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WALDEMAR KOZIOŁ

RENATA SIUDA-AMBROZIAK (EDS.)

UNIVERSITY OF WARSAW

UNIVERSITY OF WARSAW
FACULTY OF MANAGEMENT

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IN SEARCH OF LOST TIME: AN ESTIMATE OF THE PRODUCT LOSSES IN TRAFFIC CONGESTION IN BRAZIL

Guilherme Szczerbacki Besserman Vianna[*]
Carlos Eduardo Frickmann Young[**]

INTRODUCTION

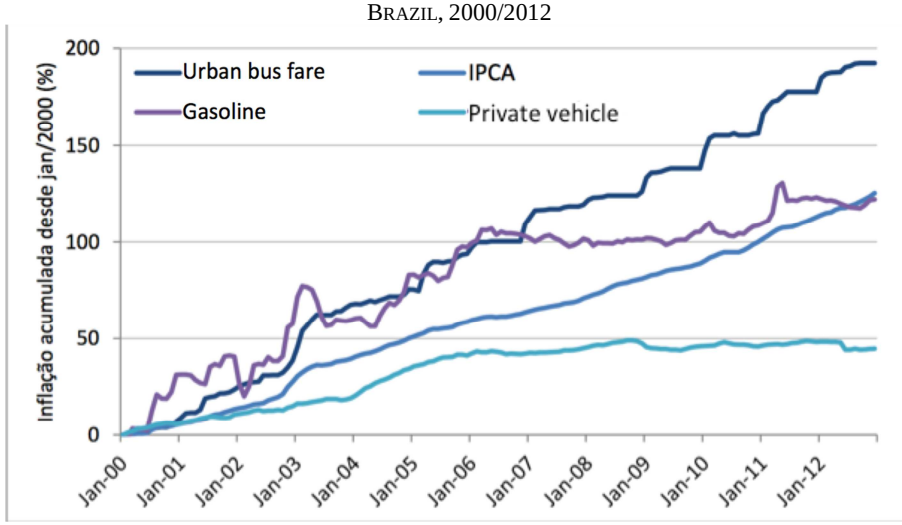
Since the demonstrations in June 2013, the topic of "urban mobility" has gained more visibility in the national scenario. The fast urbanization of the country was not followed by the necessary infrastructure investments, leading to a constant increase of traffic congestion in the big cities and to the deterioration of public transportation. These problems, together with the increase in public transportation fares, provoked popular demonstrations, thus calling the attention of the authorities to the crisis in urban planning in the major Brazilian cities. Problems related to traffic congestion in Brazil have a historical reason: after World War II, infrastructure became priority in the country, according to the developmental model. In the Juscelino Kubitschek government (1956-1961), improving transportation was one of the national development goals. In this period, the government increased investments in the area of transportation and some positive results were achieved. However, because of the partnership with car manufacturers established in the country as a booster for industrialization,

[*]. Guilherme Szczerbacki Besserman Vianna – MA in Economics at the Fluminense Federal University, Niterói, Brazil. E-mail: guilhermeszcz@gmail.com.
[**] Carlos Eduardo Frickmann Young – PhD in Economics, Associate Professor at the Institute of Economics, Federal University of Rio de Janeiro (IE/UFRJ) and researcher at the National Science and Technology Institute on Public Policies, Strategies and Development (INCT-PPED). Coordinator of the Environmental Economics Research Group (GEMA) at the Federal University of Rio de Janeiro.
E-mail: carloseduardoyoung@gmail.com.

the improvements made in infrastructure favoured individual transportation, making it clear that the urban plan for Brasília – icon of developmentalism at the time – was to make it an "automotive city". As time went by, the big cities grew and, without the necessary investments in public transportation, traffic congestion progressively increased until it reached the current situation in which the inhabitants of the big cities in Brazil have great losses.

