GLOBAL TAXI SCHEMES AND THEIR INTEGRATION IN SUSTAINABLE URBAN TRANSPORT SYSTEMS

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ABSTRACT

Taxis play an important role as a transportation alternative in many cities. In developed countries, taxis tend to be used as a substitute for private vehicles by passengers who use the service for convenience reasons or because they do not want to own a car. In developing countries, taxis are often used to supplement inadequate public transport systems based on buses or trains. But the role played by taxis can be as diverse as one can think. This study intends to provide a comprehensive and systematic analytical overview of existing global taxi schemes and their respective policies and regulations. A review of the literature regarding energy and sustainability issues is also presented. The importance of taxi operations in delivering good services in developing country cities is focused in the final part of the study. The current conditions found in the city of Rio de Janeiro, Brazil, were discussed due to projects under way to improve public transport services. These projects are under development in order to respond to a specific demand during the 2014 FIFA World Cup and the 2016 Olympic Games. The difficulty of developing strategic planning policies together with the complexity and specificity of designing an adequate regulation scheme is further developed.

1 INTRODUCTION

Taxis play an important role as a transportation alternative in all parts of the world. Although sometimes defined as a semi-public transport mode, the taxi service is, in fact, the first public transport in small towns when the distances between common origins and destinations become too large to be traveled by non-motorized modes. According to Lowitt (2006),

however, the demand for taxi services is highly heterogeneous and differs in developed and developing countries.

In developed countries, taxis tend to be used as a substitute for private vehicles by passengers who use the service for convenience reasons or because they do not want to own a car, even though they can afford it. Lowitt (2006) observes that, as in this market taxis tend to operate on a nonshared basis and their supply is limited by legislation, they can be a reasonable source of income for taxi operators. This was, for example, the market she considered in her study with the urban areas of Cape Town, Johannesburg and Durban, all in South Africa.

In developing countries, taxis are often used to supplement inadequate public transport systems based on buses or trains. In those cases, they may be also characterized by shared taxis and low cost single passenger services (e.g., motor tricycles or motor quadrucycles in India and Bangladesh, and mototaxis in Brazil). These are services demanded by upper lower income users who do not own private motorized vehicles. Although this is usually not the case in Brazil, the market in many developing country cities is quite often unregulated. For Lowitt (2006), unregulated markets result in an oversupply of services, high competition for passengers and, as a consequence, low fares and low incomes for taxi operators.

But the role played by taxis can be as diverse as one can think of. As heavy traffic volumes can make roads dangerous and difficult to cross, it is reported in World Bank (2002), for instance, that businesspersons routinely take taxis in Jakarta just to get safely to the other side of the busiest thoroughfares. In Hong Kong, according to Transport Advisory Committee (2008), taxis are a mode of transport frequently used by many overseas visitors. Therefore, they help to form Hong Kong's international image. Also, Mulley (2010) defends that shared taxi-schemes could be developed within a deregulated environment to meet rural accessibility needs, in locations where the provision and quality of bus based public transport remains erratic. Those three examples show some of the diverse functions that taxis can have in transport systems.

As this study intends to provide a comprehensive and systematic analytical overview of existing global taxi schemes and their respective policies and regulations, we start the analysis with a discussion of the general characteristics of taxi services. Next, in the third section of the document, we discuss specifically regulation and management strategies usually applied

in those systems. We also present a review of the literature regarding energy and sustainability issues, in section 4. These are some of the elements we rely on to discuss the future situation of the city of Rio de Janeiro when hosting the FIFA World Football CUP - 2014 and the Olympic Games of 2016.

2 GENERAL CHARACTERISTICS OF TAXI SERVICES

The discussion started in the introduction of this paper clearly shows that taxis perform an important function in urban transport markets in both developed and developing countries. As passengers are vulnerable to exploitation by operators, Gwilliam (2005) observes that entry to the market and fares are often regulated to avoid it. This is particularly true in industrialized countries, although it can be also found in developing countries (e.g., in Brazil). The same author states, however, that the limited number of licenses increases their acquisition value. As a consequence, there is some monopoly profit for operators at the expense of users. That is one of the reasons why these characteristics of the taxi systems (i.e., the number of vehicles and the fares) are usually investigated in studies trying to assess their level of service.

Gamrat (2001), for example, found in his study in the city of Pittsburgh (in the state of Pennsylvania, USA), that the availability of taxis was inadequate. He even suggested that one or more taxi companies could be added to the local market. His suggestions were apparently based on the fact that Pittsburgh had, if compared to cities of about the same size, the fewest number of firms, the second fewest number of taxis, and the second lowest number of trips per thousand citizens. Thus, he concluded that the level of service in the area was inadequate when compared to similar metropolitan areas. Furthermore, he identified the regulatory environment in which the taxis were operating as the major reason for the inadequate level of service. In the system established by the Pennsylvania Public Utilities Commission, potential entrants must prove that current firms are not satisfactorily servicing their customers. As potential firms must submit their plans to the PUC and they become open to public inspection, this gives the incumbents time to prepare counter arguments against the entrants. According to Gamrat (2001), this system does not make for a level playing field.

Too many or too few taxis licensed in a city can have serious effects not only on the availability and quality of service, but also on the economic viability of the taxi business. Schaller (2005) even states that setting the number of cabs is one of the most important decisions made by taxicab regulators and elected officials, in cities that control the number of

taxis by law or regulation. The same author identified, through multiple regression modeling of the number of taxis in 118 cities in the United States, three primary factors affecting the demand for taxi service. They are:

- The number of workers commuting by subway,
- The number of households with no vehicles available, and
- The number of airport taxi trips.

Although the results obtained by Schaller (2005) can be used to guide regulators in measuring changes in local demand for taxi service, this is not enough for precisely quantifying the demand for taxi service. That difficulty had already motivated other authors to search for mathematical models that could better represent the complexity of the system. One of the possible alternatives for understanding the equilibrium nature of taxi services and for assessing the impacts on traffic congestion due to taxis is to model taxi services in a network context. Yang and Wong (1998) have developed such a model as an initial attempt to describe how vacant and occupied taxis would move in a network of streets to search for customers. The model could determine a number of system performance measures at equilibrium, such as vacant taxi movements and taxi utilization for a given network and origin-destination demand patterns. The effects of the taxi fleet size and the uncertainty on the system performances were explicitly taken into account. In their conclusions, the authors were able to show how the average taxi utilization decreases sharply with the number of taxis operating, and how the higher the taxi utilization, the larger the average customer waiting time.

Wong *et al.* (2001) extended the simple network model of urban taxi services proposed by Yang and Wong (1998) in order to incorporate congestion effects and customer demand elasticity. A two-level model formulation was proposed for taxi movements in congested street networks. Their network equilibrium model was able to describe simultaneous movements of vacant and occupied taxis as well as normal traffic in an optimal manner from the users' point of view. The upper-level problem was represented by a set of linear and nonlinear equations ensuring that the relation between taxi and customer-waiting times and the relation between customer demand and taxi supply were satisfied. The nature of demand-supply equilibrium in a regulated market for taxi service was also investigated by Yang *et al.* (2002). They used a network model that can determine a number of system performance

measures at equilibrium, such as utilization rate for taxi and level of service quality, to predict the effects of alternative regulations on system performance.

