the poorest metropolitan areas in the country – exhibit an overall, albeit irregular trend of increasing commute times (Figure 2C). In contrast, Federal District presents a rather irregular pattern with an upswing at the end of the period, while the South MAs of Porto Alegre and Curitiba have shown some stability with minor oscillations and no clear trend (Figure 2D).

Figure 3 shows the share of the commuters that travel one hour or more to work (one-way trip) in each metropolitan area between 1992 and 2009, a piece of information that helps to monitor the extent to which people undertake excessively long commutes. The general trend is an increase in the share of long commutes in Brazilian metropolitan areas (Figure 3A), although with different trajectories for individual MAs.

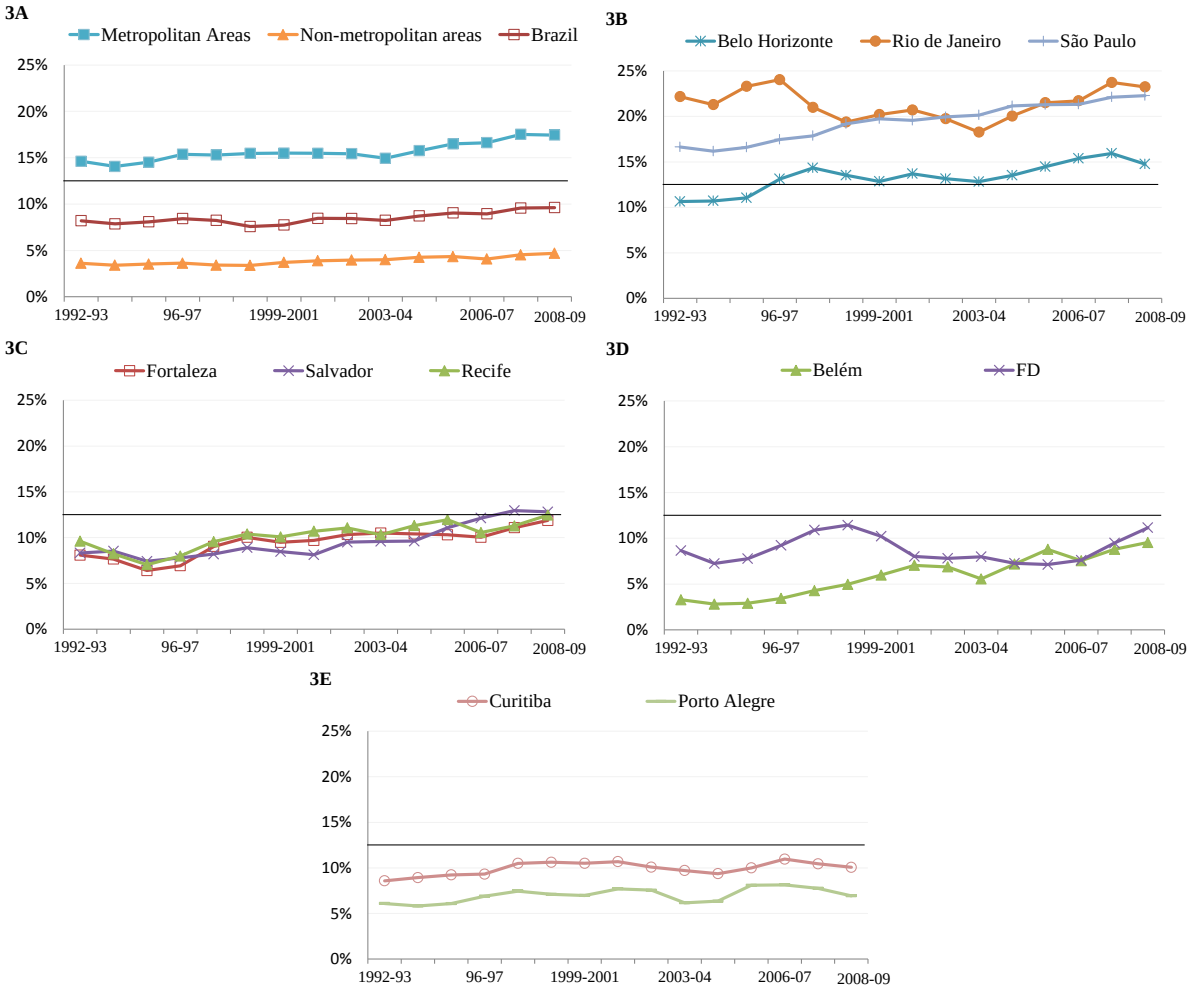

Figure 3: Share of commuters that travel longer than one hour to work (one-way trip), Brazililian metropolitan areas, 1992-2009[1]