Even with the notorious mobility problems, the current policy does not seem to point out a direction that shows better offers of public transportation, but instead encourages the continuous purchase of cars. From 2008 to 2013, the government reduced the tax on industrialized products (IPI), and Petrobras controlled the fuel price. The combination of these two factors stimulated the use of private transportation instead of public. Fuel subsidies have continued until now. In contrast with car prices, bus fares increased above inflation during the first years of the new millennium. The price of gasoline has increased according to the rise in the Extended National Consumer Price Index (IPCA). The graphic below shows that bus fares are rising far above inflation, unlike the costs of private transportation (car prices and fuel costs), thus stimulating the use of cars.

GRAPHIC 1. EVOLUTION OF URBAN BUS FARE COMPARED TO IPCA, GASOLINE AND PRIVATE VEHICLE. BRAZIL, 2000/2012



Source: IPEA, 2013

Compared to other countries, it is also worth noting that the problems regarding transportation are huge in Brazil. According to research conducted in 2013 by a company of GPS services (TomTom), Rio de Janeiro (in the 3rd place) and São Paulo (in the 7th place) were classified as two of the ten most congested cities in the world. The two were the only Brazilian cities included in the research. Therefore, other Brazilian cities could also have shown a bad performance in the study, if they had been considered and analyzed.

CONSEQUENCES OF INEFFICIENT MOBILITY SYSTEMS

Transportation obviously helps people to go from one place to another in public spaces. That is why it is extremely relevant when we talk about time wasted in going from one place to another. Good quality transportation can provide several externalities for those who live in big cities, such as an increase in productivity, a reduction in freight and in social inequalities, greater access to public services, a decrease in (or elimination of) forms of illegal transportation, less contamination of the air, less noise pollution, a reduction in inhabitants' stress levels and a decrease in the number of accidents. The increase in productivity occurs when people spend less time travelling to work, which allows them to work more and consequently produce more. Applying the same logic, it is possible to observe that there is a decrease in the cost of freight paid by companies, which transforms the development of transportation into a stimulus for industry, therefore increasing local investment (Haddad, 2006). There is also a relationship between the reduction in social inequality and the improvement in the offer of public transportation. After all, the poorer population usually lives in the urban outskirts and therefore spends more hours commuting. In addition, it is this segment of the population that spends more money on transportation compared to their income (Pero, Mihessen, 2012). Besides, if there is a good transportation system, access to public services also improves, as it becomes possible to provide health, education and safety to the population, thus reducing inequalities even more (Gomide, 2006). Offerings of illegal "public" transportation, such as vans, would also decrease, if the state government offered a more efficient service, which would, therefore, decrease the amount of unreported employment (Oliveira, 2013). With fewer cars on the streets, it is also possible

to improve the health of the inhabitants of big cities, as there is a decrease in the emission of greenhouse gases, which, in addition to affecting the urban inhabitants, also causes damages to the environment. There is also a decrease in noise pollution generated by cars (Macknight, Young, 2009). Fewer cars on the streets would also prevent stress, as well as its consequences, caused by time wasted on the streets. Finally, it is easy to see that if the quality of public transportation was better, the number of traffic accidents would also decrease, especially crashes involving motorcycles (as this means of transportation is chosen to escape from traffic congestion and it is notoriously more dangerous). Reducing the number of accidents would especially bring benefits to young people, as they are most often injured in this type of accident. In general, people think that efficient public transportation is a consequence of being a developed country. However, the various externalities due to this sector indicate that efficient public transportation can also be the cause of a country being developed. This is what we intend to show in numbers.

Monetary Losses as a Consequence of Transportation Problems in Brazil

This paper aims to present an estimate of the amount lost due to the problems with Brazilian urban mobility. We will use a method called marginal productivity to calculate this loss (Seroa da Motta, 1997). This method was chosen because it allows us to calculate the economic cost of the increase in the duration of commuting, and it has been already applied in the state of Rio de Janeiro in research performed by Young *et al.* (2013). This work applies the same methodology, but it is aimed at focusing on the whole national territory divided by regions, states, major metropolitan areas and capitals. All the calculus was based on the 2010 demographic census, which is the most proximate database with all the indexes necessary for obtaining the results. Based on the time spent travelling to and from work, self-declared in the survey, it is possible to calculate the average time lost commuting. If we multiply these averages by the workers' mean income, it is possible to calculate the total and relative monetary loss for each geographical segment. The results are shown below:

TABLE 1. AVERAGE COMMUTE TIME PER CAPITAL, PER CAPITAL WITH METROPOLITAN AREA (MA), PER CAPITAL WITHOUT MA, PER MA AND PER COUNTRYSIDE IN BRAZIL IN 2010

Area	**Time spent/day (min)**	**Workforce**
Capitals with MA	84.89	13,514,121
Capitals without MA	67.01	1,973,505
Capitals	82.61	15,487,626
Outskirts	75.30	13,776,347
MA	79.83	39,406,715
Countryside[2]	46.96	44,297,782

Source: Vianna, 2013.