Regulations were also studied by Fernandez *et al*. (2006), who were in fact looking for their social convenience. The diagrammatic approach they have used to study the characteristics of the cruising taxi market has allowed the representation and analysis of different operating conditions. System conditions were then described in terms of number of taxis in operation, number of runs produced, occupancy rates, fares charged, average production costs and generalized prices. They have shown that, for a perfectly adapted system, the long run average system cost function is always decreasing. That happens because the increase of a marginal passenger produces two positive externalities in the long run. Firstly, waiting times are reduced for all passengers. Secondly, the average taxi operating cost per run is also reduced, because occupancy rate increases. They concluded that a unique equilibrium exists for free market conditions under short and long run conditions, which corresponds to monopolistic competition equilibrium. They also describe how such equilibrium is obtained from the interactions between demand and supply conditions.

Wong *et al.* (2008) further extended the model of urban taxi services in congested networks to the case of multiple user classes, multiple taxi modes, and customer hierarchical modal choice. The idea was to take into account the several classes of customers with different values of time and money, and several modes of taxi services with distinct combinations of service area restrictions and fare levels. The introduction of multiple taxi modes can be used, for example, to model the differentiation between luxury taxis and normal taxis by their respective service areas and customer waiting times. One of the parts of their modeling approach was a combined network equilibrium model, which was formulated as a special case of the general travel demand model. Therefore, most of the parameters were observable, given that such a calibrated transport planning model was already available. The authors have demonstrated the effectiveness of the proposed methodology with the use of a numerical example.

Yang, Wong and their collaborators have also examined economic aspects of the taxi service operation, such as fare structures and profit. Yang *et al.* (2010), for example, used an extended taxi model with an explicit consideration of perceived profitability to look into the market effects of adopting a nonlinear fare structure with declining incremental charges. The

expected profit that a taxi driver expects to receive from picking up a customer in a particular place has great impact on the driver's choice of location in the search for customers. The fare structure directly governs the profitability of taxi rides of different distances originating from different locations. Thus, the nonlinear fare structure proposed could help restore a level playing field for taxi operators whose businesses have been affected by taxi drivers offering fare discounts or accepting requests for discounted fares for long trips. Sensitivity analyses of social welfare and profit gain were conducted with respect to the parameters in the nonlinear fare structure for the Hong Kong taxi market. The results of the nonlinear fare amendment have not been prejudicial to the customers. Also, taxi operators' profits were not reduced.

In summary, the simple network model of urban taxi services developed by Yang and Wong (1998) was further enhanced and extended in various ways to deal with demand elasticity, multi-class taxi services with service area regulation, congestion effects, multi-period dynamic taxi services with endogenous service intensity, and nonlinear pricing of taxi services (Wong *et al.*, 2001, Wong *et al*., 2008, Yang *et al.*, 2002, Yang *et al*., 2005a, Yang *et al.*, 2005b and Yang *et al.*, 2010a). In a recent study, Yang and Yang (2011) also investigated the equilibrium properties of an aggregate taxi market. Three specific issues were analyzed for meeting functions that exhibit increasing, constant and decreasing returns to scale. Firstly, service quality in terms of customer wait/search time and average profit per taxi were examined jointly in relation to taxi fleet size. An increase in taxi fleet size led to improvements in both service quality and market profitability. Secondly, the properties of the socially optimal solution were examined. It was found that the taxi fleet size should be chosen such that the total cost of operating vacant taxis equals the total cost of customer waiting time multiplied by an asymmetric factor of the meeting function, and that taxi services should be subsidized at social optimum only when the meeting functions show increasing returns to scale. Thirdly, the Pareto-efficient services were examined for trade-offs between social welfare and profits in the light of partially conflicting objectives of the public sector and the private taxi firms using a bi-objective maximization approach. The taxi utilization rate and the customer wait/search time or service quality are proved to be constant along the Pareto frontier and equal to those at social optimum if the meeting functions show constant returns to scale.

There is no doubt that fares and number of vehicles are central elements to understand taxi systems. However, they are certainly not enough to fully describe them. Issues such as

drivers' incomes, leasing, violence, and interactions with law enforcement are important parts of the picture and must be also examined. This was precisely done by Bruno (2009), who reported the results of a 49-item survey instrument that was administered to 920 Chicago taxi drivers between June and August of 2008. Some of the answers were not really a surprise, such as over 81 percent of the respondents agreeing or strongly agreeing that drivers need a fare increase. On the other hand, it was a surprise, and not very pleasant, the fact that a significant number of drivers was earning well below minimum wage and working nearly 13 hours per shift. This conclusion does not necessarily apply to all other cities in the United States, but it may be an indication that a similar problem may exist in some of them.

A comparison of the last point raised above in the report of Bruno (2009) with some of the suggestions made in the study of Lowitt (2006) show how taxi systems are strongly context-dependent. The aim of Lowitt's (2006) introductory paper was to stimulate thinking around the potential of the metered taxi industry in South Africa's major urban centers in the creation of jobs. For her, despite the absence of a culture of metered taxi usage, the increased traffic densities and city densities suggested that the latent demand would soon become effective demand. That would happen through the natural process of developing urban centers and their inevitable problems of congestion and parking. Also, on the supply side, the sector is biased towards owner operators and smaller companies and the skills required to participate in the industry are low. The combination of factors indicated that at least 13,000 jobs (or 26,000, using existing taxi numbers) could be created at minimum cost to the country. Lowitt`s conclusions emphasize that opportunities to generate jobs with little effort and little cost in a country with high unemployment rates are rare, but the metered taxi industry offers such an opportunity. Differently from the case previously discussed, the important point here was not the wage values, but the opportunity to create jobs.

