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Regulation of the informal transport sector in Rio de Janeiro, Brazil: welfare impacts and policy analysis

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Abstract In Brazil, the explosion of informal transport activity during the past decade has had profound effects on formal public transport systems and is a source of great controversy in the urban transportation sector. A variety of policies have been proposed to manage the growth of the sector. This study seeks to understand how proposed policies will impact the users of these systems. A corridor in Rio de Janeiro with substantial informal activity was used as a case study. Measures of welfare changes in a discrete choice framework were used to estimate proposed policies' impacts on users. Eleven candidate policies were evaluated, ranging from the eradication of the informal modes and investment in formal modes, to the legalization of the informal modes. Benefits were compared with costs and the distribution of benefits across income classes was explored. Net benefits from some policies were found to be substantial. Legalizing the informal sector was found to benefit users slightly but further investments in the sector are probably inefficient. Users benefited most from improvements in formal mass transit modes, at roughly 100–200 dollars per commuter per year. Finally, policies to foster a competitive environment for the delivery of both informal and formal services were shown to benefit users about 100 dollars per commuter per year. Together, the regulation of the informal sector and investments in the formal sector serve to reinforce the movement towards competitive

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concessions for services and help reduce the impacts of cartelization and costly in-road competition.

Keywords Informal transportation · Brazil · Regulation · Welfare · Jitneys

Abbreviations

NTU	The National Association of Urban Transportation Companies
ANTP	National Association of Public Transportation
CUT	National Workers Union
CNTT	National Confederation of Transport Workers
CV	Compensating variation
MRMC	Medium-run marginal cost

Introduction

During the past decade, in dozens of cities across Brazil, rising unemployment, worsening congestion and rising public transit fares have combined to set off an explosion of informal public transit activity using vans and minibuses. Today, tens of thousands of Brazilians have turned to providing public transit services as a means of livelihood. The poor, already subjected to agonizingly long commutes in crowded buses and trains, have largely embraced the new options. Many policies have been proposed to come to grips with the heretofore uncontrolled growth of the informal sector. Thus far, evaluations of proposals have focused on the supply side effects of these policies—effects on traffic congestion and traffic operations, the financial state of the formal transit service suppliers, as well as discussions concerning the role of informality in the urban economy. Not much attention has been given to the effects of policies on the users of transit services. Consumers of informal transit services are often in precarious economic situations, traveling long distances from outlying residences to low wage jobs. This study seeks to understand the benefits accruing to users from the various policies proposed to address the problem. The key questions to be investigated are: how do proposed policies affect the welfare of users and which are the most beneficial?

The paper begins with an introduction to the informal sector "problem," followed by a presentation of common policy responses. Our policy evaluation methodology, a review of the case study and the mode choice model are then presented. We then introduce the specifics of the policies evaluated here, followed by results of the evaluation. A discussion of the results and implications for practice is followed by an update on the situation in Rio de Janeiro since the closing of this research in 2005.

Background

For the past century, public transportation in most Brazilian cities consisted of a mixture of streetcars and small bus companies (Dourado 1994). For a variety of reasons, national policy in the 1970s began promoting an increase in the size of the bus companies. Mergers of smaller companies were encouraged, and minimum fleet sizes were adopted in many cities to spur growth of bus firms. This resulted in heavy concentration and substantial power in the bus industry (Dos Santos and Brasileiro 1999).

Informal activities exploded in the mid-nineties in response to both this stagnation, and the macroeconomic and structural changes happening to the Brazilian economy and society. The history of growth of the informal sector in Brazil are reviewed by Balassiano (1998), Cervero and Golub (2007, pp. 454–455) and in two major studies by the National Association of Urban Transportation Companies (NTU and ANTP 1997; NTU 2001). The most important factors behind the growth of the sector were thought to be the declining quality of transit service, poor or outdated route connections, low levels of comfort and safety, rising transit fares in real terms, and long and increasing waiting and travel times. Declining speed is related to growing congestion due to rising automobile use since currency stabilization in 1994 and reduced import tariffs on automobiles. By the beginning of 2000, about 70% of cities with populations exceeding 300,000 were experiencing some informal transportation activities (NTU 2001). Some particular corridors are more heavily impacted, with some witnessing a complete bankruptcy of the formal operators. These informal systems include "Vans," "Moto-táxis," and Volkswagen "Kombi" vans. "Vans," the focus of this work, are typically minivans and are used for both neighborhood circulation and suburb to center "line haul" services.

Proposed policy responses

In light of the fast growth of the sector and its growing impacts, the question of regulatory options is commonly asked. The NTU and ANTP (1997) presented responses to the illegal van activities that vary between acceptance, recognition, prohibition, and regulating the incorporation of the van services into the formal system. Prohibition would involve the confiscation of vehicles. Regulation would involve issuing service concessions to van operators and could include relegating vans to act as feeder services to the bus or train system to avoid direct competition. Other ideas included relaxing some of the "cost inducing" regulations (e.g., safety, vehicle fitness, or labor rules) on the formal system to increase its competitiveness in the changing market. Supporting the bus mode with dedicated rights of way and better modal integration and terminals were also proposed to make the buses more competitive in the market. The ANTP (2001) makes a firm stand against any deregulation and legalization of vans, and believes principally that bus firms can and should respond to van competition through offering better services. They argue that concessions should allow bus firms to offer other services, vehicle sizes, and more flexibility.