In Table 1, as expected, it is possible to verify that the average commute time in the metropolitan areas is higher than in the regions in the countryside. In addition, we can observe that the average time spent per day going from one place to the other is greater in the capitals than in the outskirts. This result is probably due to a greater concentration of economic activities within the most central regions of the metropolitan areas.

Tables 2, 3, 4 and 5 show the average commute time per region, state, major metropolitan areas and main capitals.

TABLE 2. AVERAGE COMMUTE TIME PER BRAZILIAN REGION IN 2010

Region	**Time spent/day (min)**	**Workforce**
South-East	73.18	38,111,800
Central-East	59.67	6,875,625
North-East	56.12	20,854,301
North	55.17	6,262,341
South	50.24	14,249,772

Source: Vianna, 2013.

[2] The countryside was considered to be the area outside the metropolitan area.

TABLE 3. AVERAGE COMMUTE TIME PER STATE IN 2010

State	Time spent/day (min)	Workforce
Rio de Janeiro	88.77	7,151,619
São Paulo	76.04	20,001,270
Amazonas	69.32	1,323,337
Pernambuco	61.83	3,403,873
Goiás	61.03	2,959,329
Maranhão	58.37	2,361,389
Bahia	58.23	5,841,078
Minas Gerais	57.89	9,264,527
Alagoas	57.73	1,122,014
Espírito Santo	57.17	1,694,384
Pará	55.83	2,901,864
Sergipe	55.52	832,455
Ceará	53.73	3,361,735
Paraná	53.41	5,307,823
Rio Grande do Sul	50.93	5,533,116
Rio Grande do Norte	50.35	1,238,314
Amapá	50.22	260,701
Mato Grosso do Sul	49.34	1,180,477
Paraíba	47.88	1,478,168
Piauí	47.31	1,215,275
Acre	47.10	279,287
Mato Grosso	46.06	1,448,274
Santa Catarina	44.24	3,408,833
Roraima	43.76	181,292
Rondônia	43.49	732,224
Tocantins	42.47	583,635

Source: Vianna, 2013.

TABLE 4. AVERAGE COMMUTE TIME PER METROPOLITAN AREA WITH WORKFORCE OF MORE THAN 700,000 INHABITANTS IN 2010

Metropolitan Area (MA)	**Time spent/day(min)**	**Workforce**
MA of São Paulo	100.53	9,479,401
MA of Rio de Janeiro	100.00	5,280,482
MA of Salvador	84.09	1,622,506
MA of Belo Horizonte	80.93	2,693,139
MA of Recife	78.75	1,484,673
MA of Manaus	78.67	862,220
Greater Vitória	73.76	799,495
MA of Curitiba	72.65	1,657,198
MA of Belém	71.25	883,077
Baixada Santista – MA of the coast of the state of São Paulo	69.32	746,112
MA of Fortaleza	67.91	1,585,827
MA of Goiânia	67.78	1,146,499
MA of Porto Alegre	67.30	1,998,214
MA of Campinas	63.52	1,421,372

Source: Viana, 2013.