Some other important points discussed in different studies were:

- The risks faced by taxi drivers, and existing safety initiatives (Madden, 2007). In that study, the Taxi Industry Safety and Security Taskforce has found that taxi industry safety across New South Wales could be enhanced through better coordination, cooperation and targeted initiatives.
- Key legislative and policy initiatives that have shaped the current state of the industry in Denver (in the state of Colorado, USA), the Denver metropolitan taxi market, the

relationship between the taxi companies and the taxicab drivers, substitute service providers, and pricing methods for establishing retail fares and wholesale lease rates (Colorado Public Utilities Commission, 2008);

- Feasible and appropriate improvement measures to broaden the taxi trade's business opportunities, and at the same time benefit the public through the provision of competitive taxi services in Hong Kong, China (Transport Advisory Committee, 2008). Cities which are comparable to Hong Kong in economic activities, such as Singapore, Tokyo, London and New York, were visited to study their regulatory mechanisms for taxi services and to learn how their taxi systems are operated. The regulatory regimes relating to fare bargaining in ten other major cities were also examined.
- The impacts of regulatory change in the taxi market, and measurable data appropriate to informing policy decisions (Taxi Studies Group, 2004). By developing and implementing a Combined Indicator Taxi Model, the research suggests that: *i)* policy choices made on the basis of a partial or incomplete analysis of all information increase the chances of unforeseen or negative secondary impacts working against the original goals of policy reform, *ii)* choices made in relation to the taxi industry reflect both structural and political objectives, and should be appropriate to location and geographical circumstance

3 REGULATION AND MANAGEMENT OF TAXI SYSTEMS

If Gwilliam's (2005) observations are correct, entry to the market and fares are characteristics of taxi systems often regulated to avoid the exploitation of users by operators. On the other hand, the limited number of licenses increases their acquisition value and creates some monopoly profit for operators at the expense of users. In addition, regulation can affect the availability and the quality of the service, either positive or negatively. Due to all those aspects, regulation is one of the key points in the management of taxi systems. Although the issue of regulation had already been briefly introduced in the previous section, in which the general characteristics of taxi systems were discussed, its importance justifies further discussions. That is the aim of this section, in which studies dealing specifically with the subject are reviewed.

3.1 An Overview of Taxi Markets and Regulatory Systems

A study that helps to understand the effects of entry regulation and deregulation on taxicab availability and service quality was developed by Schaller (2007), who examined the experiences of 43 cities and counties in the United States and Canada. The jurisdictions covered constitute 32 of the 50 largest taxi regulatory systems in North America as measured by the number of taxicabs, and 28 of the 50 largest cities or counties (where regulation is applied at the county level) as measured by population. The study started by reviewing the rationale for regulation. Four types of regulatory systems, based on whether there are numerical controls and whether drivers are permitted to operate independently of companies, were described by Schaller (2007), along with the differences between the street hail (also known as "flag" or cruising market), cab stand and dispatch markets. These were the main elements used by that author to assess the effects of different entry policies on taxicab availability and service quality.

In the review of the rationale for regulation, Schaller presented positive and negative arguments for both regulation and deregulation. As one could expect, economic arguments, which are often used for and against regulatory interventions in the market, are important to any discussion of entry policy. Among the arguments in favor of deregulation, for example, are the consumer benefits of lower fares and shorter waiting times for taxis. On the operators' side, the entrepreneurial opportunities, particularly for minorities and immigrants, were emphasized. On the other hand, an argument in favor of government regulation is that it is necessary to correct market imperfections. Among the market imperfections that would require regulation are, for example, economies of scope and scale that lead to uncompetitive conditions in the dispatch market. In that case, a large taxi company can pick up telephone order trips within a certain geographic area faster than a small company. The explanation for that is quite simple: more taxis in the area increase the likelihood of having a car nearby the customer's location. That condition and other aspects explored by Schaller when discussing the rationale for regulation make clear the differences between the street hail, cab stand and dispatch markets.

The cities and counties studied by Schaller were displayed in a diagram according to their relative number of dispatch, cab stand and street hail trips of their taxi systems, as shown in Figure 1. While a city in point A of the diagram would have only dispatch trips, other in point B would have exclusively cab stand trips and another one in point C street hail trips only. The

points within the triangle are cities or counties in which combinations of those market segments were observed by Schaller (2007). Some particular cases of Figure 1, such as the predominance of street hail markets in New York and the high proportion of dispatch services in Montgomery County, help to understand the diagram.

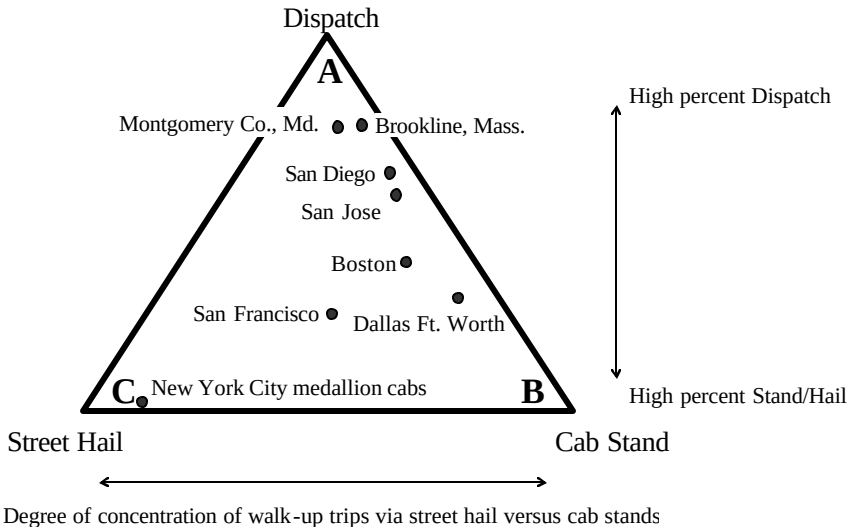

Figure 2. Typical entry policies for taxi customer market segments (Schaller, 2007).

Schaller (2007) also provided a very clear explanation about the different entry control and regulatory systems. In order to do so, he subdivided the regulatory systems into four types, according to their entry limits and entry qualifications (as summarized in Table 1). The classifications presented in Figure 1 and in Table 1 were then used to build the diagram of Figure 2, based on what was observed in the study in the United States and in Canada. They were also used to examine the effects of the distinct entry policies (as in Table 1) in the different markets (as in Figure 1). The study showed that entry controls have quite different impacts on the cab stand/street hail market and on the dispatch market. In the former case, for example, the absence of entry controls was associated to an oversupply of vehicles in the taxi stands and on the street hail market. As a consequence, the quality of the vehicles and of the drivers was negatively affected. When applied to the dispatch market, entry restrictions have an effect on the availability of taxis.

Table 1. Schematic classification of taxicab regulatory systems (Schaller, 2007).

ENTRY CONTROLS **ENTRY QUALIFICATIONS**	NO NUMERICAL LIMIT	NUMERICAL LIMIT
ENTRY QUALIFICATIONS CAN BE MET BY DRIVERS INDEPENDENTLY OF CAB COMPANIES	Type A Open entry	Type C Medallion/plate and permit systems
COMPANY-LEVEL ENTRY QUALIFICATIONS	Type B Open entry with company-level qualifications	Type D Franchise and certificate systems

