SÃO PAULO'S SHORT AND LONG TERM PRICE ELASTICITY OF BUS DEMAND ESTIMATION

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RESUMO: São Paulo é a maior cidade do Hemisfério Sul, com aproximadamente 12 milhões de habitantes que realizam por volta de 25 milhões de deslocamentos por dia. Seu sistema de transporte público (ônibus e metrô) agrega 25% delas, sendo notavelmente importante, especialmente para seus usuários frequentes – pessoas pobres cuja mobilidade pode depender dele. A Prefeitura de São Paulo gasta quase 7% de seu orçamento em subsídios aos ônibus, um número que cresceu 61% nos últimos quatro anos, uma vez que os custos são crescentes e a tarifa permanece estagnada em termos reais desde 2005. O presente trabalho visa calcular a elasticidade preço da demanda por ônibus em São Paulo, uma informação importante para responder se o preço da tarifa é eficiente em manter o ônibus acessível monetariamente e, eventualmente, em fazer com que usuários troquem o carro próprio pelo transporte público – isso é: permitir a mobilidade das pessoas e melhorar a sustentabilidade da cidade. Para tal, dois Modelos de Escolha Discreta são estimados para os anos de 1997 e 2007, usando a pesquisa de Origem e Destino do Metrô; eles fornecem a elasticidade de curto prazo dos modais. A implantação do Bilhete Único (2004), então, é considerada um choque exógeno no preço dos deslocamentos que utilizam mais de um ônibus e utilizada como oportunidade de estimação da elasticidade de longo prazo. Os resultados sugerem que a demanda por ônibus é preço-inelástica tanto no curto, quanto no longo prazo, o que corrobora a literatura prévia existente.

ABSTRACT: São Paulo is the biggest city in South Hemisphere, with almost 12 million inhabitants that make around 25 million trips per day. Its transit system (bus and subway) accounts for 25% of those trips and is remarkably important, especially for its heavy users - poor people whose mobility might depend on it. The local government spends almost 7% of its budget in bus' subsidies, a figure that grew by 61% in the last four years, since costs are increasing and fare remains stagnated in real terms since 2005. The present work aims to calculate the price elasticity of bus demand in São Paulo, an important information to answer whether the fare is efficient in maintaining bus affordability and eventually shifting car commuters to transit - that is, keeping people's mobility and enhancing city's sustainability. In order to do so, two Discrete Choice Models are estimated for the years of 1997 and 2007, using a household survey on commuting we estimate short-term elasticity. Then, Bilhete Único implementation (2004) is considered an exogenous shock on trips' cost for those using two buses or more on their commuting and used as an opportunity for estimating long-term elasticity. The results suggest that bus demand is inelastic with respect to price both in the short and the long term, which corroborates previous literature.

[1] FUNDAÇÃO GETULIO VARGAS – ESCOLA DE ADMINISTRAÇÃO DE EMPRESAS

INTRODUCTION

In 1872, São Paulo was 318 years old and its population was 31,385. The village, composed by "poorly hedged hovels, unpaved streets, puddles, few people on the street, animals sleeping by the corners" (Toledo, 2015, p. 16) began to be crossed by trams – actually, donkey-drawn vehicles, whose replacement by electric trams started in 1899. 82 years later, in 1954, São Paulo's 2.9 million inhabitants eclipsed Rio de Janeiro's and it became Brazil's largest city – and still it is.

Nowadays, São Paulo (SP) is a global city, a financial centre that accounts for 12% of Brazil's GDP. It is home to 12 million people and the heart of a 20.7 million people conurbation of 39 municipalities - the Metropolitan Region of São Paulo (MRSP). As in many other metropolises around the world - especially when fast growth caused urban sprawl -, mobility is an issue and not rarely the traffic is the subject of conversations in elevators (usually following comments about the weather). And moving around São Paulo's streets might be challenging and stressful, once traffic jams are frequent and chaotic. A radio station dedicated to informing drivers about traffic status, 24h per day, was launched in 2007 and local news daily talk about the jams. Traffic also causes economy inefficiency and many negative externalities on public health, environment, traffic flow, etc.

The decennial Origin-Destination Survey of 2007 – a 30 thousand families' household survey on commuting realized by the São Paulo Metropolitan Company (Metro), the state-owned company that runs city's subway system -, shows that MRSP resident's daily number of trips is around 38 million (METRO, 2008). The figure is 21% higher than 1997 (METRO, 1999), while the population grew by 16% during those years. This increase did not necessarily impose pressure over traffic volume and it is probably a gain for people's mobility: they are moving around town more frequently. Traffic chaos might be best explained if one notice that 42% of these trips are made by people on cars. In 2015, MRSP's vehicles fleet was around 12 million - SP accounts for 7.5 million of them, of which 70% are cars. If all of them go out on the street - SP has 17,000 kilometres of paved streets - at the same time, it would very likely cause an instant gridlock.

Abstractions aside, São Paulo accounts for approximately 25 million, or 65%, of MRSP daily trips. Of these, 31.6% are made using individual modes and 31.3% use some kind of active mobility. The other 37.1% rely on public collective modes, as Figure 1 shows. The total number of trips in São Paulo grew by 18.9% during the 1997-2007 period. Figure 2, that contains information on the principal mode taken, also shows that the main modes - walking, driving and riding bus - grew up in absolute terms. However, only the latter grew up as a proportion of all trips, from 24.05% to 24.22%.

Figure 1 - Daily trips in São Paulo (city) by transport mode - 1997 and 2007. Total is 18.9MM for 1997 and 22.5MM for 2007. The numbers on the bars represent the mode share for each year. Source: OD Surveys 1997 and 2007.
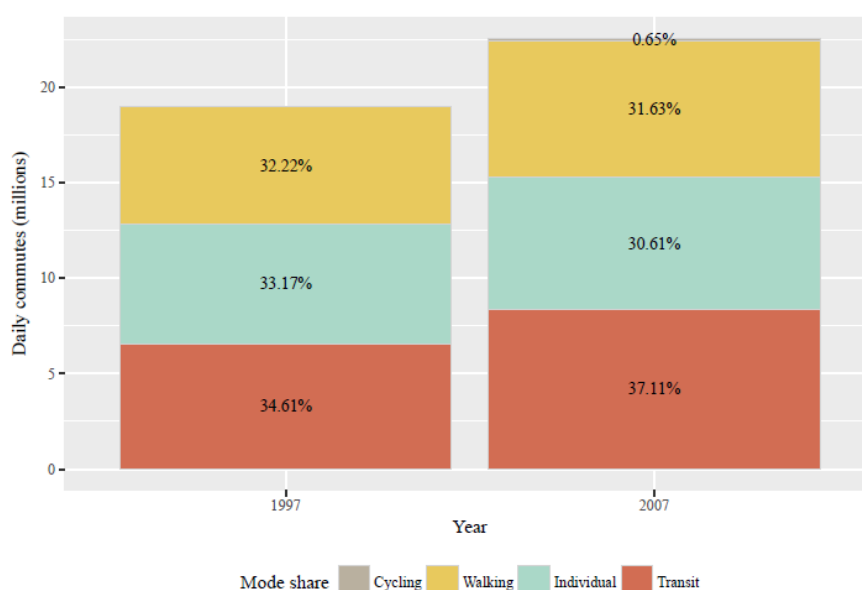
Figure 2 - Daily trips in São Paulo City by principal mode - 1997 and 2007. Total is 18.9MM for 1997 and 22.5MM for 2007. The numbers on the bars represent the mode share for each year. Source: OD Surveys 1997 and 2007.
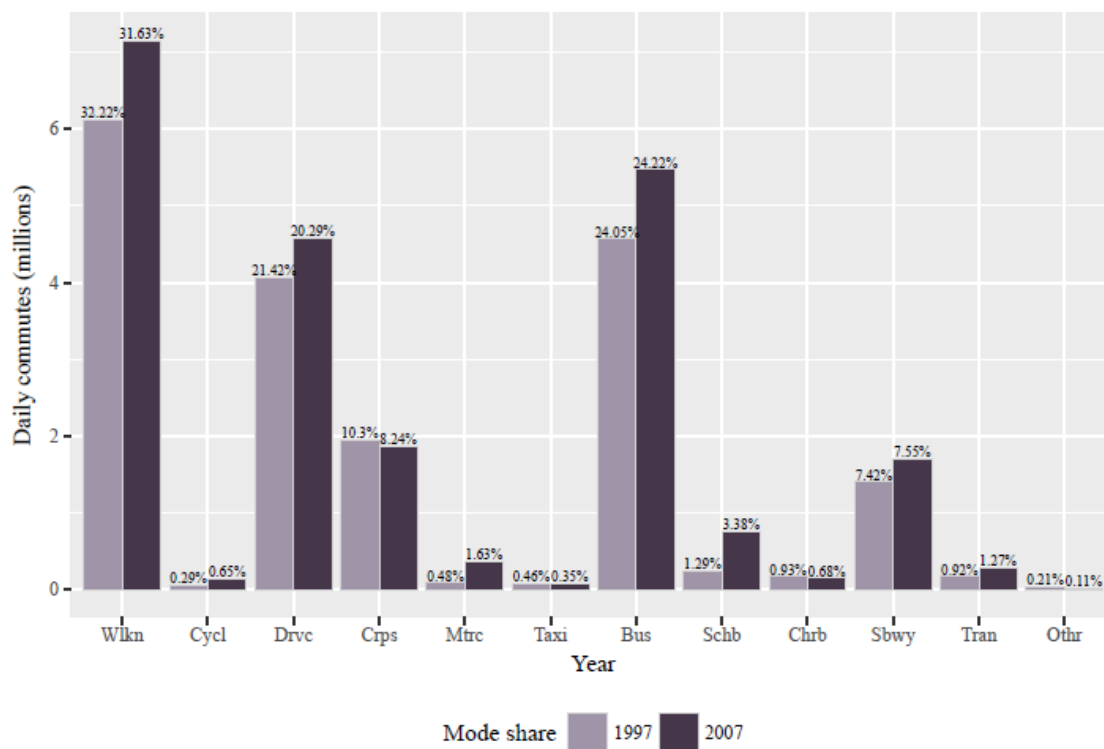
Both commuting pattern and mode share are also markedly different when considering commuters' income level. Figure 3 follows the same logic as Figure 1, but commuters are divided in deciles of familiar income. Two aspects are instantly noticed when looking at this graph: first, the number of daily trips grows up as income increases. The 20% richer commute two times more than the 20% poorer. Second, the mode share is entirely different between income levels. While the poorest commuters rely on walking and transit, more than half of the richest's trips are made by car. This simple analysis denotes the importance of transit not only for transportation system itself, but also because sometimes it is the only way poor people can move around town. That is to say: transit is remarkably important for São Paulo's mobility, and even more important for poor people's mobility.