The results showed that in Brazil the average commute time was 63.08 minutes, with a population of 86,353,839. Focusing on specific areas, it is possible to see that the results of the metropolitan area of Rio de Janeiro were worse than the ones observed in the city of Rio de Janeiro, thus reversing the average encountered. This survey suggests a greater inequality in this region, as the poorest population lives in the outskirts and suffers more with longer commuting. In addition, the average commute time is similar to the one found in the metropolitan area of São Paulo. The analysis per state and geographical region does not result in satisfactory comparisons, as the result is directly affected by the degree of urbanization of the places. For example, the comparison between Rio de Janeiro, where 73.8% of the inhabitants live in metropolitan areas, and

Sergipe, where only 46% of the population live in the metropolitan area, is not necessarily valid, as the mobility issue particularly affects areas with higher concentrations of people. However, we find bad results in Maranhão, where, although only 30% live in the metropolitan area, commute time is extremely high. The average in the North-East, where the urban concentration is high, is also of concern. In Amazonas, commute time also calls our attention, but we can attribute this fact to the geographical specificities of the region.

TABLE 5. AVERAGE COMMUTE TIME PER MUNICIPALITY WITH WORKFORCE OF MORE THAN 500,000 INHABITANTS IN 2010

Municipality	**Time spent/day (min)**	**Workforce**
São Paulo	105.23	5,549,787
Rio de Janeiro	95.05	2,922,822
Salvador	89.84	1,252,949
Manaus	82.60	750,666
Belo Horizonte	79.58	1,237,107
Brasília	78.65	1,287,544
Fortaleza	70.99	1,128,812
Recife	70.09	661,052
Curitiba	68.39	947,195
Porto Alegre	67.65	728,252
Belém	66.24	595,399
Goiânia	61.79	708,550

Source: Vianna, 2013.

By focusing the analysis on the municipalities, it is possible to observe deficiencies in Recife and Salvador. Commute time in these North-Eastern capitals is above the expected time for the population size. Therefore, the problems regarding urban mobility in these cities are even worse than the national average. For all the results, it is worth mentioning that the data for one specific region only includes the travels from or to that region. Therefore, travel times to

other areas, which are even longer, were not considered. It is possible to say that the results related to the time lost in traffic congestion are underestimated, although the comparative chart is extremely useful.

Tables 6 to 10 show the relative monetary loss for each region. To calculate it, we used the average travel times applied to the per capita income of the population in 2010, per geographical area. However, a review of the literature reveals the importance of applying a reduction factor to the calculus of the cost per hour spent by the workforce in traffic congestion. The calculus is based on the guidebook that analyzes transportation costs and benefits adopted by the Province of Victoria, in Australia (VTPI, 2012). The publication reveals that the time spent on travelling between cities and within the city of residence is equivalent to 50% to 70% of the perceived income. Therefore, we will consider four possibilities for the calculus scenario: one with an adjustment factor of 50%, the other with an adjustment factor of 50%, a third factor considering the total income value and, finally, a factor considering as the difference in wasted time between the metropolitan area and in the countryside of the same state. However, it is worth mentioning that the introduction of a discount factor is only valid to obtain an estimate of the value lost related directly to the time lost in traffic congestion. To calculate the total loss of welfare, it would be possible to consider 100% of the time lost (as it can be freely used by the individual), and it would be necessary to include the several externalities already mentioned, which have influence in welfare and in monetary terms. Therefore, the results found greatly underestimate the total losses due to mobility problems in the whole country.

TABLE 6. IMPACT OF COMMUTE TIME OVER GDP PER BRAZILIAN REGION IN 2010

Region	**% of Lost GDP**			**Lost GDP**
Factor	100%	70%	50%	MA – Countryside
North-East	3.00%	2.10%	1.50%	0.73%
South-East	2.72%	1.90%	1.36%	0.93%
North	2.48%	1.74%	1.24%	0.39%
South	2.36%	1.65%	1.18%	0.51%
Central-West	2.36%	1.65%	1.18%	0.14%

Source: Vianna, 2013.