Source: National Household Sample Survey (PNAD/IBGE).
Note [1]: 2-year moving average

Rio de Janeiro, for example, follows a somewhat erratic pattern (Figure 3B). The proportion of long trips dropped from a peak of 24% in 1996/1997 to nearly 18% in 2003/2004 and then climbed back to 23% by the end of the study period. This improvement since the end of the 1990s is likely to be related to the completion of several major transport infrastructures in the region in a short period in time, including an orbital motorway named the Yellow Line in 1997 and nine subway stations between 1996 and 1998.[3] The historical trend in the Federal District is similarly irregular (Figure 3D). Through much of the 1990s, the population proportion that spends more than one hour travelling to work followed an upward trend that

[3] Two stations inaugurated in 1996 (Thomaz Coelho and Vicente de Carvalho), seven stations inaugurated in 1998 (Cardeal Arco Verde, Irajá, Colégio, Coelho Neto, Engenheiro Rubens Paiva, Acari/Fazenda Botafogo and Pavuna) and one station inaugurated in 2002 (Siqueira Campos). The last two stations were completed in 2007 and 2009 (Cantagalo and Ipanema/General Osório). Furthermore, the administration of the metropolitan trains system was delegated to a private company under a concession agreement in 1998. The possible effect this might have had on travel times is not so straight forward though.

was reversed at the beginning of the 2000s. As in Rio, the completion of major transport infrastructural works seemed to have played an important role in shaping this trajectory. The completion of the subway system with thirteen subway stations and the Juscelino Kubitschek (JK) Bridge in the early 2000s facilitated access to the Center Business District (CBD) of the city for several satellite cities covering a large population.[4]

Yet, in Rio de Janeiro and in the FD the proportion of longer journey-to-work trips started to rise again in the second half of the 2000s. Several factors might have contributed to this recent worsening trend, including economic growth associated with increasing motorization rates and the expansion of outlying neighborhoods, where home-to-work distances are often longer than in the more central parts of the MA. Future investigation seeking to deepen our understanding of developments in particular cities should also bear in mind that that the effects of adding new infrastructural capacity are limited in a temporal sense: new infrastructure can help to reduce commute times for a certain period of time, but the effects diminish over time as travel demand approaches the saturation point of the transportation system in terms of maximum passenger capacity.

On the other hand, the proportion of long journey-to-work trips rose almost continuously from 1992 to 2009 in São Paulo and Belo Horizonte (Figure 3B), despite the completion of major transport infrastructure projects in these MAs as well: In São Paulo, eight metro stations and nineteen suburban rail stations have been added to the transport system between 1998 and 2008, against twelve metro stations in Belo Horizonte transport system between 1992 and 2002 (eight in the 1990's and four more in 2002). The difference with Rio de Janeiro and FD seems to be that the completion of these infrastructural works was not so concentrated in time. This means that the addition of capacity to existing transport networks in São Paulo and Belo Horizonte occurred more gradually over time and was less successful in bringing about substantial shifts in transport conditions at the aggregate level.

The three metropolitan areas of Northeast region (Salvador, Recife and Fortaleza) and Belém (located in the north of the country) also had a gradual rise in the proportion of long commute trips of more than 5 percentage points over the study period (Figures 3C and D). This is a troubling trend for these metropolitan areas for two primary reasons. First, the average number of vehicles per capita soared in these metropolitan areas in the last decade; with increases of more than 35% in Recife and Fortaleza and over 45% in Belem and Salvador. Despite this remarkable rise, motorization rates in these metropolitan areas are about only half the figure for the other MAs (Figure 4), and thus still have a potential to increase further in the next years. Secondly, these metropolitan areas lack the mass public transport infrastructure that is available in other major Brazilian MAs. Belém has no mass transportation system, whereas Salvador, Recife and Fortaleza have old suburban trains inaugurated back in the 1980s.

[4] Thirteen subway stations were inaugurated between 2001 and 2004. The JK Bridge was inaugurated in the end of 2002. The satellite cities that have benefited directly from the bridge (São Sebastião, Paranoá, Lago Sul) and from the subway (Samambaia, Taguatinga, Águas Claras and Guará) amounted to more than one million inhabitants in the year 2000, nearly half of the Federal District's population in that year (CODEPLAN, 2007).

