COMMUTE TIMES AND ROAD SPACE RATIONING: SÃO PAULO'S RODÍZIO VEICULAR

Resumo: Este trabalho estudo o Programa de Restrição ao Trânsito de Veículos Automotores (conhecido como Ródizio) introduzido na cidade de São Paulo em 1997. O objetivo do trabalho é avaliar como o Rodízio modificou os tempos de deslocamento para o trabalho na Região Metropolitana de São Paulo (RMSP), também comparando sua tendência com a de outras regiões metropolitanas brasileiras de 1992 a 2012. A hipótese é de que o Rodízio apenas reduz os tempos de deslocamento temporariamente, permanecendo a tendência de longo prazo inalterada. Utiliza-se os microdados do Instituto Brasileiro de Geografia e Estatística para rodar regressão linear com intervalo e censura na variável dependente. Resultados corroboram nossa hipótese de que o Rodízio não foi suficiente para reverter a tendência de aumento dos tempos de deslocamento.

Palavras-Chave: Rodízio Veicular, Economia do Transporte, Econometria.
Código JEL: R48, C13

Abstract: The present paper studies the Restriction Program for Motor Vehicle Traffic (known as Rodízio) introduced in the city of São Paulo in 1997. Our objective is to assess how the *Rodízio* changed the commute times of the Metropolitan Region of São Paulo (MRSP) and also comparing its trend to other Brazilian metropolitan regions from 1992 to 2012. Our hypothesis is that the policy can only reduce travel times temporarily, keeping long-term growth trend unaltered. We used microdata from the Brazilian Institute of Geography and Statistics to run a linear regression with an interval and censure dependent variable. The results corroborate with our hypothesis that the *Rodízio* policy wasn't enough to reverse the upward trend of São Paulo's commute times.

Keywords: Vehicle Restriction, Transport Economics, Econometrics.
JEL code: R48, C13

1. Introduction

On October 3, 1997, the Restriction Program for Motor Vehicle Traffic (known as *Rodízio Veicular*, in portuguese) was established in São Paulo's Expanded Center in order to manage road traffic. Contrary to a strong economic tradition that is based on pricing strategies, this policy is a quantity restraint.

Urban transport externalities – notably congestion, pollution, accidents and automobile dependency – are major problems of modern metropolis that impose huge costs on society. In order to manage them, pricing has been established on some places: Singapore, London, Helsinki, Stockholm and Milan, among others. On the other side, other transport policies seem to be much more widespread: transit subsidies, high-occupancy-lanes and bus-only-lanes, infrastructure investments, institutional changes in the work schedule, incentives to cycle and walk, land-use policies. This paper will treat one such policy: **road space rationing**.

Its main general objective – also valid for São Paulo's Restriction Program - is to reduce negative externalities (congestion, pollution etc.) by managing a scarce common good - road capacity - by "artificially" restricting the demand. It is usually implemented during peak-periods and/or peak pollution events in the central business district (CBD).

This policy seems to have more political and public acceptability than road pricing – for it was implemented by many cities/countries, especially in Latin America. Some permanent schemes are: Athens (1982), Santiago (1986), México City (1989), Metro Manila (1995), São Paulo (1997), Bogotá (1998), La Paz (2003), San José (2005), countrywide in Honduras (2008) and Quito (2010). Other place introduced it temporarily, such as Beijing, Italian cities, Paris and New Delhi.

The present paper aims to evaluate how the *Rodízio Veicular* policy changed the morning commute times of the Metropolitan Region of São Paulo (MRSP) before and after its introduction and also comparing the MRSP trend against other Brazilian metropolitan regions from 1992 to 2013. The main contributions of the paper are: i) it is the first scientific study to assess the *Rodízio* policy since its implementation; ii) it accounts for the interval and censure nature of the data available, as opposed to some papers, for example, Pereira and Schwanen (2013), Silveira Neto and Duarte (2015), Barbosa and Silveira Neto (2015); and iii) it provides guidance and empirical evidence for future rationing transport policies.

It is organized as the following way: it begins with the present Introduction. Then, on section 2 we talk about the history and characteristics of the São Paulo's Restriction Program for Motor Vehicle Traffic. On section 3, we make a brief literature review, since there are not many papers on road space rationing. Section 4 we discuss the theoretic framework regarding the policy and its expected effects on sector. Section 5 discusses transport data available for Brazil and our dataset choice, and then we discuss the method used as well as its limitations. Section 6 displays the main results of the interval regressions and on 7 we make a final discussion of the *Rodízio* and its implications.

2. São Paulo's Restriction Program for Motor Vehicle Traffic

On October 3, 1997, the São Paulo's town council approved the Act 12,490. It established the Restriction Program for Motor Vehicle Traffic (commonly known as Vehicle Rotation or *Rodízio Veicular*, in portuguese) in the city of São Paulo. It is stated that it aims to "improve traffic conditions by reducing the number of vehicles on public roads on weekdays (except holidays)" (SÃO PAULO, 1997a). The rotation is based on the last digit of the plate number: each weekday, two digits are forbidden to enter the so-called Expanded Center.