To the bus sector, vans are a threat to their substantial power and orderly collection of monopoly rents and therefore they are opposed to legalization of any van service which might compete directly with the bus or rail services. Most academics, while citing safety, emissions, and congestion problems from using smaller vehicles for line haul services, support the legalization of the system (Balassiano 1998; Torres 1988; Cervero 2000).

The CUT and CNTT (1999) concluded that the regulation of informal operators must come within a reorganization of all modes. Modes should be complementary and not directly competitive, respect traditional standards of quality both for users and workers and must receive appropriate attention and support from the transportation agencies. They emphasized the need for greater transparency in the fare calculations and cost reporting and for better stimulation of efficiency via the terms of the concessions.

Methodology

The proposed policies will have certain effects on users and we will attempt to measure and compare these effects. Our approach is to measure user economic welfare before and after policies are implemented to estimate how policies affect the user. This welfare calculation involves two main steps: (1) Statistically model the users' mode choice process, revealing the utility function of the users and (2) Using the utility function, calculate the change in welfare (benefit) compared to the status quo for each policy.

Step 1: Discrete choice model

In the microeconomic model of the consumer choice, welfare is derived from the qualities and prices of goods available to them in the marketplace. Consumers of transportation derive satisfaction, or "utility" from each of the mode choices available to them. That is, for consumer n, the utility derived from mode choice i, can be represented as $V_{in}(X_{in}, Z_n)$ where V is called the indirect utility function, X_{in} are attributes of the mode (such as fare or travel time) and the particular trip (such as time of day or weather conditions), and Z_n are consumer's socioeconomic characteristics (such as age or income) (Ben-Akiva and Lerman 1985). The logit form of discrete choice model is used in this study to estimate V.

Step 2: Welfare change calculation

The "compensating variation" (CV) is an estimate of welfare change resulting from a policy change. The CV asks: how much would a consumer have to pay (or be paid) to remain at the same utility level after a policy is implemented? (Hanemann 1999) For example, given a rise in transit fares, the consumer's expenditure rises if the number of trips remains as before. Here, the consumer derives utility from the number of transit trips, which is preserved and one must compensate the rider for this rise in fares in order to maintain the rider's original utility level. This needed compensation is the CV.

The logit discrete choice formulation conveniently reveals the expected maximum utility derivable from a choice set through the "log-sum" (denominator) term, $\ln \sum_{i=1}^{I} \exp(V_{in})$.

The standard derivation of the CV within the logit discrete choice formulation effectively calculates the difference between the expected utilities in the two scenarios (Small and Rosen 1981). Here, the expected CV for consumer n is:

$$E[\mathrm{CV}_n] = \frac{1}{\lambda_n}\left\{\ln \sum_{i=1}^{I^1} \exp\left(V_{in}^1\right) - \ln \sum_{i=1}^{I^0} \exp\left(V_{in}^0\right)\right\},$$

where λ_n is the marginal utility of money for consumer n, i is the index of choices in the choice set, and where 1 and 0 are the "states" after and before the policy, respectively (Small and Rosen 1981). Dividing by the marginal utility of money converts units of "utils" (the terms between brackets) into units of money. The total E[CV] for the population would be the sum of the $E[\mathrm{CV}_n]$ for all n consumers.

λ can vary between different portions of the population and the formulation for $E[\mathrm{CV}_n]$ above assumes the λ of each consumer is known, but this is rarely the case and an approximation is needed. A common finding is that λ is a strong function of income (Jara-Díaz and Videla 1989). Dividing the population into groups by income will help reduce errors due to heterogeneity in λ. The calculation of E[CV] becomes:

$$E[\mathrm{CV}] = \sum_{j=1}^{J} E[\mathrm{CV}_j] = \sum_{j=1}^{J} \left\langle \frac{1}{\lambda_j} \sum_{n=1}^{N} \delta_j \left\{ \ln \sum_{i=1}^{I^1} \exp\left(V_{inj}^1\right) - \ln \sum_{i=1}^{I^0} \exp\left(V_{inj}^0\right) \right\} \right\rangle,$$

where j is the income class for each person (Morey et al. 2003a) and δ_j is the dummy variable for each income class. State "1" is the state of the market six months after the policy has been implemented. State "0" is the state of the market for the no-policy (status quo) scenario after six months. Six months was used because it is likely just long enough for travel behavior to change, but not long enough for residential or job locations to change. Note that even in the status quo case, some characteristics change after six months.