Figure 3 - Daily trips in São Paulo City divided by principal mode and familiar income quintile - 1997 and 2007. The numbers on the bars represent the mode share for each quintile, for the correspondent year. Data: OD Surveys 1997 and 2007.
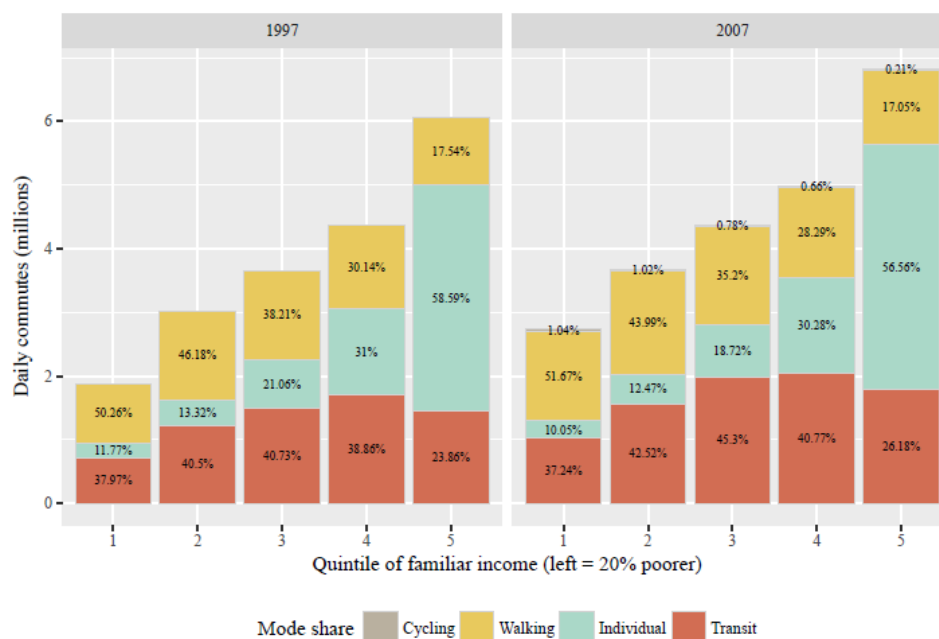
São Paulo's transportation system as a whole raises issues that reach many areas of concern. At the individual level, one person who commutes face many important decisions that can cost her time - Which

mode is faster? What time to leave? Which route to take? - and money: the average familiar income share that goes toward paying urban public transportation in Brazil is around 15% (Carvalho & Pereira, 2012). Mobility is also a government's concern, and keeping transit fare affordable - perhaps by subsidizing it - means guaranteeing people's mobility. On the other hand, governments obviously face budget constraints. Between 2013 and 2017, São Paulo's budget in real terms remained stagnated, while bus subsidies grew by 61%, reaching approximately 0.818 billion USD. This grant covers only 32% of bus system's cost and represents almost 7% of city's budget. This allocation problem reached the public debate during the past years.

Thus, one substantial problem in the intersection of transport economics and public policy is how to provide or regulate transit having in mind that **"urban transport can contribute to poverty reduction both indirectly through its impact on the city economy and hence on economic growth, and directly through its impact on the daily needs of poor people"** (Gwilliam, 2002, p. xii). This is a new paradigm in urban transport strategy that essentially comprise keeping fare affordable and the system itself efficient. The future work approaches an important information on the topic, regarding this paradigm: price-elasticity of demand.

Understanding the effects of price change over ridership is important for both practice and theory in many aspects. For instance, planning transit supply, approaching its financial aspects, considering whose familiar budget will be affected or who will face mobility deprivations in an eventual fare rise, providing clues on whether subsidies are cost-efficient, among other. Furthermore, it might also help to strengthen public transit as a whole, which is a crucial factor in cities sustainability.

Thus, the present work aims to close this gap and contribute to the debate by calculating São Paulo's price elasticity of bus demand, for both short (each cross section, 1997 and 2007) and long (ten years period) term. In order to do so, the work relies on estimating two Discrete Choice Models, as proposed by Daniel McFadden (1973, 1974), using OD Surveys' data of 1997 and 2007 and some simulation. Discrete Choice Models consider that each individual can decide on his or her commuting mode in a choice set - where price and duration associated with each mode is known by him or her - and does so in a semi-rational way; thus, one part of her utility function is considered random. The model is estimated with a multinomial logit regression - the coefficients are changes on probabilities of one choosing each mode, if some independent variable changes and everything else remain constant - from which aggregate probabilities of each mode being chosen can be derivate, as well marginal effects of independent variables on these probabilities. The latter provide short term elasticities. The first is the aggregate demand (Hensher & Bullock, 1979) that, if estimated for 1997 and 2007, can be compared in order to calculate long term elasticity; however, an exogenous price shock is required for that. Hence, the innovation proposed in this paper is to use Bilhete Único (BU) as source of an exogenous price shock.

Bilhete Único, implemented in 2004 by São Paulo's city government, is a transit ticketing smart card. The fare pattern allows users to pay for the first ride and make up to three bus transfers within three hours not paying for any transfer. Commuters can also use it to pay 23% less (in comparison to paying for both modes) when taking the metro or train before or after taking up to three buses. OD Surveys make clear that users have changed their behaviour: in 2007, around 24% of bus users made one or more transfers, against 15% in 1997. BU is also a public policy that notably makes transit fares cheaper for people who spend more time (and distance) commuting, once users pay progressively less for its use and those happen to be the poorest in the city.

One limitation of the proposed approach is that the long-term elasticity can only be calculated for the commuting form that uses more than one bus. Nonetheless, it is useful in the terms said above - especially once one considers that the affected users are workers who live on São Paulo's outskirts and commute for two or more hours to São Paulo's downtown every day.