The Decree 37,085 regulates the Act 12,490. It begins by stating "Considering that an improvement in the road fluidity increases the quality of living of the population." (SÃO PAULO, 1997b). Both previous statements are essential to our research, because they reveal what the key purpose of the *Rodízio* policy is: lowering travel times in the city. As we will discuss further in the next sections, reducing the number of vehicles on the roads (reducing the volume) must lower travel times for the remaining vehicles, which is the same meaning for improving road fluidity as well.

Further on, the Decree declares the technical procedures of the Program. For example, it cites all exempted vehicles: trucks, all kinds of transit, motorcycles, taxis, school transportation, winches, public and other essential services (police, firefighters, funeral service etc.); in other words, the primary restricted class of vehicle is the automobile. The restriction will be in force in the months of February to June and from August to December, between 7 to 10 a.m. and 5 to 8 p.m. – the morning and evening peak periods, usually the commute times. It continues by declaring which roads comprehend the Expanded Center (the place where the Program is in effect) and other complementary information.

On the following years, the legislation was only updated in order to widen the range of exempted vehicles. Decree 37,346 (SÃO PAULO, 1998) exempted valuables, food, health services transportation; Decree 39,538 (SÃO PAULO, 2000a) alters the first Decree; Decree 39,563 (SÃO PAULO, 2000b) exempted doctors private vehicles; Decree 44,099 (SÃO PAULO, 2003) exempted council of guardianship vehicles; Decree 45,273 (SÃO PAULO, 2004) exempted water, electricity, telephone, gas and other services; Decree 47,680 (SÃO PAULO, 2006) exempted the Metropolitan Company of São Paulo (*Companhia do Metropolitano de São Paulo*, or commonly known simply as *Metrô*) vehicles.

A 2014 pool from Datafolha (2014) shows how the São Paulo's citizens view the *Rodízio* policy. Most people (61%) approve the expansion of the *Rodízio* for a bigger area; a third (32%) is against this measure; and among car users, this approval lowers to 47%. For 40%, the expansion of the *Rodízio* might improve the traffic; for 29%, the expansion of the Rodízio would surely improve the traffic; and for 26%, it would surely worsen the traffic.

3. Literature Review

Road pricing has been an object of economics studies since Pigou (1920) and Knight (1924) establishing the initial proposition of transportation externalities. Later on, it was established formal mathematical models based on microeconomic and transport engineering theories by Beckmann, McGuire and Winsten (1956), Walters (1961) and Vickrey (1969). From these first authors, a myriad of studies on pricing has been developed. On the other side, the literature regarding road space rationing policies is relatively scarcer and more recent, so the following review will try to mention all of them.

Eskeland and Feyzioglu (1997) studied the effect of the car restriction "*Hoy no Circula*" in Mexico City. The policy came into force in 1989 and it had the same guidelines as São Paulo's *Rodízio*. They found that the policy had the contrary expected effect: people drove more on unrestricted days (based on aggregate gasoline consumption) and some bought a second car to bypass the ban (Mexico city went from net exporter to importer of motor vehicles), leading to an aggregate welfare loss.

De Grange and Troncoso (2011) quantified the effect of vehicle restriction on private and public transportation in Santiago, Chile. They studied two different restrictions: a permanent one for vehicles without catalytic converters from April to August of 2008 and a temporary one that banned vehicles with catalytic converters between 7:30 a.m. and 9 p.m. on days declared as "pre-emergencies" due to high air pollution levels. The permanent one had no impact on the use of private cars whereas the temporary decreases its use by 5.5%. The pre-emergency restriction had a positive effect (a 3% increase) in the Metro ridership, however not on the bus service.

Davis (2008) and Troncoso, de Granger and Cifuentes (2012) both studied the effect of the motor vehicles restriction on air quality in Mexico City and Santiago, respectively. The first study found no statistical evidence that the restraint improved the air quality, mainly because of a change in vehicle composition towards high-emission ones as well as an increase in total number of vehicles circulating. The second study found that the restriction did reduce the concentration of carbon monoxide and nitrogen oxide (emitted mainly by motor vehicles), but no significant change in the sulfur dioxide (emitted by industrial processes).

4. Theoretic Framework

One of the most complete works which deal with our subject is Wang, Yang and Han (2010) who analyze theoretically the effect of road rationing under short-term and long-term traffic equilibrium. Short-term equilibrium is the situation under which no one changes car ownership. On the other hand, long-term takes into account car consumption and disposal, characterizing the equilibrium situation in which no incentive exists to change car ownership. Two modes are considered: car and transit. The generalized cost function for transit incorporates travel time and the transit fare. For the car, the average trip cost of owning a car (acquisition, maintenance, insurance etc), the average monetary cost of per auto trip (gasoline, parking and toll cost) and travel time. The assumptions are: i) auto travel times are always less than transit; and ii) monetary cost of auto trip is larger than transit fare.