To clarify, this overall welfare calculation begins with the calculation of the welfare change for each traveler: the policy alters the characteristics of the mode choices in the choice set of each traveler and the difference of the "log-sum" terms is the welfare change for that traveler for the trip they normally make. Moving out from there, the various individual welfare changes are summed by income groups, to understand distribution effects and then summed overall to understand net effects. From there, average benefit per trip, average benefit per trip for each income group, or a net yearly benefit for all travelers can be calculated (Morey et al. 2003a, b).

The calculation assumed that total demand is fixed—partly to simplify the calculations but mostly because it is not unreasonable. Over 90% of all trips in the survey sample are work related, meaning that for most travelers, total demand is very inelastic (though there may be lively switching between modes). Furthermore, the out of pocket costs are very high for most of the travelers, meaning that if they could make fewer trips, they would—they are probably already making the minimum number that they need to make. Given that the main objective here is to compare policies to a reasonable degree of confidence, these approximations should not affect the results significantly.

Rio de Janeiro case study

Many of the most important and interesting aspects of informal transportation are exemplified in the systems in the city of Rio de Janeiro, which will be used as the case for this policy analysis. Before presenting specifics, note that four years have passed since the end of this study and some values, such as currency conversions, may have changed. As discussed earlier, the national consolidation policies resulted in bus systems supplied by what can be considered to be self-regulated cartels. In Rio de Janeiro, industry concentration is especially pronounced (Dos Santos and Brasileiro 1999). The bus fleet in the metropolitan area contains around 11,000 vehicles, carrying close to 10 million bus trips per day. There are over 25 bus companies in the system, but the top three firms carry about 40% of the total bus trips (Dos Santos and Brasileiro 1999). While service is satisfactory, according to several studies, bus fares are higher by about 80% than they should be according to the rules of the concessions and the actual costs experienced by the bus firms (Orrico Filho 1999; Ferraz and Barros 1992). Detailed estimates indicate that fares are inflated through liberally calculated items like depreciation and vehicles' residual values; general overcapitalization; and the blatant misrepresentation of ridership, vehicle mileage, and maintenance costs (Orrico Filho 1999; Ferraz and Barros 1992). Minimum capitalization requirements, no longer used, were originally intended to facilitate the move away from artisan-style owner-operators towards more modern firm structures. Some researchers claim that politically, markets remain closed (Orrico Filho 1999; Brasileiro and Henry 1999).

The suburban rail system in Rio de Janeiro has about 250 route-kms on four lines radiating out into the northern and western suburbs from downtown. For years in disrepair and mismanaged, the rail system suffered from a huge loss in ridership in the 1980s (Neto 1998), down to about 350,000 trips per day. The subway consists of 35 route-kms on two lines, also serving about 350,000 trips per day. The unregulated "Vans" serve the northern suburbs and some wealthier neighborhoods in the south zone. Total regional van ridership is about 150,000 trips per day on roughly 30 routes (Almeida Júnior et. al. 1999).

The corridor between the northern suburbs, called the Baixada Fluminense, or "Baixada," and the CBD was chosen as the case for this study. This area experiences the most vigorous informal transit activities in the region. Development in the Baixada fans out northward from the Rio de Janeiro CBD along four suburban rail corridors in a semicircle with a radius of about 80 km. The Baixada suffers from high rates of unemployment and poverty and vehicle ownership rates are around 5%. An estimate of the modal split for the corridor between the Baixada and the CBD is 5% auto/taxi, 5% van, 55% bus, and 35% suburban rail.

From the Baixada, the downtown-bound buses, trains, and vans connect to the downtown transit terminal, called "Central Station". Central Station is the largest transit terminal in the city, serving about 500,000 inbound passenger trips in the morning period. Buses make line-haul type trips starting with circulation in the various neighborhoods in the Baixada. Fares are based on distance, and are typically between 2 and 3 reais ($1.00–$1.50). Free entry is allowed for students and elderly. Suburban trains offer good services throughout the Baixada from Central Station. Headways are about 10 min during the peak hour, 20–30 min in the off peak, and travels times to the outermost neighborhoods can be over 90 min. Fares are flat at 80 centavos (40 cents) and free entry is allowed for students and elderly. The state government of Rio de Janeiro issues a free public transport fare coupon, called Vale-Transporte, to employees of larger firms to encourage transit use. These coupons are redeemed on all formal bus and rail operators.

The informal services in the Baixada Fluminense consist of late model 10–15 passenger minivans, called "Vans," that generally duplicate the long bus routes connecting to the Central Station. These routes include some circulation within the neighborhood and then enter the main freeways on their way to downtown. The fares are distance based, and about 10% higher than those of buses. However, free entry is not offered to elderly or student riders, and Vale-Transporte transit coupons are redeemed at about 80% of their face value. This effectively widens the difference between the van fares and the other modes.

Rider survey and choice model

In the Baixada-Fluminense to Central Station corridor, vans compete with at least one of the bus or suburban rail systems. Since there is little car use on this corridor, and none of it passes through the Central Station, it is not included in our choice model. The mode choice set under consideration therefore includes Van, Suburban Rail, and Bus.