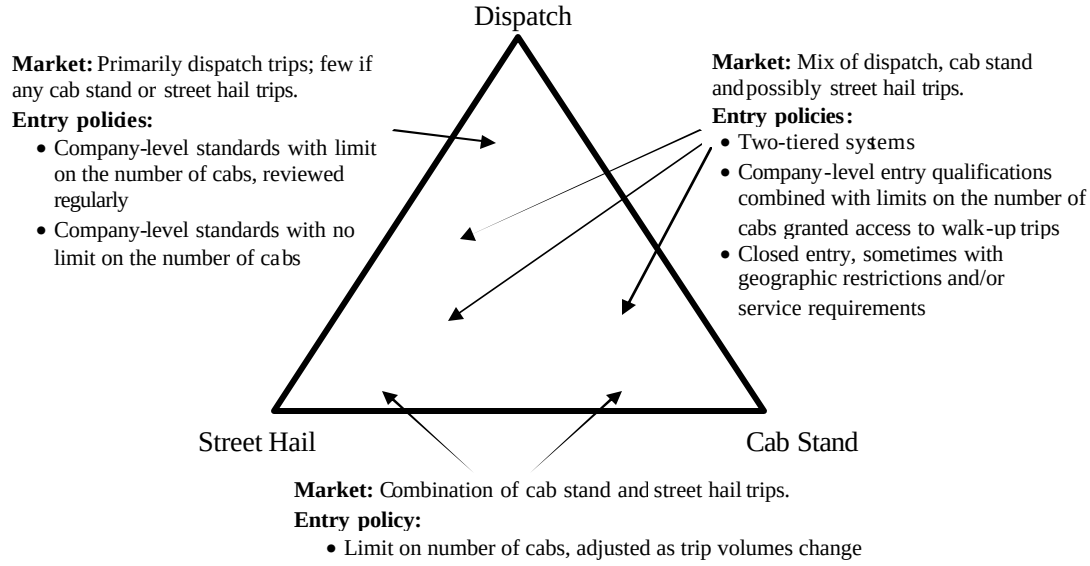

Figure 2. Schematic diagram of taxi customer market segments (Schaller, 2007).

3.2 Selected Experiences

Following what happened in other sectors of the transport industry, taxi systems were also affected by a deregulation wave. Some of these experiences were reported in the literature, with different outcomes, as described in the sequence.

3.2.1 Japan

Flath (2006), for example, discussed the case of Japan. The country has decided to change the regulation conditions of the taxi systems less than a decade ago. After February 2002, the entry conditions became more flexible, although the fares remained subject to regulation. Flath (2006) proposed a model of a cruising taxicab industry under laissez faire pricing and free entry. After comparing that model with alternative operational regimes, the author concluded that freeing entry while continuing to regulate fares could be worse than continuing a regulatory regime that effectively entails both collusive fares and restricted entry. That

happens because under collusive fares and free entry the average number of vacant taxis would rise above the efficient level. Under collusive entry, the average number of vacant taxis would be economically efficient given the fare.

3.2.2 Ireland

According to Goodbody Economic Consultants (2009), the lrish cab industry has undergone substantial change since the 1990s. Three periods in the recent development of the industry are mentioned in the study, as follows:

- *The Pre-Liberalization Period (before the year 2000)* - restricted entry to the taxi market, a fragmented administrative structure, and diversity in taxi fare structures and levels across the country.
- *The Post-Liberalization Period (starting in the year 2000)* - no more entry restrictions, but the fragmented administrative and fare structures were retained.
- *The Reform Period* - prefaced by the establishment of the Commission for Taxi Regulation in late 2004, began with the introduction by the Commission of a national taximeter area and national fare structure and other reforms in 2006.

The current regulatory model, which was adopted in the year 2000, has brought substantial benefits to consumers and to those service providers who have entered the taxi market since then. The liberalization of the market has solid foundations in the economic theory advocated by the OECD and by the World Bank and it has resulted in a much better matching of supply to demand. As a consequence, the taxi market is working well, as shown by the high levels of satisfaction of the consumers. One interesting point of the strategy adopted in that case was the presence of part-time service providers, who help to ensure that peak demands for taxi services are met. That solved one of the previous deficiencies in the provision of taxi services. Another point that must be mentioned is the sharp decline of the entry rates in the taxi market, what suggest that stabilization may occur in the near future.

3.2.3 Canada

The situation in Canada was discussed by David Seymour (2009) in a report on taxi deregulation. The study begins by showing the current conditions of taxi systems in selected cities, such as Calgary, Saskatoon, Winnipeg, and Halifax, where the media reported dissatisfaction with the taxi services. It was also observed that regulated entry into the taxi

market has kept taxi numbers lower than might be expected. As a consequence, the cost of taxi licenses has risen dramatically due to the artificial scarcity. In addition, taxi markets grew much faster than other parts of the economy when regulations were removed.

Seymour (2009) emphasized, however, that deregulation shall not only open up entry into the taxi market, but it shall also allow drivers to set their own prices. He advocates, based on empirical evidence from economists, that an open taxi market leads to better service, cheaper fares, shorter waiting times, and more employment opportunities for potential drivers. On the costumer side, a better taxi service particularly benefits low income segments and the elderly, who are more likely to rely on taxis. He gathered empirical evidence from New Zealand and Ireland to prove his point. The number of taxis increased in both cases. While in Ireland taxi numbers tripled shortly after deregulation and the public reported much greater satisfaction with the taxi services, reduced fares and a much wider variety of taxi services were reported in New Zealand. The same author recognizes, however, that a more accurate description of what these countries have done would be re-regulation instead of deregulation, given that they control the car conditions and the driver skills regarding safety.

Also from Canada was the study written by Belzile and Geloso (2010). They cited several examples of cities (Kansas City, Milwaukee, Phoenix, Raleigh and San Diego, all in the United States) and countries (Ireland, New Zealand and Sweden) that have shown it is possible and desirable to deregulate the taxi sector. Again, this shall not affect the regulations covering the quality of service, which must be maintained.

In addition to a study in Salt Lake City, USA (Mundy, 2005), Mundy (2009 and 2010) also reported the findings and recommendations of studies contracted for the examination of taxi services within the cities of Winnipeg and Saskatoon, respectively. The reports first discussed the rationale and necessity of regulating taxi operations; the current Winnipeg and Saskatoon taxi markets and company structures for the provision of taxi services; the current environment for taxicab service, and finally, recommendations for the future. In addition to the results found, one aspect of particular interest for our study is the list of project tasks that have guided those studies. They will be presented in the end of this section.

3.2.4 United States

An experience of taxi deregulation and re-regulation, which took place in the city of Seattle, USA, was discussed by Leisy (2001). Taxi rates and entry in the system started to be regulated in Seattle since 1914. The system was deregulated in 1979 in an attempt to provide the public with improved service and lower rates. However, as the service quality declined and rates were often higher, it became partially re-regulated in 1984. Initially, the rates were regulated but the entry remained open. A few years later, in 1990, the number of licenses was fixed in 667.