Under short-term rationing, a Pareto improvement exists if the average travel time is reduced, thus, a carefully chosen rationing level can benefit everyone. Under long-term rationing, the authors demonstrate that there always exists an equilibrium pattern and it is unique. In order to see how rationing affects travelers, groups are separated based on their car ownership choices. The generalized cost for people with no car before and after remained unchanged. Generalized cost for people who went from zero to one car is reduced. Generalized cost for travelers who went from one to zero cars increases. Cost increase/reduction depends on value of time for travelers who remained with one car and who bought a second car. The fourth proposition states that if average travel time is reduced, then a Pareto improvement can be achieved. One important result for our work is the case when 20% of vehicles are rationed in the long-term equilibrium: auto travel time is greatly reduced, many low income travelers purchase their first car and few high income travelers buy their second car

Daganzo (1995) derives a congestion reduction scheme – something between pricing and rationing – that has the interesting feature of not penalizing anyone, even if collected revenues aren't returned. Therefore, his strategy is not welfare maximization, but a *Pareto optimum* improvement. Pure pricing and pure restraint will always lead to a utility loss to some users. He proposes a flow control as a restraint scheme, but people could buy exemptions on their restrict day.

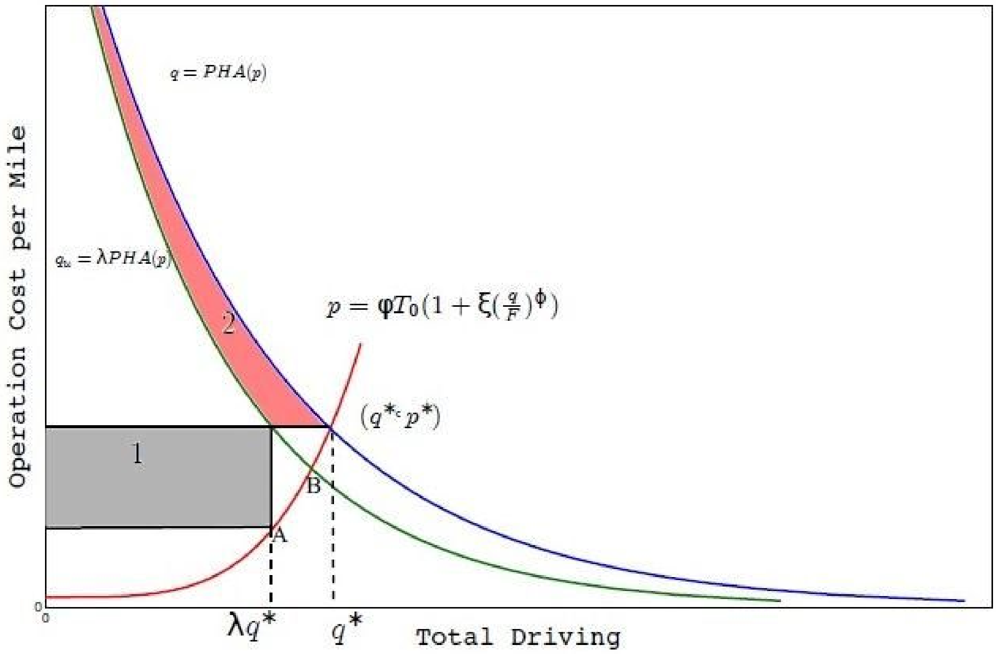
Although Daganzo (1995) gave a numerical example to illustrate his propose, it was more theoretical than realistic, and also oversimplified. Nakamura and Kockelman (2002) applied Daganzo's strategy on the San Francisco Bay Bridge corridor. Defining four income groups residing in 459 origin zones, they choose between the Bridge and the Bay Area Rapid Transit to reach their workplaces. They found no combination of toll and rationing rate that could benefit all groups of travelers studied.

Han, Yang and Wang (2010) studied the theoretical implications of a plate-number-based traffic rationing in a general network. Efficiency is accounted as the ratio between the user equilibrium after and before the restriction is in effect. The number of users (vehicles) is fixed, which is true for a temporary restriction, for example, what was implemented during the Beijing Olympics in 2008. Also, the restriction is defined in the entire network, which is normally not the case in permanent schemes.

Zhu, Du and Zhang (2013) developed an analytical framework to study, among other policies, vehicle usage restrictions, which consists of a mathematical model of joint household ownership and usage decision and welfare analysis. They derive a strong proposition: when induced demand is taken into account (also supposing homogeneous users), vehicle usage rationing will always result in a user welfare loss.

We will explain some of the most important insights on vehicle restriction of Zhu, Du and Zhang (2013) using two of their graphics. Assuming: i) one link with a single origin-destination pair; ii) a demand function for driving depending on income, operational costs, capital costs of owning a car; iii) a BPR supply function which depends on the value of time, travel demand, road capacity and free flow time.