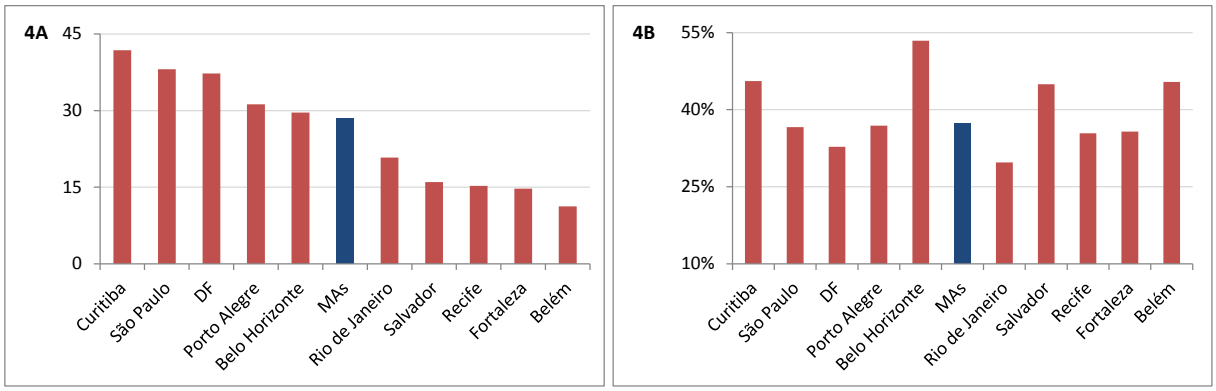

Figure 4 – Number of automobiles[1] per 100 people in 2010 (A) and rise in motorization rate between 2000 and 2010 (B), Brazilian metropolitan areas

Source: Population Census (IBGE). National Registry of Motor Vehicles (Renavan/Denatran).
Note [1]: Includes cars, pickups, sport utility vehicles, vans, and minivans.

To sum up, the proportion of long journey-to-work trips rose gradually in Brazilian MAs during the period 1992-2009, especially in the last five years. The exceptions to this general tendency were Porto Alegre and Curitiba which have presented fairly stable figures over the whole period. Perhaps, this stability is due to more successful control over urban expansion and more efficient public transportation systems in these MAs. The differences between observed trends may result from a combination of several factors that are known to affect travel patterns, such as urban population growth, increasing motorization rates, investments in mass transit systems and outward urban expansion. Identifying the role played by each of these components on historical trends, though, would need a deeper investigation for each case.

Income differences

Based on PNAD data for 2008 and 2009, we have also analyzed how much time people from different income groups spend on their journey to work. This analysis is relevant in that it provides evidence on how people from different income groups might face different levels of mobility constraints. Figure 5 shows the average commute time length (Figure 5A) and the share of population that commutes longer than one hour (Figure 5B) for the poorest segment of the population (the 1st income decile) and the wealthiest segment (the 10th decile) of each metropolitan area.[5]

As a rule, the wealthiest commuters tend to make shorter journeys to work than do the poorest. On average, the poorest population in the analyzed metro areas spends almost 20% more time commuting to work than the wealthiest. For instance, 19% amongst the poorest spends commutes longer than 1 hour (one-way trip) while this share amongst the wealthiest

[5] The classification of workers by income strata was performed using per-capita household income deciles calculated separately for each Metropolitan area.

population is only 11% [6]. These findings reinforce previous studies showing that it is usually the poorest population that is most vulnerable to transport disadvantage (Lucas, 2012).