Another change in a taxi system reported in the literature took place in the city of Los Angeles (in the state of California, USA). Blasi and Leavitt (2006) examined what has happened to the drivers since 2000, as well as how the structure of the taxicab industry has evolved after new taxi franchises were granted for the first time in a quarter century. They tried do answer the following questions about Los Angeles taxi drivers: who they are, how much they make, how many hours they work, their family status, health, stress levels, access to health insurance, and so on. Some of the conclusions found were not very positive, as follows. Long work hours, low wages, high stress and poor health were common among taxi drivers. Also, the taxi cooperatives sometimes created the conditions for simple corruption and practices that were not good for drivers. Despite the complete authority of the local administration over the taxis operating in the city, not much was done to protect franchised taxicab companies from illegal competition and to protect taxi workers from exploitation by their companies. According to the authors, before that study little was found about the taxi industry in Los Angeles and how it came to be dominated by "cooperatives" of owner/drivers, sometimes controlled by a relatively small number of people. As their research project intended to fill these gaps in the collective knowledge, they examined the issues from both a "top down" (company and regulator) as well as a "bottom up" (individual driver) perspective. The study findings help to understand how the circumstances of drivers are affected by the structure of the industry and by government policy and regulation.

3.2.5 United Kingdom

According to Mulley (2010), bus based public transport has enjoyed revitalization in many urban areas in UK. However, the picture is different outside large towns and cities. Public transport supply in those areas is not adequately performed by buses. One of the negative characteristics of the service in rural areas is the low frequency. This was acknowledged by

the UK Government in 2007 in the study named Towards a Sustainable Transport System. Mulley's paper reports work undertaken for the Commission for Integrated Transport, an advisory body to UK Government, on how shared taxi-schemes could be developed within a deregulated environment to meet rural accessibility needs. The study was based on an analysis of institutional barriers and of successful schemes adopted in UK and in other countries in Europe. The paper also discussed the economic viability and the levels of subsidy currently used to provide accessibility in rural areas and showed the potential for a collective taxi-based service as part of the public transport mix needed to increase rural accessibility.

3.3 Summary and Recommendations

In the studies reviewed hitherto no single strategy for planning, management and operation of taxi systems that could be applied anywhere, was found. The alternatives discussed are very context-sensitive and most of them were tested in developed countries. In developing countries, this is a very complex subject, as emphasized by the Brazilian delegate cited in the report of OECD (2008), who said it would be very difficult to find best practices in Brazil, especially given that demand elasticity depends very much on the public transport services provided. Attention must be given, however, to some recommendations for developing countries done by Gwilliam (2005), based on theoretical and empirical considerations. They are partially reproduced and commented in the sequence.

- One of the key points when adjusting taxi regulation to specific local problems, objectives and market conditions is the behavior in the cruising market.
- As a primary point of regulation is the quality of the service, vehicles and drivers must be regularly checked. Therefore, a strong enforcement capability is needed.
- In the case of the vehicles, safety and emissions are very important control elements. The control of emissions is particularly important in large cities or in areas where taxis contribute significantly to air pollution.
- In the case of drivers, good character, safe driving skills, good health and geographical knowledge must be assured.
- Quality control is also essential as a requirement for market entry. Gwilliam (2005) sees it as a desirable element for partial regulation in the cruising market, which is likely to be more effective than total regulation (fare and entry) or total deregulation.

- Changes must be implemented gradually when involving liberalization of previously strict regulations. Also, poorer operators must be carefully considered in that case.
- In some cases, major trip generators may need some sort of specific regulation even in deregulated markets, as observed by Seymour (2009) regarding the airports.

Regardless the strategy, however, the decisions on what to do must be based on a good knowledge of the current market conditions. Mundy (2005, 2009, and 2010) provided a quite useful list of project tasks that can be used to guide other studies. The list is organized under three phases, as follows:

Phase I: Determine System Requirements and Current Situation

- Meet with officials and staff to clarify project, request further data, determine study requirements, and create lists of people and organizations to interview.
- Establish a Taxi Study Advisory Board consisting of city licensing officials, police, and representatives of major taxi users – airport, schools, and hotels.
- Conduct comprehensive customer/hotel surveys/interviews with all stakeholders as deemed necessary.
- Conduct Secret Shopper trials of all taxi companies serving the area.
- Interview taxi dispatch company brokers and taxi drivers.
- Interview current taxi plate holders.
- Obtain dispatch data, both raw and electronic, from existing taxi operators to perform service level analysis on existing taxi system at both peak and non-peak demand periods.

Phase II: System Conceptual Design

- Conduct in-house seminars with the Taxicab Study Advisory Board reviewing current conditions and comparing the city under study with other cities of similar size and situation.
- Provide several alternatives for discussion and consensus, building an appropriate "best fit" taxi regulatory model for the city under study to use in the future.

Phase III: Implementation Plan and Detailed Design

- Prepare detailed recommendations and implementation plan of the chosen alternatives for final approval.
- Prepare final report.

- Be available for public hearings and presentations as necessary.

4 ENERGY AND SUSTAINABILITY ISSUES

The importance of the taxi systems as part of a mix of public transport alternatives serving both urban and rural areas must be clear now. However, taxi systems may play an important role also regarding the environment. That was briefly discussed in section 3.3, in the list of recommendations for developing countries, when talking about strategies to control emissions. The search for low carbon alternatives to current fuels and vehicles is currently a concern in many parts of the world. In the UK, for example, road transport accounts for about a quarter of all carbon emissions (Mourato *et al.*, 2004).

Taxi occupants, both drivers and passengers, may be particularly exposed to high concentrations of pollutants, as found in the study of Fondelli *et al.* (2008). Those authors carried out a sampling survey in Florence, Italy, to estimate urban fine particle exposure concentrations inside commuting vehicles during workdays characterized by heavy traffic. Although an increasing number of Alternative Fuel Vehicle (AFV) programs appeared in recent years, they are still limited by various factors, including the relatively low price of oil. This is just one of the aspects of sustainability planning that can be influenced by taxi systems, as discussed in this section.

One of the fuel alternatives considered for public transport is Compressed Natural Gas or CNG, which is a relatively clean fuel. According to World Bank (2002), natural gas is available in abundance in many developing countries, such as Argentina, Bangladesh, and Thailand. However, the availability of CNG for transport is closely linked to its availability through distribution networks in urban areas. These exist in large cities in Bangladesh, Brazil, Colombia, Indonesia, Pakistan, Eastern Europe, and the former Soviet Union. Some governments are already stimulating the use of natural gas as a transport fuel in highly polluted areas (for example, for taxis in Buenos Aires and, more recently, for buses and all pre-1990 auto-rickshaws and taxis in New Delhi, India) where the fuel and the distribution networks are available.

CNG is one of the fuels considered in the AFV programs examined by Zhao and Melaina (2006) in the US and China when trying to define appropriate strategies for developing hydrogen vehicles and infrastructure in China. Taxis are mentioned several times in the study,

for example, when referring that more than 74 percent of taxis in Shanghai and 85 percent of buses in Sichuan province have changed to CNG/LPG (Liquefied Petroleum Gas) vehicles. That was possible because Shanghai's AFVs and supporting infrastructure went up quickly, with 103 stations supplying 37,000 taxis by May 2002 (Zhang, 2002, cited by Zhao and Melaina, 2006). According to the authors, however, less than 30 percent of taxis capable of using LPG in Beijing actually did so. That was about to change, given that Beijing had one of the largest bus and taxi fleets in the world implementing LPG and CNG, with around 5500 buses (of 11,000 buses in Beijing) and 37,000 taxis.