Figure 1: Consumer surplus change after usage rationing without induced demand



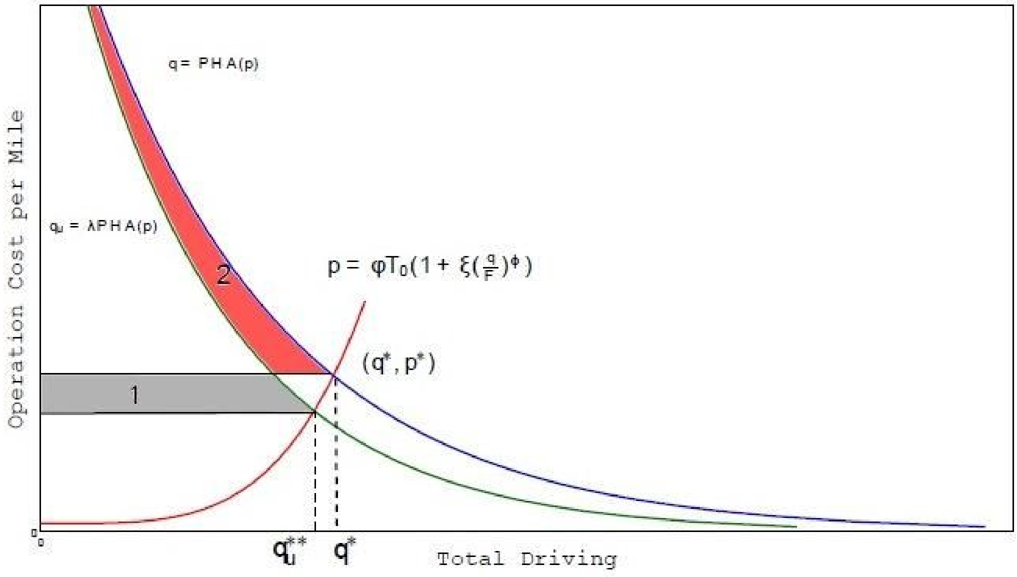
Source: Zhu, Du and Zhang (2013, p. 460)

Travel doesn't comprise a "final demand", but rather is mean for fulfilling other activities in daily life (work, leisure, shopping etc.), so we say it is a derived or induced demand. After the restriction is introduced, in the short term, people won't drive more on days they are allowed to, so they will keep the same level of travel demand (which is a feasible assumption for commuting, for example). Figure 1 shows the effect of rationing without considering the induced demand. Area 1 represents the welfare losses due to the amount of driving that is rationed out by policy, whereas area 2 represents welfare gains for the remaining trips that benefit from travel time reductions.

Figure 2 considers a scenario that accounts for induced demand. Then, more trips will enter the network when the days they are allowed, which could be true for activities other than commute (shopping, for example). In such case, welfare gains stay the same, but welfare losses are much smaller, for people compensate their driving on permitted days.

Although it might seem that, after considering the effect of induced demand, welfare gains and welfare losses could cancel each other (or even generate a welfare surplus), the authors have demonstrated mathematically that, as stated before, pure rationing will always lead to welfare losses.

Figure 2: Consumer surplus after usage rationing with induced demand



Source: Zhu, Du and Zhang (2013, p. 461)

5. Methodology

In this section we will discuss the dataset and method used and the paper limitations. We will compare the three main sources of data availability in Brazil, listing their advantages, disadvantages and our choice. Given that, the method takes into consideration the interval and censure nature of the data, which gives better estimates than other methods (such as Ordinary Least Squares after an arithmetic average of the dependent variable). Also, we know our method doesn't capture all possible effects of the rationing policy, therefore, it has many limitations, which we acknowledge.

5.1. Data

There are three important sources of transportation data, each one with their advantages and disadvantages: the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* or simply *IBGE*), National Department of Traffic (*Departamento Nacional de Tráfego* or simply *DENATRAN*) and Metrô's. IBGE's surveys are standardized to the whole country and made at regular intervals, on the other hand they are not transport oriented, since it is not its primary goal. DENATRAN dataset has the same advantages as IBGE's, but its main problem is the initial year of availability: information is accessible only since 1998. Metrô's information is transport-specific and made at regular times, but it has some methodological issues.

The IBGE makes two surveys which include information about commute times: the Census and the National Survey by Household Sampling (*Pesquisa Nacional por Amostra de Domicílios* or simply *PNAD*). Unfortunately, for our purposes, the Census will not be useful because only in the 2010 one the question was introduced. On the other hand, it appears in the PNAD's person section since 1992, making it possible to make comparisons on commute times: i) before and after the introduction of the *Rodízio*; and ii) between the Metropolitan

Region of São Paulo (MRSP) and other ones. The household section of the PNAD has information about car ownership, however, the question was only introduced in 2006, making it impossible to compare to the period prior the *Rodízio*.

The DENATRAN dataset has information about vehicle ownership at city level. It would be extremely useful to observe the ownership trend separated by vehicle categories. The problem, as mentioned before, is the data unavailability prior 1997.