This work is organized in five sections including this introduction. In the following section we position the paper in the literature, which will go over transport economics, to qualify the hypothesis and

research questions. After that, the methodological section presents the econometric strategy to answer the questions of interest discussed above. The results are presented in the homonym section and discussed thereafter considering the consequences for public policy. The conclusion is the last section and sums up the paper.

TRANSPORT ECONOMICS AND THE RELEVANCE OF PRICE ELASTICIY IN TRANSPORT PLANNING

Although transport economists usually focus on price and demand, there are many other important factors affected by transport related issues - and influencing them. Brueckner (2011), for example, converge upon transport many aspects of urban economics' analysis, as firm location and spatial concentration of jobs. The latter is explained by two major forces: scale economies and agglomeration economies. The first regards the fact that specialization leads to more productivity and economic gains. The second is about the gains that happen when firms locate one next to another, due to easiness on hiring workers, competition and/or cooperation between firms, knowledge spillovers, among others.

Transportation costs savings are one type of agglomeration economy in that final product shipping cost is (very likely) reduced when a firm locates in a city - closer to its final market, workers and, perhaps, to its inputs supplier. Those forces not only explain cities formation, but they also explain why many cities are monocentric (a town in which employment is concentrated close to the city centre) because firms tend to concentrate where others are already located (Brueckner, 2011; Quinet & Vickerman, 2004). Brueckner (2011) argues that transport plays a central role in cities formation itself, what is empirically discussed by Glaeser (2011) emphatically. Urban transportation is then key for people's location on cities and, in a big town, one is very likely to spend a big amount of time commuting, every day. Transportation costs are one of the most important forces on cities dynamics: it influences firm location, cities formation and subsequent size, residents location and land and dwellings prices (Brueckner, 2011; Quinet & Vickerman, 2004).

Those factors make transport as a natural subfield of economics, as mentioned by McFadden (2011) in the foreword of A Handbook of Transport Economics, edited by De Palma, Lindsey, Quinet and Vickerman (2011). His opinion is that there is a specific subfield of "economics of transport" in the sense that the problems addressed by it - namely: supply, demand and regulation (Quinet & Vickerman, 2004) - are fundamentally of economics. But why should it be so special? Could not it just be a subfield of microeconomics? The authors agree that transportation is a very specific sector which "deserves its only economics subfield" because it has some very specific characteristics that make necessary adjustments on models. The most remarkable specific features are the role of *space*, *time* and the *multiplicity of agents' decisions* (McFadden, 2011).

Regarding *space*, he shares what was said about urban factors before in this work. Activities are located in space and the gaps between them affect costs and, therefore, influence land cost and generates spatial inequalities. *Time* is seen as an attribute of all consumption, but is even more important for transport, once it is required for mobility itself. The role of transport in *individual's decision process* unfold in two parts: choices regarding mobility consumption itself and those that are part of a much wider set of decisions, once transportation is necessary for (or consequence of) other activities. That is, one has to choose where she is going to live, for instance. Her home location is, therefore, influenced by commuting costs to her workplace. This long-run decision unfolds itself in many short-run, daily choices: to use car or transit, what time to leave, whether to park on the street or to pay for a spot in a private parking lot, etc.

Lately, great attention has been given to urban transport, particularly public collective transport, once developing country cities' sustainability depends on less congestion - mainly caused by cars - and more efficient and intensive uses of the existent infrastructure (Brinco, 2006). Thus, this is a relevant subfield in many disciplines, and the exhaustiveness of research is accompanied by methodological sophistication that have led to very robust results and theoretical progress.

Regarding pricing form, Bird (2001) defends user charges - a direct price for a service or good which is paid by the identified user of it - whenever possible, because they should maximize efficiency and welfare

of a scarce resource. The author says that "the main economic rationale of user charges is thus not to produce revenue, but to promote economic efficiency" (p. 172), in that people will over consume a scarce resource - what is a problem because of the very simple reason that resources are scarce, particularly in developing countries - if it is funded by general taxes. Over-consumption would happen because consumers choose to consume a good until its marginal cost equals marginal benefits of consumption. If citizens are not directly charged when pursuing a good or service (i.e. they do not perceive the cost they pay for a good once it is financed by general taxes), the cost of consuming an additional unit is virtually zero. Over-consumption is then tightly associated with under (or subsidized by non users) pricing.

User charges appears to be literature's preferred form of urban services financing. Bahl and Linn dedicate a chapter of their seminal book Urban Public Finance in Developing Countries (1992) to discuss issues that exist on public services pricing. They highlight four main concerns associated with that: efficiency, fiscal constraints, equity and growth and political and administrative feasibility. All of them must be considered together and their principles can be applied to any kind of public service.

Efficiency on pricing urban public services is fundamentally maximizing welfare and, as mentioned before, this is achieved when the price is set equal to the marginal cost of its production. Bird (2001) points that efficient public services or goods user charges (prices) should be exactly its marginal economic cost. This would also enable the achievement of a socially desirable level of prices. "The justification of this rule is that welfare is maximized when the benefit of an additional unit of the service to the consumer - which is reflected by his willingness to pay the price - is equal to the cost of producing this additional unit." (Bahl & Linn, 1992, p. 241).

Marginal cost pricing rule allocates resources efficiently because it achieves the output level that produces the highest net utility for the Economy (Bahl & Linn, 1992; Bird, 2001). Although it is clearly the scheme of taxation recommended by literature, it requires a few assumptions which are hard to find in practice: perfect information, absence of externalities, distortions in the economy, transactions costs and zero economic surplus. Besides these, there is another assumption that the present work might help to relax (or not) in practice: demand cannot be perfectly price-inelastic: it should respond to price changes. Even though those aspects impose several limits to the rule's application, Bahl and Linn argue that it still provide relevant implications, such as drawing government attention to economic costs (and not to sunken or "historical" costs) and to the necessity of price readjustment during inflationary periods.

There is no evidence on how bus fare is priced in São Paulo, but the financial deficit generated by the system is heavily subsidized by general taxes. General fund financing might be acceptable if the following conditions are met: a deficit still exists after marginal cost pricing, general funds can be collected with no distortion to resource allocation and if the financial deficit does not affect investment and management decisions. There is also an equity concern: is it fair and/or social desirable to fund someone's consumption in a crucial service?

Nevertheless, distortion-free levies are virtually non-existent and thus the question becomes whether general fund financing - that is, subsidies - causes a smaller distortion than users charges higher than the marginal (or full) cost of service provision. The latter might be advantageous to bear governments in mind of a service affordability when they are designing it - that is, governments should never design services which the population cannot afford. Developing, resources constrained, governments always face a trade-off between service quality and coverage. These arguments add to Bird (2001) opinion that positive externalities caused by the provision of a service can justify government subsidies.

Congestion causes many externalities - air pollution, noise, accidents, urban barriers, landscape effects, energetic inefficiency (Friedrich & Quinet, 2011) and even plunges on workers productivity (Haddad & Vieira, 2015). If there is good evidence that public transit mitigates those negative externalities, it might make sense to subsidize this service. However, in 2016, São Paulo's government spent around BRL 2.7 billion (approximately USD 0.818 billion) in subsidizing the bus system, which costs around BRL 8.2 billion (or USD 2.485 billion). Spent estimate for 2017 is around BRL 3.4 billion. Subsidies have been

growing through the years while city's budget is stagnated in real terms. Those figures are even more impressive once reappraising that most cities in Brazil do not even subsidize transit and brings up again the question on whether transit should or not be subsidized.

Pricing the fare adequately means not only to promote efficiency, but also to keep transit affordable - what is of extreme importance. Carruthers, Dick and Saurkar (2005) refers to affordability of public transit as whether "the financial cost of journeys put an individual or household in the position of having to make sacrifices to travel or the extent to which they can afford to travel when they want to" (Carruthers et al., 2005, p. 1). Affordability might be seen as a degree of transit accessibility and is important in developing countries as Brazil, where poor's mobility depend on it (Carruthers et al., 2005; Carvalho & Pereira, 2011; Gwilliam, 2002).

Carvalho and Pereira (2011) also point out that bus system's costs and fare prices have increased all over Brazil during the last decades, while ridership has decreased during the 1990's. This dynamic makes transit more and more expensive because there are less people paying for the system as a whole (since service level takes time to adjust to ridership demand). Another problem pointed by Brinco (2006) is that Brazilian transportation policy is highly car-oriented: there is a development paradigm centred on cars, which has deleterious effects over public collective transportation.