In the Central Station, the bus and train terminals lie within 50 m of each other, and the van terminals line the edges of the bus terminals. This proximity facilitated the random surveying of passengers from all modes. The study population was defined as all those traveling outbound from the Central Station to points in the Baixada during the hours of 3 p.m. and 8 p.m. on workdays. A total of 640 surveys were conducted using a choice-based stratified sampling approach. Of those, 433 were sufficiently complete to contribute to the discrete choice model estimation. See Golub (2003, p. 64) for more details on the instrument and sampling design. Details about the choice modeling process can be found in Golub (2003, p. 81). The estimated model is shown in Table 1. Model performance was typical for logit discrete choice models.

The policies for evaluation

The following 11 policy "scenarios" address the corridor's transportation system directly and do not seek to manage demand or other exogenous factors such as fuel prices or employment or residential location. The magnitude of policies' impacts on welfare depends on the response of transportation suppliers to policy and price changes, and in turn, the response of users to changes in the characteristics of the supply. Additionally, we attempt to point out in the discussion how policies may improve or degrade safety in a qualitative manner. There was no satisfactory data or studies on accident rates, though expert opinion held that accident rates were higher among vans than the other two modes.

Status quo (do nothing)

The status quo is the "base" against which all of the 11 policy scenarios are compared. It's the "do-nothing" scenario and is presumed to be the state of the do-nothing case at the time policy effects are being analyzed, which is six months after "time zero". It is assumed that demand for vans would remain steady during the six-month period. Note that bus fares are assumed to rise slightly in keeping with the normal rate of fare increase of 5% per annum.

Weak restriction, "restrict 1"

The vans are illegally providing transit services and the means are already in place to enforce those laws being broken. A weak restriction of the vans could be carried out with the placement of a small group of traffic police or military police in areas around the outlets or inlets to the Central Station terminals. Stopping and ticketing vans would result in a slight decline in Van use because of the threat of delays.

Medium restriction, "restrict 2"

Heavier enforcement of restrictions would send the van operations even more underground resulting in a closing of the terminals closest to the Central Station. More circuitous routes combined with the greater likelihood of being stopped would increase travel times, and lower the attractiveness of the mode. Bus firms, in keeping with their rhetoric about the detrimental effects of the vans on their operations, would probably lower the rate of fare increase compared to the status quo.

Strong restriction, "restrict 3"

Complete restriction of van operation would require extensive police action, over a period of several months. Bus firms would probably not apply for any rate increases within the time frame considered in this analysis, and the same lower rate of fare increase from

Table 1 Estimated utility functions from logit model

	Constant	Peak (dummy)	Income (sextile)	Out of vehicle travel time (min)	Qualify for special age discount (dummy)	Transfer (dummy)	In-vehicle travel time[a] (min)	Cost[a]
Train	−0.2702 (−0.7)	−1.265 (−4.7)	0.440 (3.7)	−0.0517 (−2.6)	0	−0.1685 (−0.4)	−0.0058	−6.923 Income
Bus	0	0	0	0	0	0	−0.0058	−6.923 Income
Van	−1.573 (−3.0)	−0.694 (−1.4)	0.137 (0.7)	0	−0.4456 (−0.6)	0	−0.0058	−6.923 Income

Numbers in parenthesis are asymptotic *t*-statistics

Model statistics: Number of observations, 433; initial log-likelihood, −359.7142; log-likelihood with zero coefficients, −351.0918; final value of log-likelihood, −293.1856; likelihood ratio (w.r.t. zero), 115.81 [χ^2 ($df = 9$, $\alpha = 0.01$) = 21.66]; r^2 (w.r.t. zero), 0.1649

[a] Cost and time coefficients are constrained to the values determined by a separate sub-model and therefore do not have *t*-statistics within this model. See Golub (2003) for information about the submodel. Income is in units of dollars per day

“Restrict 2” was used. Because of significant reduction in van use, we assume safety would be positively impacted.

Change terms of bus concessions to lower operating costs, “change bus concession”

The state transportation regulatory body is charged with managing operating concessions to firms, defining fares, inspecting and licensing vehicles and drivers, and managing all public transportation between the Central Station and the municipalities of the Baixada. These operating concessions are long term, on the order of 20 years. Changing their terms to lower bus operating costs would be very controversial, but often cited as an important option for discussion (NTU and ANTP 1997; ANTP 2001). Lowering labor restrictions, safety, and fitness specifications for vehicles, among other things, would help lower production costs. We would assume these savings would result in a lowering of bus fares, and concomitantly, van fares. There are additional negative safety impacts which should be considered here.

Restrict Vale-Transporte (VT) transit coupon use to buses and trains, “change VT”

The Vale-Transporte ticket is a small coupon with a computer printed value and barcode stating its value. It is redeemable through a variety of means, and anyone can sell or trade the ticket illegally for nearly its face value at numerous street markets. The vans accept Vale-Transporte tickets at slightly less than their face value, modeled in this analysis as 80% of the value the employee received. Technologically changing the Vale-Transporte ticket to make it impossible to redeem illegally would be a way to decrease van use by forcing ticket receivers to use the formal modes, or forfeit the value.