Metrô's Origin Destination (O-D) Survey has a wide range of information about transportation. It has data on socio-economic variables of the individual and its household, also the geographical coordinations of the place of residence, work and education. The most important section is about the trip pattern: origin-destination pair, purpose, mode, distance and length. However, it has some disadvantages that make it almost impossible to use it: i) it changes the way questions are made each survey; ii) the intervals are not quite frequent (five years); and iii) information is public available only since 1997. These reasons make it very difficult to create a uniform time series that could be statistically used.

From all the existing options, we will focus on the PNAD dataset for the stated reasons. In the next paragraphs, we will mention briefly the characteristics and the necessary adjustments of the data in order to use it properly.

The PNAD asks people three questions regarding their commute times; hence it is only answered by people who worked in the reference week (people who didn't work then will be marked as a "missing"). The first question is whether the workplace is the same as the residence place, the second is if the person goes daily straight from home to work. The possible answers are: 1 - yes; 2 – no; 3 – ignored; or missing.

If the person answers "yes" to both previous questions, it will answer the third one: "how much time does it take to go straight from home to work?". The possible answers are: 1 – less than 30min; 2 – more than 30 to 60min; 3 – more than 60 to 120min; 4 – more than 120min; 5 – ignored; or missing. A "missing" here is given to people who doesn't work or, more importantly, whose answer was "no" to at least or both the previous questions.

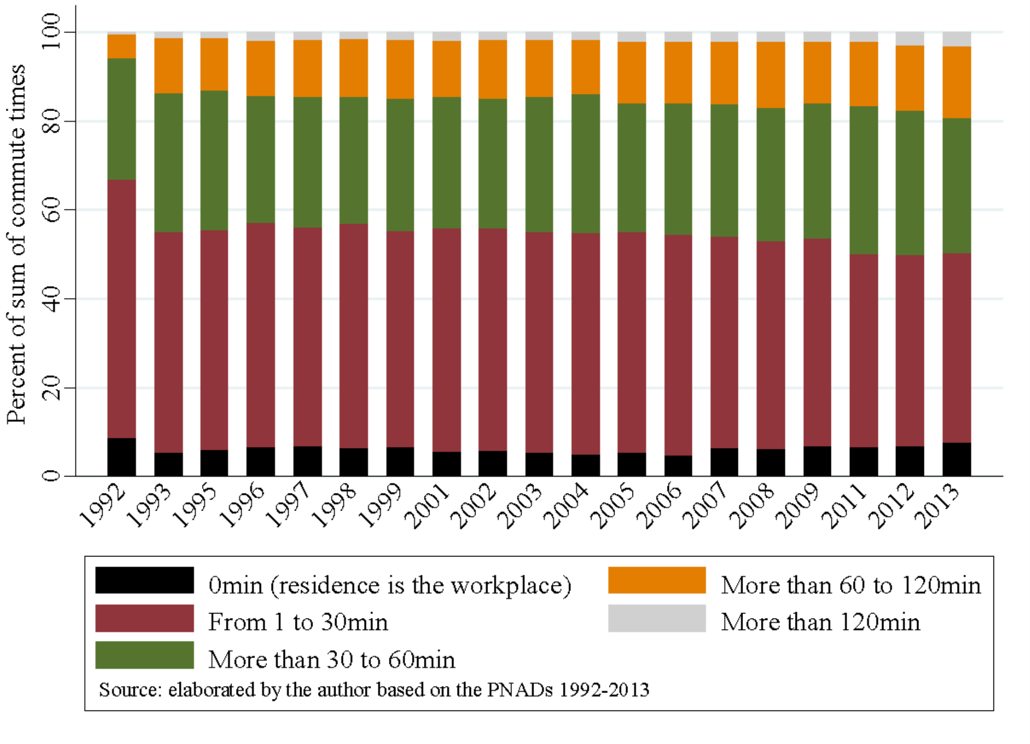
First, as mentioned before, people who didn't work displayed a missing in their line, therefore we excluded them from our analysis (4,519,929 observations or 67.15% of the sample). Then people whose answer was "ignored" in any of the three questions were excluded (272 observations or 0.02% of the sample). We will pay some attention on the two first questions, before moving on to the commute times itself.

About the second question, people who don't go straight from home to work were excluded from the sample, because there is no possible way to know exactly what their travel times are. It might be more or less similar someone who does go straight from home to work. Fortunately, we could expect that it doesn't represent a sample bias for it constitute only a small percentage of the sample and their values might have a distribution approximately equal the people who go straight (87,279 observations or 4,68% of the sample).

On the other side, people who live on the same place they work are marked as a missing in the third question, but actually their commute times aren't a missing but a zero. They do work, but there is no need for them to commute, so, instead of excluding them from the analysis, we replaced their values as "zero" in the upper and lower intervals. They comprise 347,655 observations or 16.37% of the sample.

Finally, we only keep observations for the metropolitan regions (our level of analysis – 1,337,193 observations excluded). Our final micro dataset has 786,430 observations for all Brazilian metropolitan regions, and 126,550 for MRSP only.