In the US, taxis are among the niche markets targeted through the US Clean Cities Program, along with transit buses, school buses, airports, law enforcement, and postal delivery, to mitigate air pollution. That potential for taxis was confirmed, for example, by Gao and Kitirattragarn (2008) in a study carried out in New York City (NYC), where 13,087 yellow taxis were found. They estimated a likely penetration of 9.35 % of hybrid-electric vehicles (HEVs) in the 5-year future NYC taxi fleet. The environmental impact of a conversion of this percentage of fleet toward HEVs resulted in the following decreases in the emissions over the current fleet: 2.29 % in carbon dioxide, 1.45 %, in carbon monoxide, 1.12 % in hydrocarbon, and 1.70 %, nitrogen oxide. There would be, however, a likely increase of 0.03 % in particulate matter, due to an anticipated higher proportion of sport-utility hybrid taxis. An even higher percentage of conversion to HEVs may occur if government measures, such as mandates or incentive programs, are implemented. That would further improve the environmental effects of the NYC taxi fleet conversion to HEVs. The New York taxi system was also mentioned by Lieven *et al.* (2011), who have forecasted the market potential of electric vehicles (in Germany) by looking at 14 categories of vehicles. According to them, the 130-200 miles covered by a taxi driver per shift in New York is a range perfectly met by electric vehicles equipped with lithium ion technology.

Despite the potential benefits of AVFs, just a few cities in the world have adhered to the technology shift. This is discussed by Silvestrini *et al.* (2010), who examined the implementation of the EU Biofuels Directive (2003/30/EC) and related voluntary measures at the local level in Germany, UK, Italy, and Finland and the cities of Berlin, London, Milan, and Helsinki. In Berlin, for example, since the end of the 1990s, many projects and activities with the support of local authority and local businesses have been dedicated to promote the use of natural gas. One example is the TUT Project (Thousands Environment Taxis,

http://www.tut-berlin.de/) which aimed at introducing 1000 taxis running on natural gas with the support of the German National Government. Another one is TELLUS, which aimed at helping fleet operators to convert their cars to natural gas-driven vehicles (http://www.fav.de/Pro_TELLUS.html).

In the UK, the central government got involved in the Green Cars Initiative, which offers an environmentally friendly taxi service for government employees. Silvestrini *et al.* (2010) also mentioned voluntary initiatives taken by single companies, such as Radio Taxis Group Ltd. The company, which is the largest taxi company in London and manages 3000 black cabs, announced that the entire fleet will run on diesel, 30 % of which will consist of biodiesel.

As drivers are directly affected by these changes, it is also important to know how they react on them, as studied by Martin et al. (2004), Shaheen et al. (2008), and Martin et al. (2009). Of particular interest here is the study of Mourato et al. (2004), who investigated the preferences of London taxi drivers for driving emissions-free hydrogen fuel cell taxis, both in the short term and in the long term. The results show that in the short term, if drivers are part of a pilot project, their willingness to pay seems to be driven mostly by the expectation of personal financial gains. However, in the long term, if fuel cell taxis become regularly available in the market, environmental considerations are found to affect taxi drivers' vehicle purchasing decisions. Also, taxi drivers heard in London did not mention safety concerns with respect to driving hydrogen powered cars.

Safety aspects of the taxi industry were also treated in some studies, in many different ways. The focus can vary from safety concerns regarding the vehicle fuel, as just mentioned, to the attitudes of taxi drivers on wearing a seat belt, as in the study of Routley *et al.* (2009). They have found that taxi drivers in Nanjing (Jiangsu Province, China) are particularly resistant to seat belt use. Innovative strategies, including occupational health and safety approaches, may be required to increase the levels of seat belt use. Another safety issue related to taxis is the increasing number and severity of the accidents involving mototaxis. According to Souza and Lima (2006), along with moto-delivery services, mototaxis were responsible for a significant increase in the rate accidents involving motorcyclists in Brazil. The rate that started at zero in 1980 reached 4.4 and 0.5 deaths of men and women per 100 thousand inhabitants, respectively, in 2003. Those accidents have victimized both drivers and passengers.

5 TAXIS IN BRAZIL AND THE CASE OF RIO DE JANEIRO

The importance of taxi systems as a supplementary public transport mode has already been shown through studies conducted in previous editions of the major events, as in Song *et al.* (2008). In the case of Rio de Janeiro, which is going to host two major international sports events - the 2014 FIFA World Cup and the 2016 Olympic Games, the actual conditions of all transportation modes must be carefully examined. However, given that some other Brazilian cities must be also involved in the World Cup, we start the analysis in this section by looking at some of the systems available in other major Brazilian cities. We then move to the particular case of Rio.

5.1 Taxi Systems in Selected Brazilian Cities

Rio de Janeiro and São Paulo are the cities with the largest taxi fleets in the country. Both have around 32,000 vehicles each, running regular and special taxi services 24 hours a day. While the city of São Paulo concentrates a population of 11 million inhabitants distributed in an area of 1,500 km^2, the city of Rio de Janeiro comprises a total of 6.3 million inhabitants in a 1,200 km^2 area. Those figures highlight the difficulty and complexity of determining the ideal taxi fleet size, especially in the case of large cities of developing countries. Is the city of São Paulo running taxi services with a fleet that can not respond to the current demand or is the city of Rio de Janeiro oversupplied in terms of taxi services? As mentioned before, these are difficult questions to be answered, based only on variables such as population and area of the cities. Both can be running an adequate fleet to the current service demand while the opposite could also be true.

In the case of Rio, the analysis of the operating taxi fleet, its characteristics and current quality of services is of upmost importance. The city will host (as São Paulo) several matches of the 2014 FIFA World Cup and also the Olympic Games in 2016. Both events will bring to the city a high number of foreign tourists and also Brazilians living in other states of the country. Those two events have required a commitment from all levels of government as well as private enterprise to make significant investments in infrastructure, including the improvement of public transport systems. This will be also an opportunity for Rio de Janeiro to showcase itself as a modern and prosperous city and society. Trying to control and regulate taxi operations is likely tied to this bigger political agenda. During those events, it is also expected a high level of participation from different socio-economic parts of society, thus

influencing the structure of a desired future scenario for the transport sector including taxi services operation.

There are some interesting aspects, regarding taxi services attributes in Rio de Janeiro, compared to other Brazilian capital cities, that should be mentioned. Rio de Janeiro is the city with the highest initial taxi fare in the country. While in Rio the convertional service fare starts at US$2.50, in Brasilia, the capital of the country, the same service charges US$1.94. Figure 3 shows a comparison of initial taxi fares among 11 capital cities in Brazil.