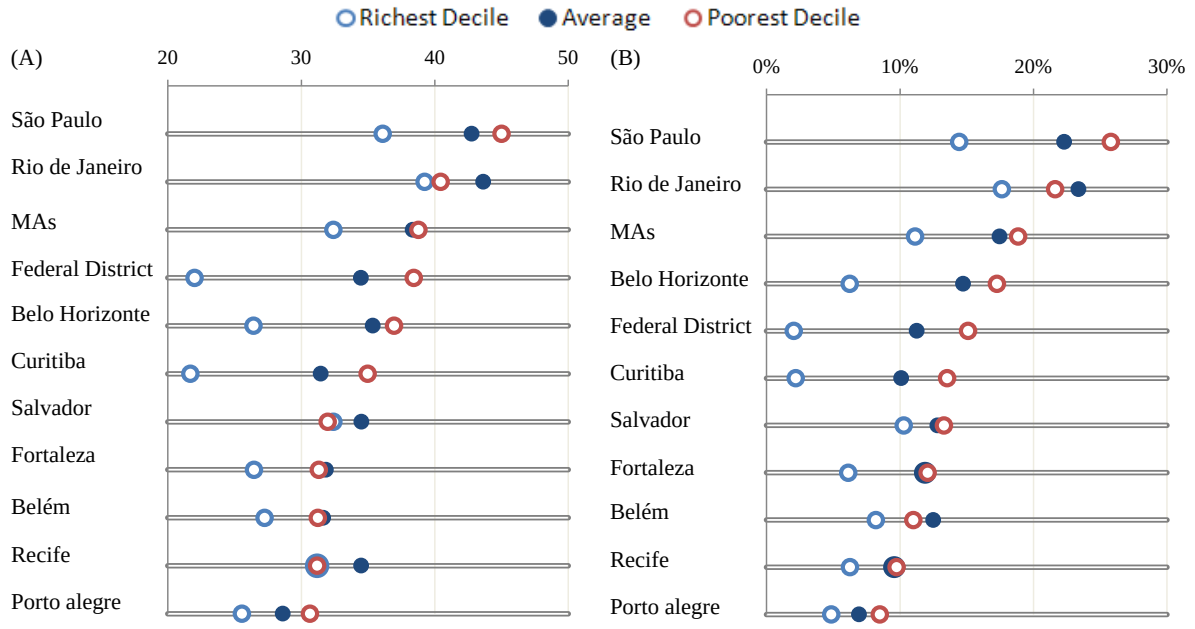

Figure 5 – Average commute time length in minutes (A) and share of commuters who travel to work longer than 1 hour (one-way trip) for the 1st and 10th income decile[1], Brazilian metropolitan areas, 2008/2009[2]

Source: National Household Sample Survey (PNAD/IBGE)
Note [1]: Per-capita household income deciles
[2]: 2-year average

Figure 5 also shows that this commute time gap between rich and poor is much larger in some metropolitan areas and almost non-existent in others. In Salvador, Recife, Fortaleza and Belem, for instance, the commute time gap between rich and poor people is rather small despite the often markedly different capacities in terms of residential relocation and public transport dependence amongst the richest and poorest commuters. On the other hand, in the metropolitan areas of Belo Horizonte, Curitiba and in the Federal District journey-to-work trips are respectively 40%, 61% and 75% longer amongst the poorest decile compared to the richest one. From a research perspective, these observations reveal the need for future studies into the extent to which these commute time gaps between rich and poor can be explained as a result of spatial segregation and neighborhood accessibility in Brazilian MAs.

Curitiba, for example, is a remarkable case that should be the object of further investigation. Despite Curitiba's reputation for having succeeded in integrating land use regulation and transport planning (Newman, 1996; Cervero, 1998; Kenworthy, 2006), it has the second largest discrepancy in average commute time between the highest and lowest income groups. This is likely related to the fact that Curitiba metropolitan area contains the largest total area

[6] As we have mentioned earlier, the PNAD data include commute time as an ordinal variable. This prevents us from estimating confidence intervals around the commute time averages computed from PNAD data. Nonetheless, Chi-square tests show that the observed differences in commute time presented in this paper are statistically significant with more than 99% confidence.

and has the lowest population density amongst Brazil's major MAs (see also Table 1). Additionally, strong urban policy and regulation in Curitiba have been partly responsible for high and increasing residential land prices in central areas and nearby transport corridors, which have pushed low-income population to outlying areas where commuting conditions are usually much more unfavorable (Smith and Raemaekers, 1998; Avila, 2006). Curitiba's success in promoting public transport appears to have come at a price; environmental sustainability and social sustainability are not easily reconciled in a transport context.