Figure 3: Evolution of commute times of all Brazilian metropolitan regions (1992-2013)



One last transformation is needed: the PNAD dataset is microdata (the observations relate to individuals) in nature, but we want to analyze commute times at the metropolitan region level. So, we collapsed the data by year and by metropolitan region using the sample weights, this way we create a "single" observation for each year/region that contains the five intervals (described here as lower and upper interval, respectively): i) zero and zero (so it isn't an interval, but actually a point data); ii) 1 and 30; iii) 31 and 60; iv) 61 and 120; and v) 121 and "missing" (this way the statistical software knows this interval is right-censored).

Our "new" frequency weight variable is how many people choose one of the five categories *per* year/region. The final "macro" dataset has 910 observations: from 1992 to 2013 (except 1994, 2000 and 2010, years which there was no survey) to nine metropolitan regions: Belém, Fortaleza, Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, Curitiba, Porto Alegre and Distrito Federal[1].

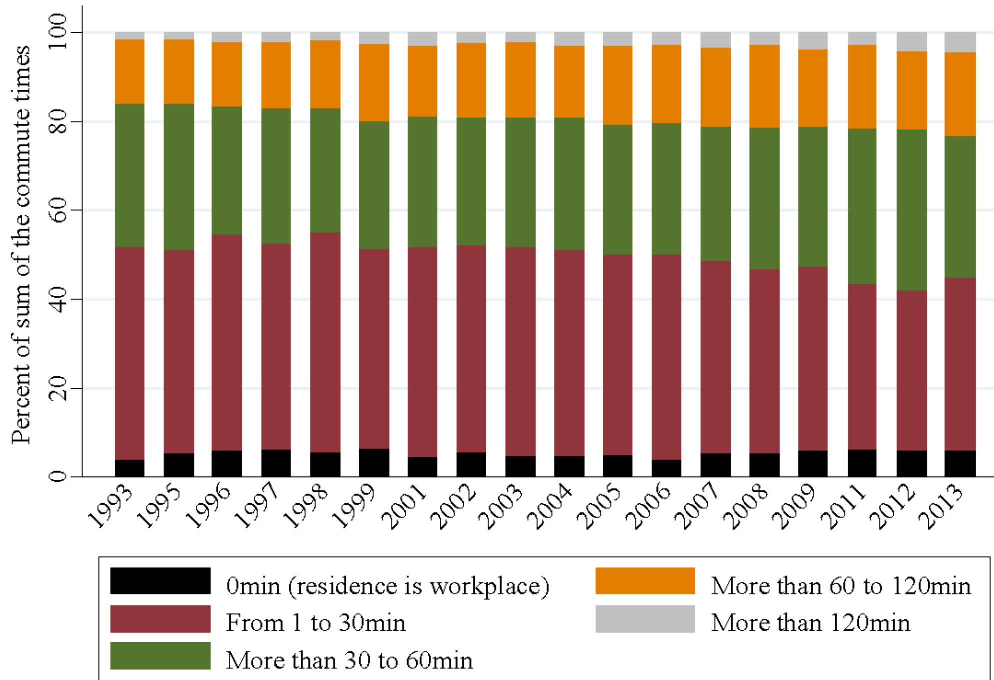
Instead of presenting a table showing the descriptive statistics of the variables, it is better to visualize it through two graphics: the evolution of commute times of the Brazilian metropolitan regions in Figure 3 and for the MRSP only in Figure 4. From the first one, we can see clearly how 1992 represent an outlier – the proportion of people choosing the second category (from 1 to 30min) is much higher compared to other years. That is because in the first year (1992), the question related to the commute times was only applied to two regions:

[1] Since Distrito Federal is not actually a Brazilian State, but rather a Federal District (as its name implies), the official term to describe its conurbation isn't metropolitan region, but Integrated Region of Development of the Federal District and Surrounding Areas (Região Integrada de Desenvolvimento do Distrito Federal e Entorno or simply RIDE), according to the Decree nº 2,710 (BRAZIL, 1998).

Belém and Fortaleza. The general trend is not so clear: it seems the categories representing more than an hour are growing while commutes less than an hour are shrinking.

The MRSP trend is a little bit clearer. People commuting less than 30min are decreasing in percentage with people living in the same place they work oscillating. Longer commutes (especially over 120min) are showing a clear upward trend. The intermediate categories are indistinguishable.

Figure 4: Evolution of commute times of the MRSP only (1992-2013)



Source: elaborated by the author based on the PNADs 1992-2013

5.2. Method

We use the interval regression approach in order to deal with both the interval nature of the variable regarding the commute times and the right-censure of the last interval (more than 120min). We will explain it briefly in the next paragraphs according to Davidson and MacKinnon (2004) and Cameron and Trivedi (2010).

Let $y = X\beta + \varepsilon$ be the model. The dependent variable represents continuous outcomes—either observed or not observed. Our model assumes $\varepsilon \sim N(0, \sigma^2 I)$.