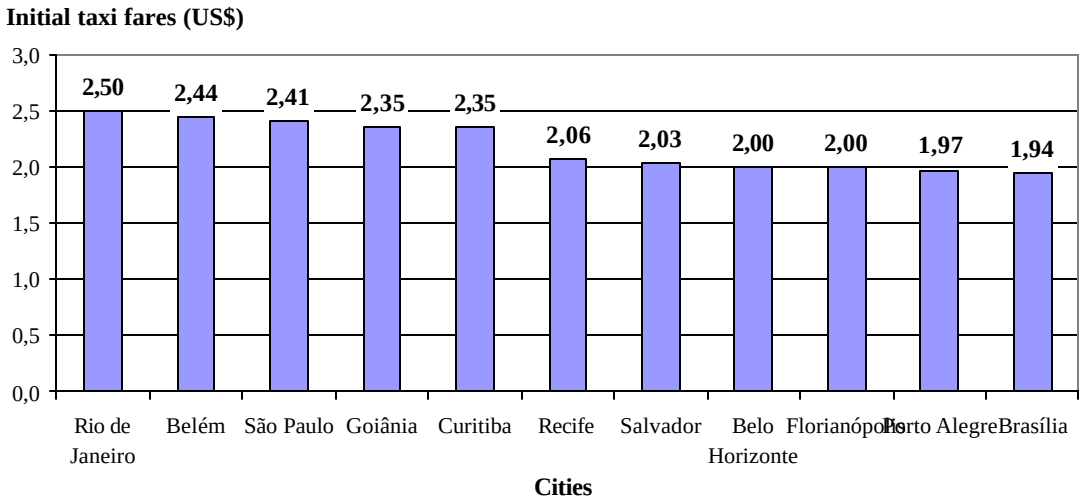

Figure 3. Initial taxi fares in 11 major cities in Brazil (Bessi, 2010).

On the other hand when analyzing the fare charged per km of service run, Rio de Janeiro has the lowest one, compared to the same cities. While this fare is US$0.80 in Rio de Janeiro, it is US$1.80 in Belém, the capital of the state of Para in the north of the country. São Paulo charges US$1.47 per km of service run, almost twice the fare charged in Rio. Figure 4 gives a comparison of the fare charged per km in the 11 capital cities. This comparison also highlights and ratifies the complexity of determining and regulating fares on taxi services. While all 11 cities are state capitals and thus possibly facing similar taxi demand characteristics, fares are diversified, confirming that each case should be analyzed individually. The level of employment and how jobs are spatially distributed, the land use characteristics, the spatial location of housing, commerce, services and etc. together with other important social and economic aspects should be considered when strategic planning for taxi services in large cities is needed.

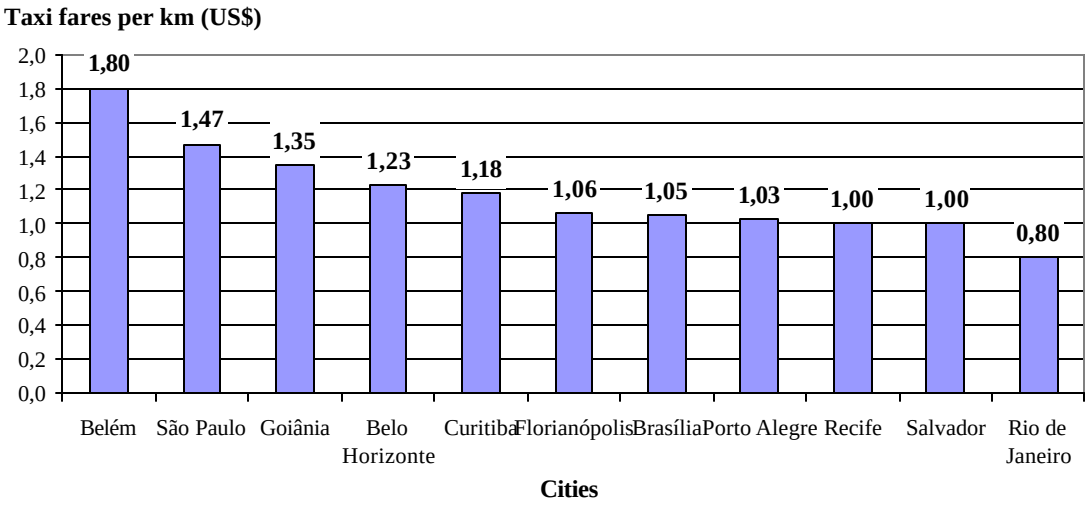

Figure 4. Taxi fares per kilometer in 11 major cities in Brazil (Bessi, 2010).

Another important aspect that should be analyzed in more detail, regarding taxi fleet operation in large cities such as Rio de Janeiro, is the relationship between the number of inhabitants and number of taxi vehicles available. In the case of Rio, this figure confirms that the city is the one with more available vehicles to users. There is one vehicle for each 198 inhabitants in the city while in cities such as Brasilia and Curitiba (a city well known for the quality of its public transport system) show a figure of one vehicle for around 750 inhabitants. Those figures stress again the difficulty and complexity of adequately planning taxi services to guarantee a reasonable level of service and the quality and safety of operation. See Figure 5 for taxi fleets and Figure 6 for the comparison among cities regarding the number of inhabitants per vehicle.

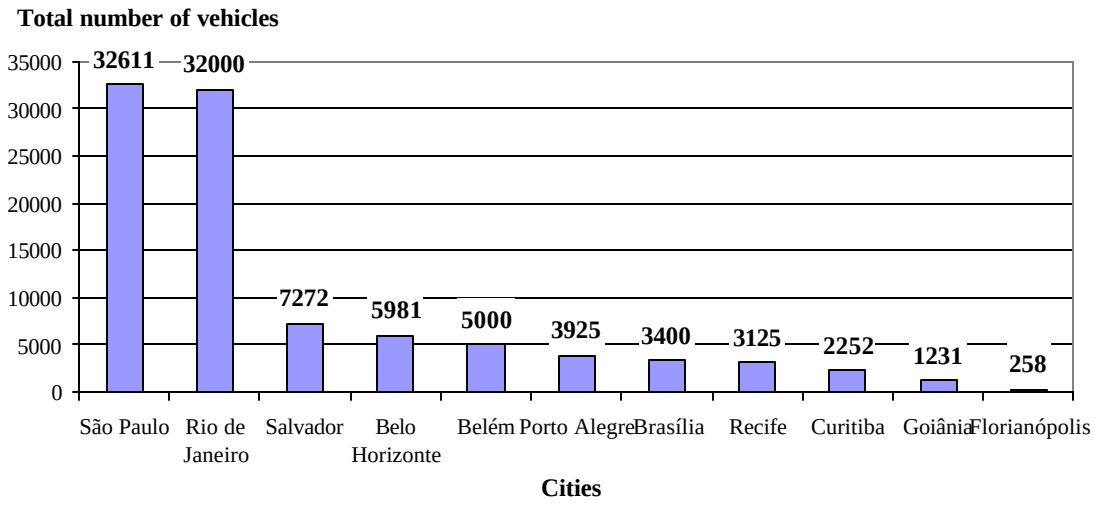

Figure 5. Taxi fleets in 11 major cities in Brazil (Bessi, 2010).