TABLE 7. IMPACT OF COMMUTE TIME OVER GDP PER STATE IN 2010

State	**% of Lost GDP**			**Lost GDP**
Factor	100%	70%	50%	MA – Countryside
Maranhão	3.38%	2.37%	1.69%	0.53%
Goiás	3.36%	2.35%	1.68%	0.28%
Alagoas	3.32%	2.32%	1.66%	0.59%
Rio de Janeiro	3.30%	2.31%	1.65%	1.29%
Piauí	3.15%	2.21%	1.58%	0.00%
Pernambuco	3.05%	2.14%	1.53%	0.88%
Bahia	2.97%	2.08%	1.49%	0.76%
Paraíba	2.90%	2.03%	1.45%	0.63%
Ceará	2.85%	2.00%	1.42%	0.90%
Rio Grande do Norte	2.77%	1.94%	1.39%	0.75%
Sergipe	2.72%	1.90%	1.36%	0.63%
Pará	2.69%	1.88%	1.35%	0.47%
São Paulo	2.66%	1.86%	1.33%	0.94%
Amapá	2.66%	1.86%	1.33%	-0.07%
Minas Gerais	2.60%	1.82%	1.30%	0.54%
Paraná	2.56%	1.79%	1.28%	0.60%
Mato Grosso do Sul	2.47%	1.73%	1.24%	0.00%
Acre	2.46%	1.72%	1.23%	0.00%
Rondônia	2.33%	1.63%	1.17%	0.00%
Roraima	2.33%	1.63%	1.17%	0.00%
Rio Grande do Sul	2.32%	1.62%	1.16%	0.49%
Tocantins	2.24%	1.57%	1.12%	0.00%
Amazonas	2.20%	1.54%	1.10%	0.70%
Espírito Santo	2.17%	1.52%	1.08%	0.70%
Santa Catarina	2.13%	1.49%	1.06%	0.42%
Mato Grosso	2.05%	1.44%	1.02%	0.38%

Source: Vianna, 2013.

TABLE 8. IMPACT OF COMMUTE TIME OVER GDP PER STATE COUNTRYSIDE IN 2010

State	**% of Lost GDP**	**% of Lost GDP**	**% of Lost GDP**
Factor	100%	70%	50%
Maranhão	4.15%	2.91%	2.08%
Amazonas	4.11%	2.87%	2.05%
Piauí	3.94%	2.76%	1.97%
Paraíba	3.80%	2.66%	1.90%
Pernambuco	3.76%	2.63%	1.88%
Alagoas	3.63%	2.54%	1.81%
Bahia	3.48%	2.44%	1.74%
Sergipe	3.46%	2.42%	1.73%
Ceará	3.44%	2.41%	1.72%
Amapá	3.00%	2.10%	1.50%
Goiás	2.99%	2.10%	1.50%
Roraima	2.65%	1.86%	1.33%
Rio Grande do Norte	2.50%	1.75%	1.25%
Paraná	2.50%	1.75%	1.25%
Minas Gerais	2.48%	1.74%	1.24%
Santa Catarina	2.41%	1.69%	1.21%
São Paulo	2.32%	1.62%	1.16%
Pará	2.31%	1.62%	1.16%
Acre	2.24%	1.57%	1.12%
Espírito Santo	2.22%	1.55%	1.11%
Tocantins	2.17%	1.52%	1.09%
Rondônia	2.11%	1.48%	1.05%
Rio Grande do Sul	2.10%	1.47%	1.05%
Mato Grosso do Sul	2.08%	1.46%	1.04%
Rio de Janeiro	1.68%	1.17%	0.84%
Mato Grosso	1.57%	1.10%	0.79%

Source: Own elaboration based on Vianna, 2013.

TABLE 9. IMPACT OF COMMUTE TIME OVER GDP PER STATE, PER METROPOLITAN AREA WITH AN OCCUPIED POPULATION GREATER THAN 700,000 INHABITANTS IN 2010

Metropolitan Area	**%of Lost GDP**			**Lost GDP**
Factor	100%	70%	50%	MA – Countryside
MA of Belém	4.81%	3.37%	2.41%	1.57%
MA of Goiânia	4.63%	3.24%	2.32%	0.76%
MA of Rio de Janeiro	4.41%	3.09%	2.20%	1.91%
MA of Salvador	3.54%	2.48%	1.77%	1.54%
MA of Belo Horizonte	3.43%	2.40%	1.71%	1.41%
MA of Recife	3.38%	2.37%	1.69%	1.36%
MA of Fortaleza	3.37%	2.36%	1.68%	1.36%
MA of São Paulo	3.19%	2.23%	1.60%	1.56%
MA of Curitiba	3.04%	2.13%	1.52%	1.25%
MA of Porto Alegre	2.78%	1.95%	1.39%	1.11%
Greater Vitória	2.47%	1.73%	1.24%	1.11%
Baixada Santista – MA of the coast of the state of São Paulo	2.36%	1.65%	1.18%	0.61%
MA of Manaus	2.28%	1.60%	1.14%	0.81%
MA of Campinas	2.18%	1.53%	1.09%	0.42%

Source: Vianna, 2013.