For observations $j \in C$, we observe y_j (continuous or point data). Observations $j \in L$ are left-censored; we know only that the unobserved y_j is less than or equal to y_{Lj}, a censoring value that we do know. Similarly, observations $j \in R$ are right-censored; we know only that the unobserved y_j is greater than or equal to y_{Rj}. Observations $j \in I$ are intervals; we know only that the unobserved y_j is in the interval $[y_{1j}; y_{2j}]$.

The log likelihood function, optimized va Maximum Likelihood method, is:

$$lnL = -\frac{1}{2}\sum_{j\in C} w_j\{(\frac{y_i - x\beta}{\sigma})^2 + log2\pi\sigma^2\} + \sum_{j\in L} w_j log\, \Phi(\frac{y_{Li}-x\beta}{\sigma}) + \sum_{j\in R} w_j log\, \{1 - \Phi(\frac{y_{Rj}-x\beta}{\sigma})\} + \sum_{j\in I} w_j log\, \{\Phi($$

$$+ \sum_{j \in I} w_j log \{\Phi(\frac{y_{2j} - x\beta}{\sigma}) - \Phi(\frac{y_{1j} - x\beta}{\sigma})\}$$

Where $\Phi()$ is the standard cumulative normal and w_j is the weight for the j_{th} observation. If no weights are specified, $w_j = 1$.

We are going to test two main comparisons: 1) whether the MRSP trend is different from other metropolitan regions; and 2) whether the MRSP trend is different before and after the implementation of the Restriction Program. So, the general equation to test our hypothesis is:

$$CT_{it} = x'_{it}\beta + \alpha_i + \delta_t + \varepsilon_{it}$$

In which, for t = 1992, ..., 2013 and i=1, ..., 9 metropolitan regions, CT_{it} is the commute times – our dependent variable. x'_{it} comprises the constant term; the deterministic trend; and a variable which is an interaction between the deterministic trend and a dummy whose value is “1” for the MRSP; for testing hypothesis “1”. x'_{it} includes the constant term; and a deterministic trend; for testing hypothesis “2”. The terms α_i and δ_t are the time-invariant individual effect and the time effect, respectively. Therefore, we will run a fixed effect dummy model; we introduce a dummy variable for each metropolitan region and for each year.

5.3. Problems and limitations

Commute decisions and, more broadly, a metropolitan transportation system is a rather complex system in which the morning commute time is a single component. Therefore, there are important data and methodological limitations in the present paper that we acknowledge and discuss in the following paragraphs.

First, there may be a geographical bias. The Restriction Program is only valid in a small portion of the MRSP: the Expanded Center. Although we might expect that most of the trips with a work purpose must be concentrated in CBD, there may be a significant portion of them that are made elsewhere.

Second is the income (or a more specific transport term: value of time) bias. People (or purposes) with low value of time – other than work – would be simply rule out of the transport market in their restriction days, because their benefit is less than their costs. However, high income groups (regardless of time valuation) were able to buy a second and a third vehicle with a different plate-number end, in order to bypass the *Rodízio*. Probably this second vehicle will be a cheaper and older one, so it will cause other negative externalities, mainly pollution and noise. This is not supported by the data, since the motorization rate (number of vehicles *per* thousand people) stayed the same in the years 1997 and 2007: 184, because vehicles and population grew at the same rate (METRO, 2007).

Third is the alternative mode bias. Medium and low income groups (who weren’t able to afford another vehicle) who still need to go to the Expanded Center to work need to choose another transport mode: carpool, motorcycle, transit (bus, subway or tram) or walk. A carpool choice would make commute times equal to prior the *Rodízio*. A motorcycle shift most probably will decrease commute times (but it will cause another negative externality: accidents). A transit and walk shift will increase commute times, but it will cause positive externalities (improve individual health) and decrease negative ones: less pollution and congestion.

According to the Metrô (2007), the transit share stayed the same (except for school mode that increased from 2 to 5.3%) in the years 1997 and 2007, whereas automobile trips decreased from 47.1 to 41.3% and motorcycle increased from 0.7 to 2.9%. It also shows that low income groups shifted to non-motorized modes; while high income groups shifted to individual modes (medium income remained the same as before).

6. Results and discussions

The regression output for the two models is presented in Table 1. We ran both models in the statistical software package Stata/SE 11 (StataCorp, 2009). "Model 1" refers to the model which tests our first hypothesis and the second model tests the second hypothesis. Therefore, Model 1 uses the Brazilian trend as well as the MRSP trend, besides we introduced dummy variables for each metropolitan region and for each year. Model 2 uses the MRSP trend and a trend after the *Rodízio*, besides dummy variables for each year (blank spaces means the variable wasn't used and omitted ones are due to high multicolinearity):

Table 1: Interval regression: commute times in the metropolitan regions of Brazil (1992-2013)