Broadly speaking, PNAD data indicate that the major Brazilian metropolitan areas have shown worsening conditions of urban transportation since 1992, reflected in longer commuting times. However, these worsening conditions are not equally distributed across different income groups. Across the metropolitan areas combined, the poorest population (the1st income decile), and especially the wealthier (above the 6th decile) have had the largest rise in commute time in the period 1992-2009 (Figure 6). This suggests that the overall differences across income groups have actually weakened between 1992/93 and 2008/09. This result is confirmed by Gini coefficients we have calculated over the average commute times for each income decile (ten observations): the value has decreased from 0.047 to 0.028 between 1992/1993 and 2008/2009.[7]

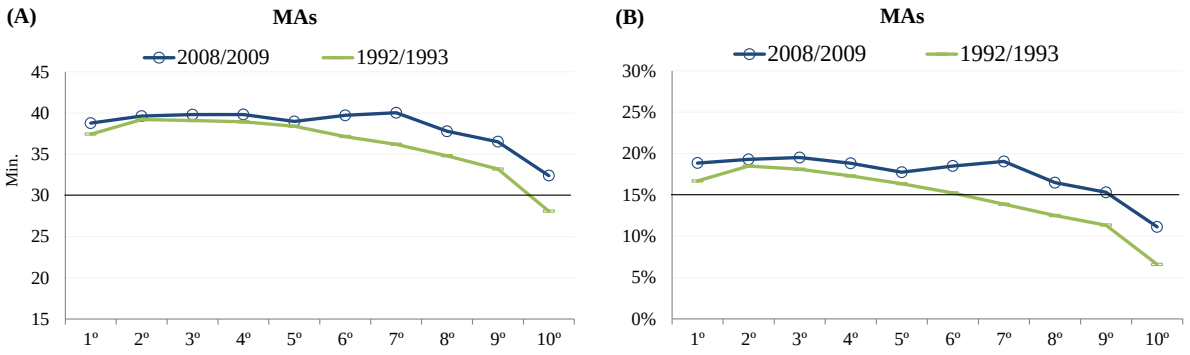

Figure 6 – Average commute time length in minutes (A) and share of commuters travelling longer than 1 hour to work (one-way trip) by income decile[1], Brazilian metropolitan areas, 1992/1993 - 2008/2009[2].

Source: National Household Sample Survey (PNAD/IBGE)
Note [1]: Per-capita household income deciles
[2]: 2-year average

[7] The values for the Gini coefficients are so close to zero because of the small number of observations and the relatively modest variations in average commute time by income. It should also be appreciated that the values say nothing about the strength or direction of any statistical correlation of income and the average commute time; they simply show that differences in the average commute time across the ten income classes has decreased over time.