TABLE 10. IMPACT OF COMMUTE TIME OVER GDP PER MUNICIPALITY WITH AN OCCUPIED POPULATION GREATER THAN 500,000 INHABITANTS IN 2010

Municipality	**% of Lost GDP**			**Lost GDP**
Factor	100%	70%	50%	MA - Countryside
Salvador	6.43%	4.50%	3.21%	3.03%
Belo Horizonte	5.08%	3.56%	2.54%	2.03%
Goiânia	4.48%	3.14%	2.24%	0.37%
Belém	4.38%	3.07%	2.19%	1.21%
Fortaleza	3.95%	2.77%	1.98%	1.70%
Rio de Janeiro	3.54%	2.48%	1.77%	1.43%
Curitiba	3.49%	2.44%	1.75%	1.31%
Recife	3.44%	2.41%	1.72%	1.13%
Porto Alegre	3.43%	2.40%	1.72%	1.38%
São Paulo	3.34%	2.34%	1.67%	1.71%
Manaus	2.30%	1.61%	1.15%	0.89%
Brasília	1.90%	1.33%	0.95%	-

Source: Vianna, 2013.

A total loss of 2.6% of the Brazilian national GDP (R$99 billion) was calculated in 2010. If the population in the metropolitan areas spent the same time commuting as people in the countryside of the same state, it would be possible to reduce 27.6% (R$26.73 billion) of the total losses, which is equivalent to 1.8% of the country's GDP. Analyzing these tables, it is possible to observe that the region that suffers more relative losses is the North-Eastern region (the poorest in the country). Nine of its 11 states are among the 11 states with greater relative loss, which indicates that there is a relationship between poverty and transportation offer. The "intruders" in the list are the states of Rio de Janeiro and Goiás, as they show greater mobility problems than what is expected for the level of development of these states. These results show that a correlation exists between the level of development of an urban place and the level of efficiency of its transportation system.

If we compare the states, again it is possible to observe a deficiency in the state of Maranhão, which shows high losses in spite of the fact that it has a low urban population. We could also observe that states such as São Paulo and Santa Catarina, which have several metropolitan areas, do not show worse results, i.e., greater losses. The existence of multiple areas with job opportunities helps to disperse the population and, therefore, reduce mobility problems. Again, the worst indexes in the metropolitan areas of Rio de Janeiro in comparison to the capital show problems in the outskirts of the region. These results differ from what was observed in the rest of Brazil, which shows a substantial inequality in the region. Overall, it is possible to see that the monetary losses due to mobility problems are significant. Obviously, in absolute terms, the richer areas have greater losses. However, in relative terms, the poorer areas are the ones in which the population suffers more, indicating that there is a relationship between income inequality and mobility, in addition to direct loss in production.

CONCLUSION

This study showed that Brazil has obvious problems regarding urban mobility. It is possible to observe an important relationship between development and relative losses due to mobility, as the big cities in the North-East, which are the poorest in the country, are also the ones suffering more with this problem. It was shown that Rio de Janeiro has mobility problems in spite of its high development indexes in comparison to other areas in the country. In addition to the possibility of getting back R$26.73 billion per year, we could make advances in the solution of several problems in Brazil, if public transportation was improved. Due to the peculiarities of public transportation, there are several negative consequences for the population. It is worth mentioning that the results are underestimated, but even so they are significant, which indicates that investments in transportation would bring benefits for the country. Therefore, reducing the average commute time, combined with a greater offer of public transportation, would help to reduce greenhouse gas emissions, to improve the conditions of urban planning, to reduce social inequality, to increase productivity, among other benefits. Thus, these investments could bring social and economic benefits to the country.

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