Hence, the picture that literature makes of public transportation system in Brazil is that of municipalities and concessionaires providing a poor service while central government agenda does not accommodate policies that could favour it. Transit cost is high and has soared lately, imposing pressure over people's (and a few municipalities') budget, specially over those who are poor, live on the outskirts of metropolitan areas and whose mobility depends on public transit. Looking closer to public policies' state of practice, they struggle to follow academic recommendations. Public policies of transport find themselves in the middle of complicated theoretical models and a "world which does not comply with its requirements for optimality" (Quinet & Vickerman, 2004, p. 341). Public collective transportation is a subfield affected by the same, but even more critical, adversity. This is notably true in developing countries where - although academics' recommendations are less developed - state's built capacities are even worse (Bräutigam, 2008; Fjeldstad & Moore, 2007; Keen, 2012). Thus, a huge imbalance between the state of the art and practice exists.

Besides cities sustainability - and especially if we shift our analysis to Brazil - another feature of public urban transportation worth attention: transit is how poor people's mobility might be guaranteed (Gomide, 2003, Carvalho & Pereira (2011)). Public transit then becomes even more important if one considers its capacity of poverty alleviation and social development (Gomide, 2003). But this might only happen if it is priced properly (Estupiñán, Gómez Lobo, Muñoz Raskin, & Serebrisky, 2007). To price fare adequately also means to strengthen transport system itself (Carvalho & Pereira, 2011) because of efficiency reasons.

If one considers that investment on public transit has positive externalities through congestion mitigation (McFadden, 2011; Quinet & Vickerman, 2004) it can also have positive impact over economy and productivity (Gwilliam, 2002, Haddad & Vieira (2015)) and poverty-reduction (Gwilliam, 2002). In brief, valuing public transit is valuing urban development and sustainability. It is then possible that transit generates enough positive externalities for society in that subsidies might be justifiable.

On the other hand, there is a debate in the literature about how efficient are subsidies in urban transportation on getting the poorest better. Estupiñán et al. (2007) suggest that supply-side subsidies are neutral or regressive, while demand-size subsidies might be more efficient.

The two major recommendations made by literature thus are to keep transit affordable and make it as efficient as possible - possibly through proper user charges and pricing. Thus, keeping transit fare affordable means guaranteeing people's mobility and boosting development. On the other hand, governments obviously face budget constraints and subsidize one policy that can be priced on marginal cost does not bring maximum efficiency. **Thus, once transit strengthen might consolidate urban**

development and sustainability and mitigate congestion externalities, a key factor to be known in any transit system is price elasticity of demand, because (a) it helps on pricing the fare on the demand level that causes the greatest welfare and (b) it helps to mitigate effects on demand shifts caused by fare variation that can jeopardize people's mobility.

For all passenger transport (not only just public collective), price elasticity is usually small or inelastic in the short-term and larger in the long-term (Quinet & Vickerman, 2004). Quinet and Vickerman (2004) review a series of studies and present that urban public transport's elasticities are, at average, -0.3, varying from -0.1 to -0.6, in the sort-term. In the long-term, they are usually about double these values.

Wang and Skinner (1984) calculate this values for seven American cities and achieved values ranging from -0.042 to -0.62. They use a time-series model, considering monthly ridership as the demand and controlling for many variables, real price being one of them. The literature reviewed by them find values from -0.04 to -0.87 through various methods. Hensher and Bullock (1979) calculate price elasticity of Sidney's, Australia, rail services. The value found was -0.57. In Brazilian literature, only a few studies that seek those numbers are found. Carvalho and Pereira (2011) get price elasticities for 10 cities together. At average, the number they get is around -0.6.

Thus, work's research question is **"what are long and short-term price elasticities of bus demand in São Paulo?"**, given city's and system's importance. This is useful to enrich academical debate - and might also provide transit planners and technicians good information to act - on bus subsidies and fare pricing.

Research question also entail another two questions brought by the literature review:

1. Since one of subsidies' justification is transit positive externalities, larger subsidy for bus system would make commuters shift from car to bus, mitigating congestion and improving city's mobility? and
2. How does it differ between poor and rich people and what does it means for user charges?

The **hypothesis** raised during the literature review are the following:

1. Price elasticity of bus trips demand in São Paulo is negative and smaller than one, that is, inelastic, in the short-term.
2. Price elasticity of bus trips (with one or more transfers) demand in São Paulo is negative and greater than the short-term one, that is - less inelastic - in the long-term.

It is worth mention that the approach for verifying the second hypothesis is, somehow, innovative, once it identifies Bilhete Único implementation as an exogenous price shock in trips that use more than one bus - that is why long-term elasticity is only calculated for this kind of trip. In 2004, São Paulo's city government changed the system of payment for buses and implemented a public policy called Bilhete Único (BU), a smart card that allows users to pay for the first ride and make up to three bus transfers - that is, taking up to four buses - within three hours. Imagine an individual that takes two buses to work. In 2004, this individual happened to spend half of she used to spend on transit - literally - overnight.

EMPIRICAL METHODS

To answer the question and verify the hypothesis, we propose to make use of Daniel McFadden's Discrete Choice Model (1973, 1974), an approach which is traditionally used in transport economics field - and in others, also. McFadden's work is considered to has "fundamentally changed the way empirical economists study individual behavior" (Manski, 2001, p. 224). His 1973 article's "most striking characteristic (…) is its smooth progression from a conceptual contribution of great generality to a practical contribution of immediate usefulness" (Manski, 2001, p. 224), what also make the model interesting here.

The model is as follows: consider that an individual i chooses her commuting mode, called here m (which belongs to her choice set[2], M). Consider also that she does so maximizing her utility U (the well-being achieved when consuming the good (Nicholson & Snyder, 2005; Quinet & Vickerman, 2004)), which is subject to budget constraints:

$$MaxU_{im}, \quad p_m x_m \leq R, \tag{1}$$

where p_m and x_m are the price and quantity consumed of mode m and R is the budget to be spent on commuting.

On the semi-rational model proposed by McFadden (1973), the utility function is not fully observable or quantifiable by the researcher; nevertheless, it can be modelled in the following way: first, divide U in two terms - one that is observed and one that is not. The first, V_{im}, is usually called *representative utility* or *systematic component* (Train, 2009). The latter, ε_{im}, is the unobserved part and it is considered *random* or *stochastic*. According to McFadden (1973, p. 108), the first term *"reflects the 'representative' tastes of the population"* and the second, *"the idiosyncrasies of this individual in tastes for the alternative"*. Then, U is defined as:

$$U_{im} = V_{im} + \varepsilon_{im}, \tag{2}$$

where V_{im} is the indirect utility, that incorporate budgetary constraints and price. Given the choice set M, the decision maker will choose the mode m that maximizes her utility. Let's say that b and c are possible choices and $P_b = Pc$, one might choose the latter when $U_b > Uc$.

As the researcher do not observe ε_{im}, *"choices can only be modelled in terms of probabilities"* (Croissant, 2012, p. 11). Then, considering ε_{im} stochastic, the joint density of vector $\varepsilon_i = \langle \varepsilon_{i1}, \ldots, \varepsilon_{im} \rangle$ is $f(\varepsilon_i)$, that allows for making probabilistic statements about an individual's choice (Train, 2009). In other words, from decision maker's point of view, the choice is purely deterministic; however, from the researcher's point of view, there is an unobserved part that composes utility and, then, it can only be formulated in probabilistic terms (Croissant, 2012). In a similar way as proposed by McFadden (1973), probability P_{ib} that i chooses b over other modes m in the choice set M is then:

$$\begin{aligned} P_{ib} \quad &\equiv P(b|i, M) \\ &= P(U_b > U_m), \forall m \neq b \\ &= P(V_{ib} + \varepsilon_{ib} > V_{im} + \varepsilon_{im}), \forall \, m \neq b \\ &= P(\varepsilon_{im} - \varepsilon_{ib} > V_{ib} - V_{im}), \forall \, m \neq b \\ &= \int_{\varepsilon} I \, (\varepsilon_{im} - \varepsilon_{ib} > V_{ib} - V_{im}) f(\varepsilon_i) d\varepsilon_i, \forall \, m \neq b, \end{aligned} \tag{3}$$

where $I(\cdot)$ is an indicator function which is equal to 1 if the expression is true and 0 if is not (Train, 2009). Considering all m modes available at the choice set, the probability of b is chosen (i.e., a general form that relates all the choice set of equation (3)) is, therefore:

$$\begin{aligned} P_{ib} \quad &= Pr(U_b > U_1, \ldots, U_b > U_c, \ldots, U_b > U_m), \forall \, m \neq c) \\ &= Pr(\varepsilon_{i1} - \varepsilon_{ib} > V_{ib} - V_{i1}, \ldots, \varepsilon_{ic} - \varepsilon_{ib} > V_{ib} - V_{ic}, \ldots, \varepsilon_{im} - \varepsilon_{ib} > V_{ib} - V_{im}), \forall \, m \neq c) \end{aligned} \tag{4}$$