Bus system improvement, “improve bus”

This would be a major infrastructure investment with the goal of increasing bus travel speeds, comfort, and adding new niches like express or executive services. The project might include the construction of exclusive bus lanes and ramps to access the downtown terminal, special feeder concessions, new route and service configurations, signal priority, or other new management approaches. It is expected that such improvements would result in travel time reductions for most origin-destination pairs and overall safety improvements.

Train system improvement, “improve train”

Similar to the bus improvements, upgrading the train system is also an important option. A new control or power system to allow longer trains or faster service could increase the system’s attractiveness, especially during the peak hour. An improvement in image, cleanliness, and its reputation for safety and comfort might improve ridership beyond what the time savings might yield.

Legalize the vans, “legalize”

The seven policies described thus far have dealt with the vans externally, changing their competitive environments while leaving their operations unaffected. The next three policies affect the internal operations and costs of the van service. Current van operator’s revenues just cover short run marginal costs, with little discernable revenues for long term investments to sustain the business (Araújo 2001). The reason for this is most likely the van operators' desire to match bus fares. Van operating costs per boarding are likely much higher than for bus, and though bus fares are inflated, they still leave the vans operating on the margins of profitability. Legalizing van activity would subject them to the same requirements for business taxes, licensing, social security fees, insurance, etc. that other formal transit operators are. These costs are estimated from Araújo (2001), and data in the national bus fare cost tables (Ministry of Transportation of Brazil 1996). There are additional negative safety impacts which should be considered here.

Regulation (following decreto 25.955), "regulate"

A proposal in the state assembly to regulate the vans, called Decree 25.955, is the best model available for the regulatory scenario (Governor of the State of Rio de Janeiro 2000). This policy response would restrict van entry to the market, enforce a set of rules concerning vehicle type, age, fitness, licensing for drivers and vehicles, insurance, acceptance of Vale-Transporte coupons, and honoring free entry for the school aged and elderly. Safety would likely be improved in this scenario.

Regulation and additional support, "regulate + invest"

This policy extends the previous to include additional public investments to improve the van service. New terminals and amenities could add even more capacity and ridership. This might include commitments from the Baixada municipalities or the city of Rio de Janeiro to improve van terminals, signage, and coordinate routes and timetables to improve integration. Again, safety would likely be improved in this scenario.

Competitive case, "prices = medium run marginal costs (MRMC)"

In this scenario, a regime of competitive tendering for concessions, by route, is implemented. Barriers to entry are lowered, and information about potential costs, risks, etc. is good enough to make the bus and van sectors contestable. The essential effect here is that the resulting fares are at the estimated medium-run marginal costs—enough to cover operating costs, vehicle depreciation, and an allowance for other fixed costs, such as driver training, insurance, etc. According to the literature concerning the inflation of bus fares mentioned earlier, true medium-run marginal costs for the buses are equal to about 60% of current fares. Araújo (2001) estimated medium-run marginal costs for formalized van operations would be about 18 cents higher per boarding than the status quo. Because of a reduction in van use, safety would likely be improved in this scenario.

A summary of how the eleven policies affect different aspects of demand and supply is shown in Table 2. These effects are then used to change the mode characteristics via the indirect utility function in the welfare model to calculate the welfare changes.

Policy costs

Each of the eleven policies has costs associated with any capital investments and recurring operating costs. Table 2 includes the "back-of-the-envelope" cost estimates for each of the

Table 2 Summary of policy effects and costs

Scenario	Policy effects			Costs (dollars per year)		
	Travel times	Fares	Demand	Capital	Operating	Safety
Status quo		Van, bus +2.5%	Van +2.5%	–	–	–
1. Restrict 1	Van +5% Bus −0.4 min		Van −10%	None	10,000	None
2. Restrict 2	Van +10% Bus −2.8 min	Bus −2.43%	Van −70%	None	90,000	None
3. Restrict 3	Van +∞% Bus −4 min	Bus −2.43%	Van −100%	None	3,500	Reduce
4. Change bus concession	Bus, van −0.03 min	Bus −10% Van −5%		None	None	Increase
5. Change VT	Bus, van −0.25 min	Van −10% while also not adjusted for Vale-Transporte		5 Million	(Included in capital)	None
6. Improve bus	Bus −15% Van −0.86 min		Bus +10%	30 Million (total = 250 M$)	(Included in capital)	Reduce
7. Improve train	Train −15% Bus, van −0.21 min		Train +20%	30 Million (total = 250 M$)	(Included in capital)	Reduce
8. Legalize	Bus +0.2 min		Van +5%	None	None	Increase
9. Regulate	Bus +0.4 min	Van = max[bus × 1.15, van + 0.15]	Van +10%	None	220,000	Reduce
10. Regulate + invest	Bus +0.6 min	Van = max[bus × 1.15, van + 0.15]	Van +15%	11.5 Million (total = 100 M$)	220,000	Reduce
11. Prices = MRMC	Bus, van −0.51 min	Van = present + 0.18, Bus = present × 0.60		None	220,000	Reduce

policies. Capital costs were amortized over 20 years. All costs appear as yearly costs to facilitate comparison with the yearly social costs/benefits from the user welfare calculation. For details on all of these assumptions and estimations, please consult Golub (2003). Additionally, we attempt to add a qualitative note regarding impacts on safety.