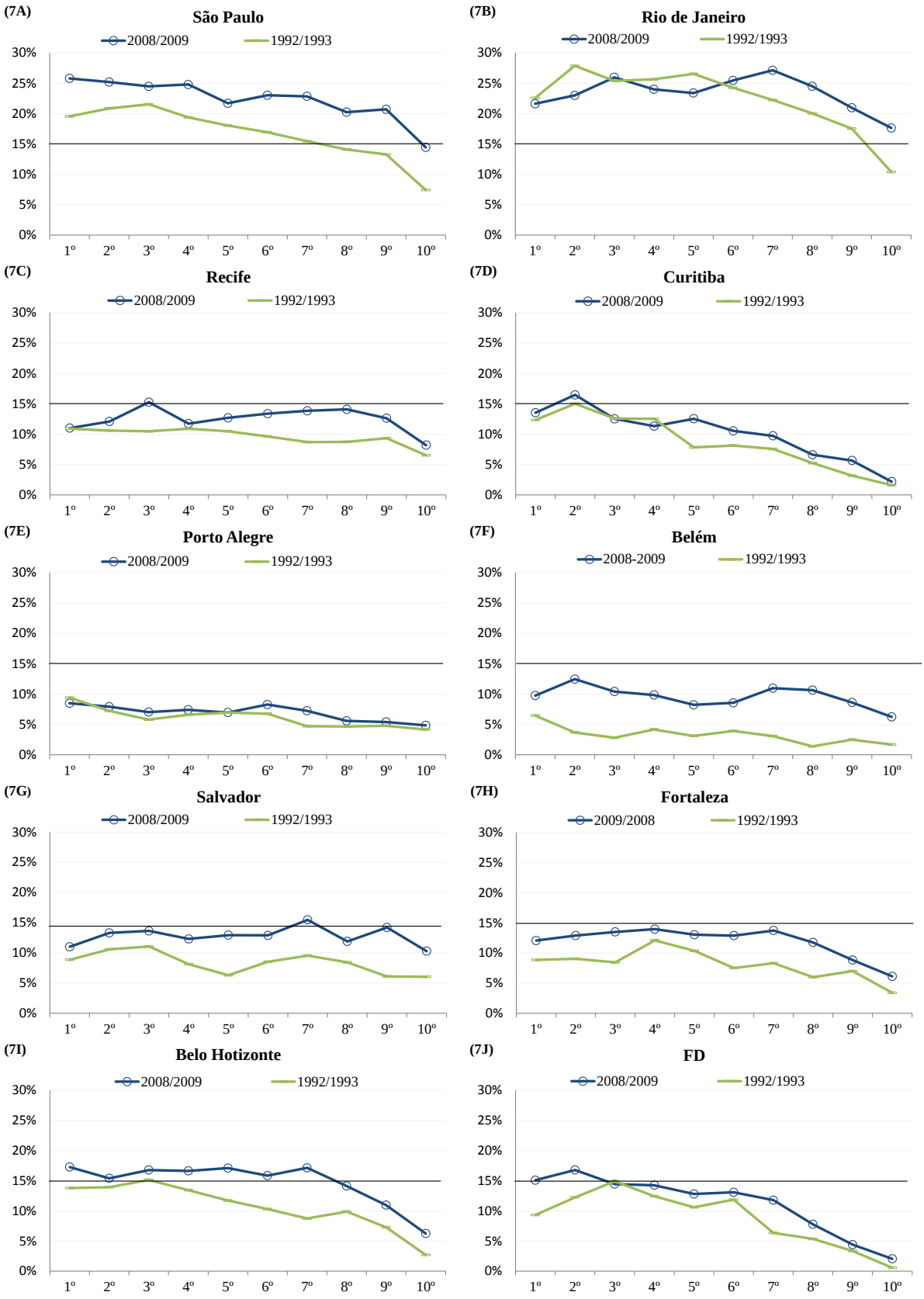

Figure 7 – Share of commuters that travel longer than one hour to work (one-way trip) by income deciles[1] in selected Brazilian metropolitan areas, 1992/1993 - 2008/2009[2].

Source: National Household Sample Survey (PNAD/IBGE).
Note [1]: Per-capita household income deciles, [2]: 2-year moving average

Again, distinct patterns emerge when the MAs are analyzed separately. For the sake of brevity, Figure 7 only represents the trends over time in the share of long commutes for each metropolitan area; the trends over time in the share of long commutes follow roughly the same patterns as those for average commute time. Regarding the pattern, the Federal District follows the general pattern, whereas in four metropolitan areas (Belem, Fortaleza, Porto Alegre and Curitiba) inequalities in mobility conditions amongst different income groups have not changed substantially over time. Something similar seems to apply to São Paulo, although trip lengths for the lowest income deciles have exacerbated more clearly in the analyzed period. In Belo Horizonte, Recife and Salvador, on the other hand, the extension of commuting time between 1992/1993 and 2008/2009 has been more pronounced in the middle and higher income groups. Finally, Rio de Janeiro is an interesting case since it is the only MA where the time spent commuting by the poor has improved over time, despite of worsening conditions amongst higher classes.

Why journey-to-work trips have on average become longer for the middle and high income classes in the study period is not immediately clear yet. To some extent this pattern reflects that the poorer segments of the population already had the most adverse commuting conditions with relatively long journeys times in 1992/1993. Still, the emergence of specific patterns in the relations over time between commuting and income in each metropolitan area requires further investigation. Brazilian metropolitan areas have experienced a range of transformations in the recent decades, such as investments in new infrastructure and changes in spatial distribution of population and economic activities (Villaça, 1998; Diniz e Campolina, 2007; Ribeiro and Bógus, 2010; Silva and Rodrigues, 2010) but it is at present unclear how and why these trends have worked out differently in particular MAs. In a recent study, Lago and Mammarella (2010) set out how the intra-metropolitan location of social classes have changed in four MAs (São Paulo, Rio de Janeiro, Belo Horizonte and Porto Alegre) between 1991 and 2000. The growth of middle-class and upper-class suburbs observed by the authors is certainly one aspect to be taken into account as it would extend journey times faced by higher classes.

Gender differences

Gender differences in commuting behavior are another important aspect to consider because they reflect, and can inform our understanding of gender inequalities in access to different forms of transport, the functioning of the labor market, the division of domestic responsibilities within households, and personal identity (Hanson and Johnston, 1985; Crane, 2007; Schwanen, 2011). As is common across the Global North (OECD, 2011), men used to commute some three minutes (8.6%) longer than women in Brazil in the early 1990s. However, a noteworthy change has occurred in the country since then; the gender difference declined to forty seconds (1.7%) by 2008/2009.