Being F_{-b} the multivariate distribution of all but b's error terms, the unconditional probability can also be written in the following terms:

$$P_b = \int F_{-b}[(V_b - V_1) + \varepsilon_b, \ldots, (V_b - V_m) + \varepsilon_b] f(\varepsilon_b) d\varepsilon_b \tag{5}$$

McFadden (1974) then shows that, if 3 assumptions holds, probabilities' closed forms can be estimated through a multinomial logit. They are organized by Croissant (2012) in a simpler way, that are shown on the Appendix. It is demonstrable, then, that a logistic transformation of the deterministic utility,

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[2] The choice set is the group of alternatives that might be chosen by one individual in a discrete choice process.

V_{im}, is equal to the closed form of the probabilities. Departing from equations (3) and summing up hypothesis 1 and 2,

$$P(\varepsilon_b < V_b - V_m + \varepsilon_b) = e^{-e^{-(V_{ib}-V_{im}+\varepsilon_b)}} \tag{6}$$

The unconditional probability of b being chosen is, hence:

$$P_b = \frac{1}{\sum_m e^{-(V_m-V_b)}}, \tag{7}$$

which is exactly the logit probability:

$$P_b = \frac{e^{V_b}}{\sum_m e^{V_m}}, \tag{8}$$

and can be estimated by maximum likelihood with a multinomial logit regression.

Once the model is estimated, the marginal effects with respect to individual-specific variables is:

$$\frac{\partial P_{im}}{\partial z_i} = P_{im}(\beta_m - \sum_b P_{ib}\beta_b), \tag{9}$$

and the marginal effects with respect to mode-specific variables is:

$$\frac{\partial P_{im}}{\partial x_{im}} = \gamma P_{im}(1 - P_{ib}), \tag{10}$$

Applying (10) with respect to price, in this context where there is one model for each OD Survey year, gives exactly the **short-term price elasticity of demand**.

We can also justify that a weighted sum of each individual's P_{im} equals the demand Q_{im} of trips by the modal m (in terms of all trips), as made by Hensher and Bullock (1979), Train (2009):

$$\hat{Q}_m = \sum_i w_i P_{im}, \tag{11}$$

Which supply the demand on the equation below, which provides the **long-term price elasticity of demand**:

$$e_P = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}, \tag{12}$$

However, in practical situations, it is not possible, for example, to know if an eventual variation of Q was really due to ΔP or caused by any other factor (Wang & Skinner, 1984). Then, we propose applying 1997's model's coefficients over 2007's model's data, which works as a prediction of 2007's demand if the environmental characteristics of 1997's would not have changed.

Summing up, the research design is:
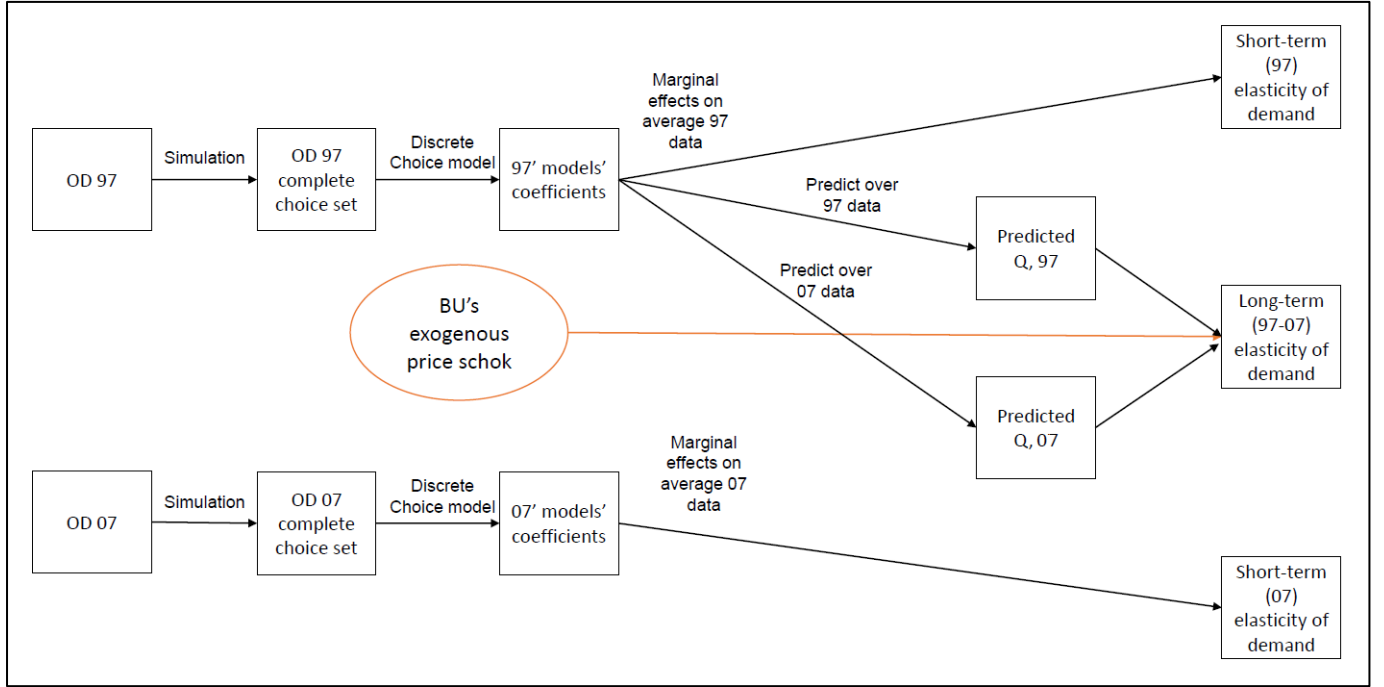
RESULTS

V_{im} can be described in terms of:

- Individual specific variables z_i with an alternative specific coefficient γ_m,

- Alternative specific variables t_{im} with an alternative specific coefficient, δ_m and

- Alternative specific variables x_{im} with a generic coefficient β,

The second and third set of variables differ on whether their coefficients are different for each mode. This allows for valuating one attribute differently for different modes. The representative utility is generically specified as:

$$V_{im} = \alpha_i + \beta x_{im} + \gamma_m z_i + \delta_m t_{im}, \forall m \tag{13}$$

Thus, the present work estimates models using OD data with the following specifications: first, one with cost and time associated with generic coefficients (one minute spent on whatever mode causes the same disutility for the individual):

$$V_{im} = \alpha_i + \beta_1 cost_{im} + \beta_2 time_{im} + \boldsymbol{\gamma_m Z_i}, \forall m \tag{14}$$

and then, treating time's coefficient as mode specific (allowing time spent on one mode to causes different disutility than time spent on other modes):

$$V_{im} = \alpha_i + \beta_1 cost_{im} + \boldsymbol{\gamma_m Z_i} + \delta_m time_{im}, \forall m \tag{15}$$

$\boldsymbol{Z_i}$ is a set of demographic variables concerning individuals, and $\boldsymbol{\gamma_m}$ stands for the coefficients associated with each variable, for each mode.

The variables are found on (or are possible to simulate based on) the Metro's OD surveys. The surveys also inform which mode was used on the trip. As mentioned before, Metro's OD surveys ask each resident of a sample of households about their trips on the previous day of the interview. Therefore, it collects information about the respondent (as age, gender, income, educational level, occupation, *etc.*) and

the trip (duration, starting and ending point, motivation, hours, *etc.*). This means that the ODs do not present all the mode options (and option's features, as price and time it would take) that are available to this person before she makes her decision about the mode to be used on a trip. For example, if someone has made a trip using a bicycle, we know how long did this trip take, but we do not know how long it would take if this individual has chosen to go by bus. Thereby, a few assumptions and simulations are required. First, we assume that all modes are available to be chosen by every individual for every trip reported on the OD survey. Second - once the model also requires information on price and time of all mode options available for the trip - we simulate trip's price and time in non-taken modes. We also have to simulate trip's price if it was made by a mode which has not a fixed price (namely, car; bus fare, for example, is fixed, thus we know exactly how much did a trip by bus cost). Simulation's description can be find in the Appendix.