Results

Results are expressed in terms of net benefits for the entire commuter group, as well as by income subgroup. Costs are then subtracted from benefits for the entire commuter group to get a net benefit. Table 3 summarizes the net benefits for the population of commuters during 1 year. This is presented in terms of benefits "per boarding" ($/boarding) and a total summed benefit over an entire year of travel for the entire study population (M$/year).

Net benefits don't reveal differences in benefits between different portions of the population. To understand the distribution of benefits within the commute group, the

Table 3 Net benefits and costs for the policy scenarios

Policy	Benefit ($/boarding)	Benefit (M$/year)	Cost (M$/year)	Net benefit (M$/year)
1. Restrict 1	−0.02	−5	0.01	−5
2. Restrict 2	−0.11	−33	0.09	−33
3. Restrict 3	−0.16	−47 + Safety[a]	0.003	−47 + safety
4. Change bus concession	0.05	14	Safety	14 − safety
5. Change VT	−0.01	−2	5	−7
6. Improve bus	0.38	115 + Safety	30	85 + Safety
7. Improve train	0.24	72 + Safety	30	42 + Safety
8. Legalize	0.01	3	Safety	3 − Safety
9. Regulate	0.02	6 + Safety	0.22	6 + Safety
10. Regulate + invest	0.03	8 + Safety	12	−4 + Safety
11. Prices = MRMC	0.18	54 + Safety	0.22	54 + Safety

[a] "Safety" is used here to represent the general safety benefits or costs resulting from policies. For example, it is assumed that the legalization of vans (Policy 8) would lead to some additional safety costs from rising accident rates

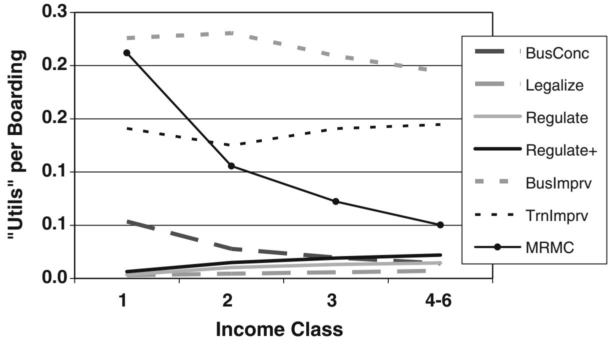

Fig. 1 Distribution of benefits for policies with positive net benefits (The highest three income groups are combined because of low counts)

calculations were done separately for the income sextiles. Here, the values of the utility changes from the policies will be compared in units of “utils” (the units of utlity, or welfare, employed within the mode choice model). We focus on the seven scenarios resulting in positive net benefits and their benefit distributions are shown below in Fig. 1.

Discussion

Net benefits are the measure of economic efficiency of a policy—the more public benefits surpass public costs, the more “efficient” a policy is in creating welfare. (Private producer costs or savings have been mostly represented by changes to fares within the welfare model.) The best choice from a set of mutually exclusive policies with no budget constraint is the one that creates the most positive net benefits.

The first three policies, “Restrict 1, 2 and 3”, reduce the utility of the van mode. For these scenarios, the slight savings in bus travel times from reduced van congestion and slight safety cost reductions from reducing van use don’t create positive net benefits. The fifth policy, “Change VT”, also results in negative net benefits, because of an effective rise in van fares. The sixth and seventh policies, “Improve Bus” and “Improve Train”, result in large net benefits of 85 and 42 million dollars, respectively, resulting mainly from the fact that they improve the truly “mass transit” modes used by large shares of the population (and they reduce safety costs by reducing van use). Even small changes made to the mass modes can have large economic benefits. The rich benefit slightly more from the improvement in train, as they are more likely to take the train, while the poor benefit slight more by improvements to the bus, because of higher bus ridership.

The fourth policy, “Change Bus Concession” results in a positive net benefit, as it effectively lowers fares in exchange for lowered safety and vehicle fitness regulations. The poor are more fare sensitive and appear to benefit the most from the fare reduction in units of utils. The rich do not gain as much utility from fare reductions. It should be noted again that safety costs are not included in these results.

The eighth policy, “Legalize,” creates benefits purely from removing the stigma of the illegal status and adding additional demand for the service, though because of increased use with no improvements in safety, additional safety costs will likely be incurred. The ninth and tenth policies “Regulate” and “Regulate + Invest”, also shown in Fig. 1, create benefits even though van fares are assumed to rise slightly in response to the additional costs of formalized operation. The increases in the “immeasurable” attractiveness outbalanced these fare increases, though just barely for the poorest group. For the rich, increases in levels of service are highly valuable. This means that the wealthier groups receive slightly greater benefits. Investing in van services in addition to regulation is not efficient, as benefits don’t exceed costs (“Regulate + Invest”).