	Model 1	Model 2
Brazilian trend	0.1861	
MRSP trend	0.1649	0.2922
Belém	(base category)	
Fortaleza	0.2420	
Recife	4.1844	
Salvador	4.2001	
Belo Horizonte	4.7179	
Rio de Janeiro	13.0807	
São Paulo	8.3091	
Curitiba	-0.1767	
Porto Alegre	-2.2916	
Distrito Federal	2.6660	
1992	(base category)	
1993	0.4798	(base category)
1995	-0.4255	-0.7162
1996	-0.3531	-1.4708
1997	-0.3578	-1.0583
1998	-0.9647	-2.1904
1999	-0.5025	-0.1280
2001	-0.8371	-0.5554
2002	-1.1397	-1.4599
2003	-1.1095	-1.5124
2004	-1.2771	-1.1227
2005	-0.8407	-0.5239
2006	-0.8785	-0.8126
2007	-1.0204	-0.4342
2008	-0.6300	-0.3258
2009	-1.3448	-0.4683
2011	-0.5902	-0.3417
2012	0.0523	0.6042
Constant*	25.7093	35.0344

*All variables were statistically significant at 1% on both models

Source: elaborated by the author

Our main interest in both models is the coefficients values, so that is what we look to interpret our results. However, we can note that, as a general measure of goodness of fit, that all variables were statistically significant at 1%. Also, the last year was omitted due to high multicollinearity

From Model 1, we can see that commute times in the metropolitan regions of Brazil have an upward trend – each year increases, an average, 0.19min, *ceteris paribus*. Besides, São Paulo's trend grows even faster than the rest of Brazil: an average 0.16min more each year. Being said that, we could say, preliminarily, that the *Rodízio*, by itself alone, wasn't able to stop the growing trend in the commute times in the region as a whole.

For the MR dummies, Belém is the base category (it is the only North region). Southeast regions – São Paulo, Belo Horizonte and Rio de Janeiro – have higher commute times compared to it, being that São Paulo is the second highest. Northeast region – Fortaleza, Recife and Salvador - have medium increases compared to the base category. South regions – Curitiba and Porto Alegre – have lower commute times compared to Belém.

The second column shows the MRSP data prior and after the Restriction Program. São Paulo's commute times grows, an average, at 0.29min each year, *ceteris paribus*, as shows the deterministic trend coefficient. For the year dummies, it is interesting to note both the sign and the size of the coefficients. The sign is negative for all years, except the last one (2012). It means that commute times are lower from 1995 to 2011 compared to the base category – 1993.

The highest negative sign is exactly for the year of 1998 and, by no coincidence, it is the first year of implementation of the *Rodízio* and the period that it was more effective. The next years we can almost see a decrease in its effectiveness, since the signs are becoming less and less negative, until 2012 when it becomes positive. If we account for both the deterministic trend and the year dummies, we shall see that 1998 is the last year that commute times are lower than 1993.

7. Conclusions

São Paulo's Restriction Program for Motor Vehicle Traffic was truly milestone in the history of Brazilian traffic policies. Despite strong political and public difficulties, it was implemented in the heart of the largest metropolitan region of the country.

Transport data in Brazil is quite scarce, so we opted for the IBGE's PNAD for its coverage, length and methodological advantages. The main question about commute times is both interval and censored in nature. Consequently, we used an interval regression approach that takes both into account.

Given the results, we can state two consequences about the Restriction Program of São Paulo. First, the policy alone wasn't enough to stop the growing trend in São Paulo's commute times given its unique and complex traffic and socioeconomic dynamics. Since it has many intrinsic limitations: as space (it is valid in the Expanded Center); mode (only valid for automobiles and trucks); and time (a vehicle is only prohibited of circulate one weekday).

Second, the *Rodízio* was highly effective in the "short-run" (its first year). After that, agents could adapt to the new scenario in order to live with or to bypass it, in the first moment changing their mode choice or simply buying another vehicle. After that, people could think about new options of workplace/residence and, also, by the very own trend growth of income, employment and population more trips were made to the Expanded Center and it was becoming less and less effective (on the legal side, more categories of vehicles became exempted from the Restriction as time passed).

Recent political scenario changed the transport paradigm as happened with Ken Livingstone's election in the early 2000's in London. The election of Fernando Haddad as mayor of São Paulo in 2013 shifted the auto-oriented policies towards transit and cycle. At the beginning of his term, São Paulo had almost no cycle infrastructure and only 90km of exclusive bus lanes; his objective was 400km of cycle paths and 150km of bus lanes. By 2016, it accounts for 318.7km of exclusive bike lanes and 31.9km of cycle routes according to the Traffic Engineering Company (*Companhia de Engenharia de Tráfego* or simply *CET*) (CET, 2016). By 29 February 2016, the city of São Paulo reached the mark of 500km of exclusive bus lanes (SÃO PAULO, 2016).

Yet, a policy that always seems to hover around the city is the congestion charge. Although it is a consensus between economists and even politician, it still faces strong public opposition. Still, it is the sole policy that can truly cope with the congestion problem. We expect to see it in the future as more vehicles are dumped into the road and traffic conditions worsen.

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