Thus, these steps provide a sample of trips in São Paulo collected by the ODs surveys. For each trip, we have individual's demographic characteristics (observed), a set of alternatives modes and its respective price and time (either observed or simulated), and the mode chosen by the individual (observed). This last feature classifies the approach here proposed as a ***revealed preferences*** model. It works as if one person - the decision maker whose age, income, gender, *etc.* are observed - has the option to choose between a set of modes to make a trip. This person also knows how long a trip would take and how much it would cost in every mode, and chooses one of them - revealed through the survey.

It is worth also describing some other features of data. Walking is only considered as one mode if the person walked to work or school (any level) or, for other trip purposes, if distance was greater than 500m. Also, the ODs surveys register up to four modes taken in a (multimodal) trip. For example, if one took the subway and one bus, both modes will be registered[3]. This entails another problem: which mode to consider on multimodal trips? We chose not to use the "main mode" hierarchy defined by the Metro Company[4]. Instead, we've tested many grouping combinations. Once almost all combinations suited well the model, we opt for the one which makes further analysis easier to interpret. Modes are reported on Table 1, below, whose average cost, cost per kilometre, distance and speed, for each mode observed in OD Surveys data – which do not consider the simulations - are shown in Table 2.

Table 1: Choice set and respective modes combination (if multimodal)

Mode chosen	Multimodal combination
Car	Car (driver) only
More than one bus	More than one bus
Multi transit	Combinations including bus and subway and/or train
One bus	One bus only
Rapid transit	Subway and/or train and its combinations
Walking	Walking only

Table 2: Average cost, cost per kilometer, distance and speed, according to the mode chosen, for 1997 and 2007

Mode	Cost 07	Cost 97	Cost per km 07	Cost per km 97	Distance 07	Distance 97	Speed 07	Speed 97
Car	3.51	4.21	0.61	0.74	5774.48	5714.16	10.42	11.76
Multi_Transit	3.46	3.51	0.31	0.34	15681.19	15200.39	10.79	11.49
One_Bus	2.23	1.44	0.63	0.43	6600.58	6477.45	6.93	7.53
One_Plus_Bus	2.48	3.53	0.31	0.42	12838.37	13108.97	7.78	8.34
Rapid_Transit	2.30	2.04	0.50	0.58	9332.46	7696.72	10.36	10.44
Walking	0.00	0.00	0.00	0.00	816.50	681.86	3.11	2.85

Cost is in BRL, 2007. Cost per km is in BRL, 2007, per km. Distance is in kilometers. Speed is in kilometers per hour.

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[3] Walking, however, does not figure as one mode on multimodal trips. It is also, an only, a unique mode taken. For example, if one walked from home to the bus stop, took a bust, an then walked again from the bus stop to work. It is registered on the data that this person walked for x minutes on the origin and y minutes on the destination, but on the (up to four) modes fields, only bus is registered.

[4] Described on the Introduction section. This hierarchy makes sense for transport planning and does not fit future work's methodology and objectives.

Regressions results of Models denoted on equations (14) and (15), for 1997 and 2007, are presented on Tables (5) and (6), on the Appendix. Their coefficients are not interpretable straightforward. Intercepts are omitted. Before any odds-ratio transformation, some interpretation might be useful: for cost and (generic) duration, coefficients' signs are negative for every model, for both years. The meaning of such signs is that the probability of choosing any mode decreases if price or duration increases as expected. As car is the base mode, when duration have mode-specific coefficients, they are interpreted in relation to car. The pattern is the same for both years: if duration of all modes but walking increases, holding everything else constant, the probability that the respective mode is chosen to the detriment of car increases. Following the same logic, if familiar income and age increases, there is less chance to each of the listed modes being chosen in comparison to car. The same is observed for being male or student. Again, in comparison to car, to have a job increases the probability of one to choose rapid transit and its combination with bus, but decreases the probability of choosing bus only or walking - this might be due to low accessibility of rapid transit in São Paulo. The work with those logit coefficients that is worth doing here is getting their marginal effects, in order to answer to research's questions.

The sixth models presented in each table for both years, presented the best fit, then, will be the only one used in the next subsections. Test statistics as Hausman-McFadden (Independence of Irrelevant Alternatives), likelihood-ratio test shows that the model is robust.

Applying Equation 10 to every mode - using the average value of each modes price - provides Tables 5 and 6. Their interpretation is: "how much does the probability of one individual, picked at random, choosing the *column* mode changes given a 1% change at *line* mode price's average".

The figures of interest are on the diagonals. It is possible to notice that **price elasticity of one bus demand in São Paulo is -0.012 for 1997 and -0.05 for 2007. For two (or more, up to four) bus, it is -0.075 for 1997 and -0.089 for 2007.** Another useful information is given by the cross price elasticities of demand. They tell us that if bus fare decreases, there will not be so much people shifting from other modes to bus.

Table 5: Marginal effects with respect to price: Model (6), 1997. Prices at the average.

	Car	Multi_Transit	One_Bus	One_Plus_Bus	Rapid_Transit	Walking
Car	-0.063	0.016	0.016	0.016	0.016	0.016
Multi_Transit	0.005	-0.075	0.005	0.005	0.005	0.005
One_Bus	0.020	0.020	-0.012	0.020	0.020	0.020
One_Plus_Bus	0.005	0.005	0.005	-0.075	0.005	0.005
Rapid_Transit	0.003	0.003	0.003	0.003	-0.043	0.003
Walking	0	0	0	0	0	0

Table 6: Marginal effects with respect to price: Model (6), 2007. Prices at the average.

	Car	Multi_Transit	One_Bus	One_Plus_Bus	Rapid_Transit	Walking
Car	-0.076	0.038	0.038	0.038	0.038	0.038
Multi_Transit	0.007	-0.131	0.007	0.007	0.007	0.007
One_Bus	0.039	0.039	-0.050	0.039	0.039	0.039
One_Plus_Bus	0.010	0.010	0.010	-0.089	0.010	0.010
Rapid_Transit	0.006	0.006	0.006	0.006	-0.086	0.006
Walking	0	0	0	0	0	0

Applying Equation 11 to one model provides one mode's aggregate probability of choice, for one year. Results are reported in Tables 7 and 8 for 1997 and 2007.

Table 7: Predict aggregate probabilities of each mode for 1997 (Model 6)

Car	Multi_Transit	One_Bus	One_Plus_Bus	Rapid_Transit	Walking
0.265	0.055	0.240	0.046	0.027	0.369

Table 8: Predict aggregate probabilities of each mode for 2007 (Model 6)

Car	Multi_Transit	One_Bus	One_Plus_Bus	Rapid_Transit	Walking
0.337	0.046	0.188	0.075	0.029	0.326

To control for spurious effects on demand caused by other variables, before inserting these values on Equation 12, we propose to apply Model's (6), 1997, coefficients on the 2007 dataset, and, then, calculating the aggregate probabilities of each mode again. This is equivalent to predict the demand for 2007, using individual's comportment of 1997. These results are reported in Table 9.

Table 9: Predict aggregate probabilities of each mode for 2007 (Model 6), using coefficients of 1997

Car	Multi_Transit	One_Bus	One_Plus_Bus	Rapid_Transit	Walking
0.326	0.059	0.219	0.047	0.031	0.318

Thus, Equation 12, which is estimated supposing that Bilhete Único caused an exogenous price shock on bus trips with transfers[5], and the demands for 1997 and 2007 (estimated with 1997's coefficients) are the ones found in Tables 7 and 9.

$$e_P = \frac{\frac{\Delta \hat{Q}}{\hat{Q}}}{\frac{\Delta P}{P}} = \frac{\frac{(0.047 - 0.046)}{0.046}}{\frac{(2.48 - 3.53)}{3.53}} = -0.073$$

The estimation gives **a price elasticity of two or more buses demand of -0.073 in the long-term.**

DISCUSSION AND CONCLUSION

The present work briefly discussed transport economics and public finance theory and previous works about fare pricing, including one important aspect of analysis: price elasticity of transit demand.