Finally, the theoretically competitive “Prices = MRMC” scenario, where prices of buses are lowered, while those of vans are slightly higher, results in benefits highly skewed in favor of the poor. The poor have the highest marginal utility of money, and benefit greatly from reductions in fares, combined with the fact that the fare reductions are on the bus mode, the mode used most by the poor. On the other hand, the rise in van fares hurts the rich who choose the van disproportionately. The rich do gain slightly as there are some time savings as mode share shifts slightly from the vans to the buses and trains. This scenario illustrates just how sensitive the poor are to fare. The total net benefit also rivals the two investment scenarios, illustrating the magnitude of welfare loss the population is currently experiencing under the bus cartel. Again, because of regulation of vans, there are some additional safety benefits.

The benefit model is only as accurate as its inputs. The sensitivity of the benefit estimate to the overall accuracy of the estimated inputs, like an estimated change in travel time derived from simple network models, is large. It is hoped that these estimates were the best available given the resources and time. Understanding these uncertainties leads us to recognize that only several conclusions can be drawn with high confidence. The first is that heavy restriction of the vans (Restrict 2, Restrict 3) leads to losses in net benefits. A second conclusion is that both of the investments in the mass transit modes, “Improve Bus” and “Improve Train”, and the competitive scenario “Price = MRMC” create economic benefits greatly surpassing those of any of the other policies. Third, regulating vans shows a greater net benefit than either legalizing (Legalize) or regulating and investing (“Regulate + Invest”) do. Finally, “Change VT”, “Restrict 1” and “Legalize” show net benefits that are probably not significantly different from zero.

Implications for policy

It was the goal of this study to look at the effects of the regulatory options on users. From a users’ viewpoint, regulation of informality, eradication of monopoly in the formal sector, along with improvements in the service levels of the mass modes hold potential to bring substantial welfare gains. The difficult question is how to achieve these scenarios in practice.

Together, these three approaches: operating concessions, regulation of vans, and investments in the formal modes, reinforce each other. Regulation of vans insures that marginal costs, and thus fares, are higher, which prevents the further uncontrolled growth of the sector based on head-to-head competition. Formalization and legalization of the vans lowers perceived investment risks and can induce better investments on the part of van operators. These two processes: higher van fares and physical segregation, increase confidence in the markets which both contribute to the push towards contestable markets for bus operations. Restated: eliminating in-road competition with vans might boost confidence enough to open discussions of competitive concessions for bus operations. Further protection from competition in the market would remove risk from the operations sphere and place it in the new sphere of competitive tendering, bringing fares closer to MRMC. Considering the effects uncontrolled entry of informal operators has had on the market, the bus operators might be persuaded to give up some rent opportunity in exchange for this new form of security.

Based on the research presented here, policy directions should prioritize the mass modes over the informal operators in this corridor, while attempting to instill competition and regulation in both the informal vans and formal bus sector. Monopoly operations are more costly and detrimental to users than informality, and working on these problems together could yield a more sustainable solution. In this way, informality has opened up the question of users’ welfare and has, at the least, brought other important issues like the losses from monopoly into the discussion.

Postscript

During the four years since this work was completed, some significant changes have occurred to the informal sector. Araújo et al. (2005) revisited the national situation through several case studies in 2005, including Rio de Janeiro. In Rio de Janeiro, several of the policy recommendations tested here have been enacted. Something we did not consider as public policy in this study was changes to private practice. Formal operators have begun adding new niches to their services, including increased use of automatic transmissions, air conditioning, and adding parallel minibus services, all of these at prices above the base fares (Golub and Ferreira 2004). Similar investments in air conditioned trains have been made, but the impact on ridership has not been studied. Included in our policy options, the transport coupon has been electrified to cut down on black market activities, and this purportedly reduced Van ridership, as was expected. More significantly, since 2004, the city began supporting bus priority measures on some stretches of the more congested expressways in the Baixada area, but these improvements have not yet been studied.

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References

Almeida Júnior, A.D., Araujo, A.M., Silva, B.E., Bandeira, C.A., Porto, D.R.M., Silva, K.V.C., Vianna, M.M.B., Sant'ana, R.: Alternative Transportation in the Rio to Baixada Fluminense Corridor (Transporte Alternativo na Ligação Baixada Fluminense e Rio). Working Paper, Transportation Engineering Program of the Federal University of Rio de Janeiro, Rio de Janeiro (1999)

ANTP: Clandestine Transport in Brazil (Transporte Clandestino no Brasil). ANTP, Sao Paulo (2001)

Araújo, A.: A proposed methodology for the calculation of alternative transportation costs (Uma proposta metodológica para o cálculo dos custos do transporte alternativo por vans). Master's Thesis, Programa en Engenharia de Transporte, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil (2001)