This decline reflects for the most part that the increase in commute times has been more pronounced amongst women. The average commute time rose approximately 10% for women, against only 3% for men during the period. This narrowing of the gender gap in commuting time is consistent with a couple of sociodemographic changes also observed in

Brazil, such as declining birth rates, changing family composition (with more female headed households and fewer children), growing participation of women in the labor force and significant improvements in women's educational levels (Strambi and Van de Bilt, 2002; Crane, 2007; Nonato et al., 2012).

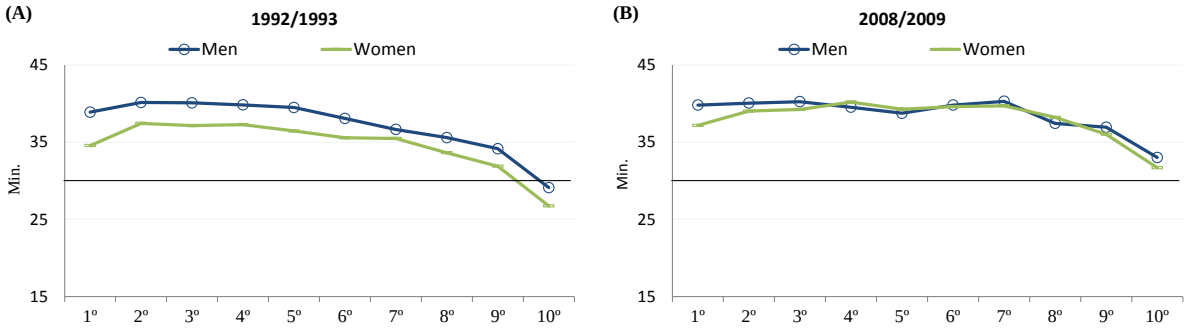

Fig. 8 – Average commute time in minutes, by gender and income decile[1], Brazilian metropolitan areas, 1992/1993 and 2008/2009[2]

Source: National Household Sample Survey (PNAD/IBGE)
Note [1]: Per-capita household income deciles, [2]: 2-year average

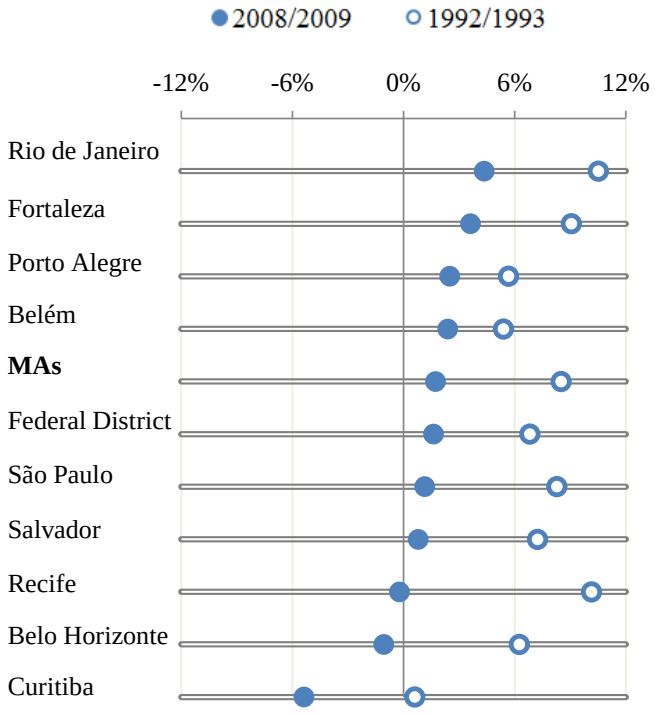

Fig. 9 – Ratio between average commute time by men and women. Brazilian metropolitan areas, 1992/1993 and 2008/2009[1]

Source: National Household Sample Survey (PNAD/IBGE)
Note [1]: 2-year average

Again, the national average hides important differences across metropolitan areas (Figure 9). For instance, the metropolitan areas of Belo Horizonte and especially Curitiba stand out from

other MAs as the gender gap has reversed in these areas, with women spending on average more time commuting to work than men. The reasons behind such variations are not clear, though they likely depend on how deeply Brazilian MAs have been penetrated by those sociodemographic changes previously mentioned.