Using a discrete choice econometric framework and data from the OD Surveys of 1997 and 2007, it has estimated short term price elasticity of bus demand in the city of São Paulo at -0.012 for 1997 and -0.05 for 2007. For two (or more, up to four) buses, the figures are -0.075 for 1997 and -0.089 for 2007, and -0.073 in the ten-year period, that is, the long-term.

First, it is worth to comment that figures follow what have been found in literature. The pattern for São Paulo is the same of developed cities and other major Brazilian metropolitan regions: demand for bus is price inelastic. That is, demand is not very much responsive to price fluctuation. According to the value achieved, in the long term, if fare for two or more buses increases by 1%, demand is expected to decrease by 0.073%. It is plausible to extend these results to bus demand as well, given the short-term elasticities results.

Real fare prices remained stagnated around BRL 3.80, in real terms, since 2005. However, as the literature points out, costs are rising. Thus, São Paulo's subsidies for bus have increased by 61% during the last four years - after violent demonstrations in 2013 and an election pledge in 2016. This might be good by one side: state is maintaining fare price at the same level, what might bring easiness on familiar budget planning. However, at what cost? Is this policy imposing pressure over city's budget? Is the fare really affordable and progressive? Does it put system operation at risk? Service levels and quality have also been maintained? In the 21st Century, with a whole new amount of technology at people's hands, does this huge market intervention make sense? Those questions might be answered for the final work.

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[5] Price value for 2007 is one fare price, BRL 2.30, because any commuter taking two or more bus in 2007 payed for just one. For 1997, it is the average cost of those trips, BRL 3.50 , in 2007's real terms.

The shallowest meaning of the elasticities calculated is that the government can increase fare, and people would still use transit. From governments perspective - if one considers that governments have the incentive to maximize revenue -, to do so is tempting, but might not be adequate: as we have argued, the most needed people's mobility rely on public transit. There is also the other side of the coin: reducing fare price will not make much commuters shifting from private transport to transit. Hence, this seems not to be an adequate policy for taking cars off the street, or encouraging people to use transit - a must for more sustainable cities.

The picture for São Paulo seems to be the following: state is maintaining fare price at a high cost, but this is not necessarily making city's mobility better. Many people are still using car and another huge amount rely on a system that might collapse due to increasing costs, once subsidies are finite; the other option would be to rise the fare, what would put people's mobility at risk. The cross elasticities estimated also suggest that reducing bus prices will not make commuters leaving their car at home. Another kind of policy - as taxes that make drivers internalize the externalities generated by their cars, or nudge instruments - might be more effective.

The models were estimated with no division on data. That is, behavior was implicitly assumed to be homogeneous for all trip purposes, familiar income, age, etc. One possible interesting further analysis is to estimate models for each of those groups, what would overcome heterogeneity between groups. For policy, this might be interesting because we would know how each group reacts when fare price varies. Poor people's ridership plunge because they can not afford it anymore? Or their behavior is more inelastic once they might have no other option? There are many future advances that can be made.

APPENDIX

1. MODEL'S ASSUMPTIONS

H1: Independence of errors, that states an univariate distribution of the errors terms. They allow the calculation of only a one-dimensional integral to compute probabilities, later.

$$(P_b | \varepsilon_b) = \prod_{m \neq b} F_m \left(V_b - V_m + \varepsilon_b \right)$$

$$(P_b) = \int \prod_{m \neq b} F_m \left(V_b - V_m + \varepsilon_b \right) f(\varepsilon_b) d\varepsilon_b$$

H2: Gumbel distribution, which says that all ε follow a standard Gumbel distribution, where F is the cumulative and f is the density functions:

$$F(x) = e^{-e^{-x}}$$

$$f(x) = e^{-(x + e^{-x})}$$

H3: Homoscedasticity, which says that errors are identically distributed.

The three put together, the conditional and unconditional probabilities shown in equations become the ones below, where F is the cumulative and f is the density functions of the standard Gumbel Distribution.

$$(P_b | \varepsilon_b) = \prod_{m \neq b} F \left(V_b - V_m + \varepsilon_b \right)$$

$$(P_b) = \int \prod_{m \neq b} F \left(V_b - V_m + \varepsilon_b \right) f(\varepsilon_b) d\varepsilon_b$$

2. MODEL'S REGRESSIONS RESULTS:

Table 3 - Models (5) - whose coefficients are presented on columns (1), (2) and (3) - and (6) - whose coefficients are presented on columns (4), (5) and (6) - estimation for 1997

Multinomial logit model - results for 1997 - intercepts are ommited

Dependent variable:

Logistic function odds, estimate in each mode and covariates. Car is the base mode.

	Cost and duration coefficients are generic			Cost coefficient in generic, duration is mode-specific		
	(1)	(2)	(3)	(4)	(5)	(6)
COST	-0.210***	-0.208***	-0.202***	-0.031***	-0.031***	-0.023***
	(0.003)	(0.003)	(0.003)	(0.007)	(0.007)	(0.007)
DURATION	-0.035***	-0.034***	-0.034***			
	(0.0003)	(0.0003)	(0.0003)			
FAMILIAR INCOME						
Multi Transit	-0.102***	-0.103***	-0.051***	-0.089***	-0.090***	-0.043***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)
One Bus	-0.188***	-0.188***	-0.105***	-0.194***	-0.192***	-0.111***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
One Plus Bus	-0.197***	-0.205***	-0.109***	-0.187***	-0.192***	-0.104***
	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
Rapid Transit	-0.032***	-0.032***	0.0005	-0.037***	-0.037***	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Walking	-0.174***	-0.170***	-0.086***	-0.183***	-0.179***	-0.089***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
AGE						
Multi Transit	-0.214***	-0.223***	-0.219***	-0.247***	-0.251***	-0.241***
	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)	(0.007)
One Bus	-0.250***	-0.247***	-0.251***	-0.254***	-0.248***	-0.253***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)
One Plus Bus	-0.183***	-0.216***	-0.236***	-0.213***	-0.231***	-0.247***
	(0.005)	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)
Rapid Transit	-0.223***	-0.219***	-0.193***	-0.213***	-0.213***	-0.188***
	(0.006)	(0.007)	(0.008)	(0.006)	(0.007)	(0.008)
Walking	-0.305***	-0.282***	-0.283***	-0.319***	-0.299***	-0.287***
	(0.003)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)
AGE^2						
Multi Transit	0.002***	0.002***	0.002***	0.003***	0.003***	0.003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
One Bus	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.00004)	(0.00005)	(0.0001)	(0.00004)	(0.00005)	(0.0001)
One Plus Bus	0.002***	0.002***	0.003***	0.002***	0.003***	0.003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Rapid Transit	0.003***	0.003***	0.002***	0.002***	0.002***	0.002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Walking	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.00004)	(0.00005)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
DUMMY 1 = MALE						
Multi Transit	-0.946***	-0.962***	-0.968***	-1.066***	-1.070***	-1.090***
	(0.033)	(0.034)	(0.035)	(0.036)	(0.037)	(0.038)
One Bus	-1.114***	-1.092***	-1.110***	-1.061***	-1.034***	-1.075***
	(0.022)	(0.022)	(0.024)	(0.021)	(0.022)	(0.025)
One Plus Bus	-0.869***	-0.965***	-0.981***	-1.063***	-1.110***	-1.138***
	(0.034)	(0.035)	(0.037)	(0.037)	(0.037)	(0.039)
Rapid Transit	-0.857***	-0.836***	-0.838***	-0.775***	-0.768***	-0.785***
	(0.044)	(0.045)	(0.046)	(0.043)	(0.044)	(0.045)
Walking	-0.995***	-0.901***	-0.922***	-1.047***	-0.953***	-0.933***
	(0.022)	(0.023)	(0.025)	(0.027)	(0.028)	(0.031)
DUMMY 1 = EMPLOYED						
Multi Transit		0.187***	0.154***		0.081*	0.063
		(0.045)	(0.046)		(0.048)	(0.049)
One Bus		-0.060**	-0.163***		-0.117***	-0.224***
		(0.028)	(0.030)		(0.027)	(0.030)
One Plus Bus		0.667***	0.534***		0.445***	0.342***
		(0.050)	(0.052)		(0.052)	(0.054)
Rapid Transit		-0.070	-0.055		-0.008	-0.008
		(0.056)	(0.057)		(0.055)	(0.056)
Walking		-0.401***	-0.518***		-0.369***	-0.507***
		(0.027)	(0.029)		(0.034)	(0.036)
DUMMY 1 = S TUDENT						
Multi Transit			0.368***			0.537***
			(0.051)			(0.054)
One Bus			0.140***			0.172***
			(0.037)			(0.036)
One Plus Bus			-0.152***			-0.029
			(0.059)			(0.060)
Rapid Transit			0.798***			0.749***
			(0.066)			(0.064)
Walking			0.202***			0.297***
			(0.037)			(0.047)
DUMMY 1 = OWN A CAR						
Multi Transit			-2.893***			-2.792***
			(0.046)			(0.048)
One Bus			-3.336***			-3.346***
			(0.037)			(0.037)
One Plus Bus			-3.409***			-3.289***
			(0.047)			(0.049)
Rapid Transit			-2.724***			-2.778***
			(0.056)			(0.056)
Walking			-3.437***			-3.925***
			(0.038)			(0.044)
DURATION WITH SPECIFIC COEFFICIENTS						
Car				-0.002***	-0.002***	-0.003***
				(0.001)	(0.001)	(0.001)
Multi Transit				0.037***	0.037***	0.036***
				(0.001)	(0.001)	(0.001)
One Bus				0.002***	0.002***	-0.0003
				(0.0004)	(0.0004)	(0.0004)
One Plus Bus				0.021***	0.021***	0.019***
				(0.0005)	(0.0005)	(0.0005)
Rapid Transit				0.009***	0.009***	0.007***
				(0.001)	(0.001)	(0.001)
Walking				-0.098***	-0.098***	-0.103***
				(0.001)	(0.001)	(0.001)
Observations	94,579	94,579	94,579	94,579	94,579	94,579
R^2	0.252	0.254	0.316	0.389	0.390	0.453
Log Likelihood	-103,173.400	-102,837.100	-94,265.470	-84,205.510	-84,071.650	-75,435.330
LR Test	69,420.760*** (df = 27)	70,093.190*** (df = 32)	87,236.530*** (df = 42)	107,356.500*** (df = 32)	107,624.200*** (df = 37)	124,896.800*** (df = 47)