Araújo, A.M., Balassiano, R., Chiappero, M.: The Market and Regulation of Alternative Transportation Services in Brazil: Experiences in some Brazilian Cities (O Mercado e a Regulamentação do Serviço de Transporte Alternativo no Brasil: Experiências em Algumas Cidades Brasileiras). XIII Congreso Latino Americano de Transporte Público Urbano, Lima (2005)

Balassiano, R.: Van transportation—what should be considered during the process of regulation? (Transporte Por Vans—O Que Considerar No Processo De Regulamentação?). Transportes **4**, 87–105 (1998)

Ben-Akiva, M., Lerman, S.: Discrete Choice Analysis. MIT Press, Cambridge (1985)

Brasileiro, A., Henry, E.: Unlimited Movement: Buses in Brazilian Cities (Viacao Ilimitada: Onibus das Cidades Brasileiras). Cultura Editores Associados, Sao Paulo (1999)

Cervero, R.: Informal Transport in the Developing World. United Nations Commission on Human Settlements, Nairobi, Kenya (2000)

Cervero, R., Golub, A.: Informal transport: a global perspective. Trans. Policy **14**(6), 445–457 (2007)

CUT, CNTT: Unemployment, informality and clandestineness in the transportation sector. (Desemprego, Informalidade e Clandestinidade no setor de Transportes). Revista dos Transportes Públicos **21**(2), 87–96 (1999)

Dos Santos, E., Brasileiro, A.: Concentration Rates in Brazilian Bus Markets. Working Paper, Transportation Engineering Program of the Federal University of Rio Grande do Norte, Natal, Brazil (1999)

Dourado, A.B.F.: Evolution of the relations between private and public sector concerning the finance of public transit in Brazil (Evolucao das Relacoes entre os Setores Publico e Privado em Torno do

Financiamento dos Transportes Coletivos Urbanos no Brasil). Revista de Transporte e Technologia **6**(12), 38–61 (1994)

Ferraz, A., Barros Jr., L.: Economic Errors in the Calculation Methods for Bus Fares (Erros Economicos nos Metodos do Calculo da Tarifa) Revista dos Transportes Publicos. ANTP, São Paulo (1992)

Golub, A.: Welfare analysis of informal transit services in Brazil and effects of regulation. Ph.D. Dissertation, Department of Civil and Environmental Engineering, University of California, Berkeley (2003)

Golub, A., Ferreira, E.: The formal bus sector response to informality: the case of Rio de Janeiro, Brazil. Proceedings of XIII Pan-American Conference of Traffic and Transportation Engineering, New York (2004)

Governor of the State of Rio de Janeiro (O Governador do Estado do Rio de Janeiro): Decreto N.° 25.955 de 07 de Janeiro de 2000 Rio de Janeiro. www.sef.rj.gov.br/legislacao/tributaria/decretos/2000/25955.shtml (2000)

Hanemann, W.: Welfare analysis with discrete choice models. In: Kling, C., Herriges, J. (eds.) Valuing Recreation and the Environment, Edward Elgar, Northampton, Massachusetts (1999)

Jara-Díaz, S., Videla, J.: Underestimation of users' benefit when income is misspecified in mode choice models. Proceedings of The 5th World Conference on Transportation Research, UBC, Vancouver (1989)

Ministry of Transportation, Brazil: The Calculation of Fares for Urban Buses (Calculo de Tarifas do Onibus Urbanos). Ministry of Transportation, Brasilia (1996)

Morey, E.R., Sharma, V.R., Karlstrom, A.: A simple method of incorporating income effects into logit and nested-logit models: theory and application. Am. J. Agric. Econ. **85**(1), 248–253 (2003a)

Morey, E.R., Sharma, V.R., Mills, A.: Estimating malaria patients' household willingness to pay for health care proposals in rural Nepa. Soc. Sci. Med. **57**(1), 155–165 (2003b)

Neto, H. R.: The new challenges for Rio de Janeiro urban transport. In: Freeman, P., Jamet, C. (eds.) Urban Transport Policy: A Sustainable Development Tool. Proceedings of the Conference CODATU VIII, Cape Town, South Africa, Balkema, Rotterdam (1998)

NTU, ANTP: Informal Transport in Brazilian Cities: Risks of Not Confronting the Problem Head-On (Transporte Informal Nas Cidades Brasileiras: Riscos de Não se Encarar o Problema de Frente). ANTP, São Paulo (1997)

NTU: Informal Transportation: Risks and Proposals (Transporte Informal no Brasil: Riscos e Propostas). NTU, São Paulo (2001)

Orrico Filho, R.: Urban Bus Transport in Brazil: Regulation and Competition. Working Paper, Transportation Engineering Program of the Federal University of Rio de Janeiro, Rio de Janeiro (1999)

Small, K., Rosen, H.: Applied welfare economics with discrete choice models. Econometrica **49**(1), 105–130 (1981)

Torres, A.: Policies to control informal transport—the Rio de Janeiro Case. In: Freeman, P., Jamet, C. (eds.) Urban Transport Policy: A Sustainable Development Tool. Proceedings of the Conference CODATU VIII, Cape Town, South Africa. Balkema, Rotterdam (1988)

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