FINAL REMARKS

In this paper, we have analyzed PNAD data on time spent commuting to work in Brazil between 1992 and 2009, in an attempt to identify the main trends that have occurred in the largest urban agglomerations in the country during this period. One of the main findings is the marked spatial variation between metropolitan and non-metropolitan areas and amongst the ten largest Brazilian cities in terms of average commute times. For instance, travel to work trips tend be 31% longer in São Paulo and Rio de Janeiro, the two largest metropolitan areas (MAs) in the country, than the in the other MAs. Limiting the focus to national averages thus conceals enormous variation and is not to be recommended for analysts seeking to understand developments in transport conditions in Brazil.

Furthermore, the data supports that the major Brazilian metropolitan areas have shown worsening conditions of urban transportation since 1992 as reflected in longer commuting times, with Curitiba and Porto Alegre being the only exceptions. The share of people with very long commutes (one-way trip longer than 1 hour) has also increased considerably and reaches in some metropolitan areas almost a quarter of all commuters. This seems to reflect a combination of factors, such as population growth, the expansion of outlying neighborhoods, and rapid increase in motorization and congestion levels. Our analysis suggests that the positive effects of building new infrastructure capacity in terms of reducing commute times have a limited duration, as illustrated by the particular cases of Rio de Janeiro metropolitan area and Federal District. Despite large investments in public transportation in these areas, reductions in commute time due to additional capacity wear off with time.

We have also found substantial differences in commuting time between income groups. In the nine largest metropolitan areas plus the Federal District taken as a whole, the poorest population segment (the 1st income decile) spends on average 20% more time commuting to work than the wealthiest group (the 10th decile). However, the relationship between income and (average) commute time varies in major ways across space: the commute time gap between rich and poor is much larger in some metropolitan areas (Belo Horizonte, Curitiba and Federal District) and almost non-existent in others (Salvador, Recife, Fortaleza and Belem). Additionally, as the increase in average trip lengths has been more pronounced for middle and high income groups, this inequality in commute times across income groups has actually weakened between 1992 and 2009. But in this case too there are remarkable spatial variations in developments over time. While income inequalities have not changed substantially over time in four metropolitan areas (Belem, Fortaleza, Porto Alegre and Curitiba), Rio de Janeiro is the only metro where the time spent commuting by the poor has actually improved, notwithstanding worsening conditions amongst higher classes. As for the commuting time differences between men and women in Brazilian metropolitan areas, the

average gender gap in commuting times has virtually been closed between 1992 and 2009. In fact, this gender gap has reversed in two MAs, with women undertaking longer commute trips than men by the end of the period.

From a policy perspective, the paper shows the usefulness of PNAD data for monitoring urban mobility conditions in Brazilian major MAs. Yearly variations in commuting time can amongst others be used to assess the effects of mass transport investments on urban transport conditions. From a theoretical and methodological perspective our descriptive study has, despite all its limitations, at least two implications for research into commute times more generally. The first is that researchers should be careful with transposing expectations and explanations regarding (developments in) commuting times that would appear sensible in a Western context to newly industrializing and emerging economies, including Brazil. For instance, from a western perspective the closing down of the gender gap in the average commute times we have observed for Brazil is quite surprising. It suggests a need for new theorizing of the links between home, work and gender that critically engages with the accepted theoretical notions developed in the context of research in the Global North. Secondly, our findings on the enormous differences between Brazil's largest metropolitan areas show that time, space and social differences are interrelated in complex ways and need to be considered simultaneously in the analysis of commuting behavior. The implication is that future research should move beyond analyses of, say, income and commute time in general or for Brazil as whole but that such work must be grounded in the concrete reality of differentiated space: in terms of theory, methodology and empirics the balance between the general and the particular must shift towards the latter, because only then will we be able to understand how such developments as motorization and urban expansion work out differently for different social groups in different settlements.

Our analysis to date has only been exploratory and limited to the aggregate level. Despite its limitations, PNAD datasets hold a large potential for more in-depth research at the level of individuals and households. For instance, future studies could analyze how socioeconomic and demographic characteristics of households (such as social deprivation and family life cycle) relate to commuting time of individuals and whether the magnitude of these relationships has changed over time in different ways in (and within) different urban areas in Brazil. Also, three PNAD editions (1998, 2003 and 2008) have supplementary data on population health conditions that could be largely explored, for example, with studies on health disabilities that impair physical mobility or on the additional risk of traffic accidents due to longer journey-to-work trips. There are numerous other urban transport issues that could be addressed in Brazil using PNAD. The 2010 Population Census data, recently released by IBGE, extends even further these possibilities of investigation since it makes commute time data available at the local level. In any case, future studies should bear in mind the stark economic and spatial disparities that characterize the country and its urban agglomerations.

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