Note: *p<0.1; **p<0.05; ***p<0.01

Table 4 - Models (5) - whose coefficients are presented on columns (1), (2) and (3) - and (6) – whose coefficients are presented on columns (4), (5) and (6) - estimation for 2007

	Multinomial logit model - results for 2007 - intercepts are ommited					
	Dependent variable:					
	Logistic function odds, estimate in each mode and covariates. Car is the base mode.					
	Cost and duration coefficients are generic			Cost coefficient in generic, duration is mode-specific		
	(1)	(2)	(3)	(4)	(5)	(6)
COST	-0.230***	-0.230***	-0.229***	-0.035***	-0.035***	-0.040***
	(0.003)	(0.003)	(0.003)	(0.008)	(0.008)	(0.008)
DURATION	-0.031***	-0.031***	-0.031***			
	(0.0002)	(0.0002)	(0.0002)			
FAMILIAR INCOME						
Multi Transit	-0.268***	-0.268***	-0.165***	-0.245***	-0.246***	-0.140***
	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)
One Bus	-0.427***	-0.427***	-0.283***	-0.447***	-0.445***	-0.300***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
One Plus Bus	-0.485***	-0.485***	-0.331***	-0.469***	-0.474***	-0.313***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
Rapid Transit	-0.136***	-0.136***	-0.055***	-0.144***	-0.144***	-0.058***
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
Walking	-0.419***	-0.419***	-0.269***	-0.411***	-0.405***	-0.250***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)
AGE						
Multi Transit	-0.213***	-0.213***	-0.204***	-0.243***	-0.247***	-0.225***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
One Bus	-0.251***	-0.251***	-0.217***	-0.263***	-0.253***	-0.233***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
One Plus Bus	-0.179***	-0.179***	-0.192***	-0.213***	-0.223***	-0.207***
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)
Rapid Transit	-0.236***	-0.236***	-0.191***	-0.236***	-0.234***	-0.200***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)
Walking	-0.306***	-0.306***	-0.256***	-0.324***	-0.300***	-0.266***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)
AGE^2						
Multi Transit	0.002***	0.002***	0.002***	0.002***	0.003***	0.002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
One Bus	0.003***	0.003***	0.002***	0.003***	0.003***	0.002***
	(0.00004)	(0.00004)	(0.00005)	(0.00004)	(0.00004)	(0.00005)
One Plus Bus	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Rapid Transit	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Walking	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.00004)	(0.00004)	(0.00004)	(0.00004)	(0.00005)	(0.0001)
DUMMY 1 = MALE						
Multi Transit	-1.131***	-1.131***	-1.129***	-1.257***	-1.255***	-1.255***
	(0.034)	(0.034)	(0.034)	(0.037)	(0.037)	(0.037)
One Bus	-1.199***	-1.199***	-1.155***	-1.172***	-1.145***	-1.145***
	(0.022)	(0.022)	(0.023)	(0.022)	(0.022)	(0.024)
One Plus Bus	-1.122***	-1.122***	-1.147***	-1.235***	-1.243***	-1.248***
	(0.028)	(0.028)	(0.029)	(0.030)	(0.030)	(0.031)
Rapid Transit	-0.961***	-0.961***	-0.935***	-0.925***	-0.916***	-0.917***
	(0.041)	(0.041)	(0.042)	(0.040)	(0.041)	(0.041)
Walking	-1.231***	-1.231***	-1.134***	-1.263***	-1.191***	-1.127***
	(0.021)	(0.021)	(0.022)	(0.026)	(0.026)	(0.027)
DUMMY 1 = EMPLOYED						
Multi Transit			0.228***		0.054	0.091*
			(0.048)		(0.051)	(0.051)
One Bus			-0.137***		-0.192***	-0.193***
			(0.030)		(0.028)	(0.030)
One Plus Bus			0.449***		0.187***	0.183***
			(0.041)		(0.042)	(0.043)
Rapid Transit			0.023		-0.041	0.036
			(0.055)		(0.052)	(0.053)
Walking			-0.490***		-0.419***	-0.409***
			(0.027)		(0.032)	(0.033)
DUMMY 1 = STUDENT						
Multi Transit			0.556***			0.719***
			(0.050)			(0.053)
One Bus			0.638***			0.632***
			(0.036)			(0.036)
One Plus Bus			0.439***			0.605***
			(0.044)			(0.046)
Rapid Transit			1.063***			0.988***
			(0.059)			(0.057)
Walking			0.518***			0.735***
			(0.035)			(0.044)
DUMMY 1 = OWN A CAR						
Multi Transit			-2.524***			-2.574***
			(0.046)			(0.049)
One Bus			-2.720***			-2.751***
			(0.036)			(0.036)
One Plus Bus			-2.798***			-2.776***
			(0.041)			(0.043)
Rapid Transit			-2.563***			-2.628***
			(0.056)			(0.054)
Walking			-2.757***			-3.179***
			(0.036)			(0.041)
DURATION WITH SPECIFIC COEFFICIENTS						
Car				-0.005***	-0.005***	-0.005***
				(0.001)	(0.001)	(0.001)
Multi Transit				0.032***	0.032***	0.031***
				(0.001)	(0.001)	(0.001)
One Bus				-0.002***	-0.002***	-0.003***
				(0.0004)	(0.0004)	(0.0004)
One Plus Bus				0.017***	0.017***	0.016***
				(0.0004)	(0.0004)	(0.0004)
Rapid Transit				0.011***	0.011***	0.010***
				(0.001)	(0.001)	(0.001)
Walking				-0.091***	-0.091***	-0.095***
				(0.001)	(0.001)	(0.001)
Observations	102,211	102,211	102,211	102,211	102,211	102,211
R²	0.248	0.248	0.288	0.391	0.392	0.430
Log Likelihood	-115,353.300	-115,353.300	-109,257.900	-93,440.320	-93,311.320	-87,403.110
LR Test	76,182.630*** (df = 27)	76,182.630*** (df = 27)	88,373.340*** (df = 42)	120,008.600*** (df = 32)	120,266.600*** (df = 37)	132,083.000*** (df = 47)

Note: *p<0.1; **p<0.05; ***p<0.01

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