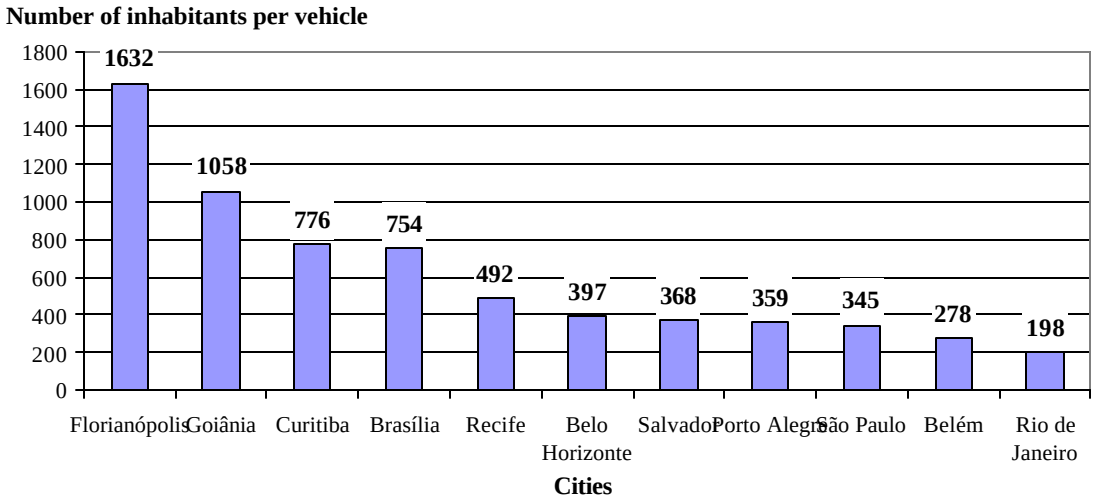

Figure 6. Relationship between the number of inhabitants and the number of taxi vehicles available in 11 major cities in Brazil (Bessi, 2010).

5.2 Taxi Services in Rio de Janeiro: An Overview

Taxi services in Rio are a concession from the Municipality to each taxi operator, either individual drivers or companies. This concession can be revoked at any time but in practice this rarely occurs. Only on cases where severe regulation violation is registered, concessions are revoked. According to the current regulation there are two types of taxi permit: a total of 18,000 permits, obtained before 1998, can be transferred to other taxi driver, after the death of the permit owner. The remaining 14,000, obtained after 2000, are not transferable under any

condition. The Municipality is not issuing new licenses and according to the city's Mater Plan, the objective is to reduce dramatically the fleet in the next 30 years. No taxi permits were issued between 1998 and 2000, while regulation was being revised.

The taxi fleet in Rio comprises different kind of services: individual drivers (taxi owners); individual drivers affiliated to cooperatives; special services charging higher fares (with taximeter); special services with no taximeter (fares even higher and pre-determined according to the link). In the case of cooperatives and all special services, vehicles are radio controlled or are equipped with a specific tracking system. There are a total of 700 taxi stands in the whole city. Those stands comprise a total of approximately 3,500 taxi parking spaces. The city centre is the area with higher concentration of those stands. There are 53 stands and almost 430 parking spaces for taxis. Barra da Tijuca, the district with higher real estate growth rate in Rio, comprises 50 stands with a total of 240 taxi parking spaces.

According to the taxi regulator, almost 20 % of the taxi fleet is illegally operating services. The problems comprise from irregular drivers' licenses to problems with vehicle maintenance and inspection. Tourist areas are the ones where most problems are registered. During the night period, it is difficult to find taxi vehicles parked at taxi stands not close to restaurants, hotels and areas with tourist concentration.

An important aspect regarding the taxi fleet in Rio de Janeiro is that all vehicles are adapted to run on CNG. There is an incentive from the Federal Government to drivers that adapt their vehicles to run on CNG. The annual tax over vehicle property (IPVA) can be reduced up to 75% and this is one of the major incentives to adapt vehicles. Rio de Janeiro is responsible for almost 39% of the CNG produced in the country and the pipeline distribution network is wide, covering not only the city but a significant part of the state. The lower cost of CNG compared to petrol and methane is another advantage leading taxi drivers to adapt their vehicles to CNG. Assuming the more clean characteristics of CNG regarding atmospheric emissions, the Rio taxi fleet can be considered the greener one in the country.

The problems faced by taxi regulators to improve services and the need to conform the service to respond for a specific demand that will be generated during the 2014 and 2016 events pushed the Municipality to review the current regulation. New rules and also a different approach to organize adequately the services provided is under way. Until 2016

many changes are expected including a more dedicated integration with other public transport systems and terminals.

5.2.1 Taxis in Rio de Janeiro: Organizing Services for the Upcoming Sports Events

According to Liu *et al.* (2008), preparing and operating transport systems for major events, such as the Olympic Games, are both complex systematic projects. According to the *Bidding Report for the Olympic Games*, the Olympic transportation services were aimed to "guarantee the Olympic family members, media, and VIPs to have access to comfortable, secure, punctual, reliable, and rapid special vehicles and special traffic routes, and to ensure spectators efficiency, security, and smoothness in going to venues. Public transportation means were given some priority so as to minimize the impact of the Olympics on people's everyday life. Special needs of the impaired were also taken into account in terms of traffic facilities and service items. Buses, taxis, Olympic vehicles all run on green fuel".

The process must start with traffic demand analyses. The results shall be used in the lay-out and design of traffic facilities and in the organization of transportation management activities for the periods before and during the events. Liu et al. (2008) presented the preparatory activities for the Beijing Olympics from several aspects, namely, infrastructure development, transportation service, and management policy. The operation of transport systems was described in four groups of activities: command system, transportation services in Olympic venues, road traffic operation, and public transport.

Studies on particular elements of transportation systems are also useful in understanding the changes that might affect the involved cities. Results of a taxi questionnaire survey conducted just before and during the Olympic Games in Beijing, for example, were presented by Song *et al.* (2008). Some of the findings were: the taxi operating rate reached over 92 % during the Olympic period, the average daily passenger volume increased by 19.2 % in comparison with the pre-Olympic period, the vacancy rate of the taxi system has decreased from 46 % to 37 %, and over 76 % of the respondents agreed that taxi speed has increased. However, only 29 % of the respondents said that waiting times were shortened. There was, therefore, a clear need for improvement in that aspect.

In general, the examples examined have shown that two aspects cannot be overlooked when organizing taxi systems for a major event. Firstly, transportation staff must be trained to deal

with athletes and supporting teams, tourists from home and abroad, and spectators. Public transportation operators must have communication skills in English. That includes: subway systems, buses, and taxis. Secondly, traffic demand management measures must be implemented to better organize the movements and to reduce environmental impacts. These measures include: the enhancement of environment protection standards, restrictions for the use of high emission vehicles, restrictions for certain vehicles to circulate in specific days of the week according to license plate numbers, and also to limit the number of vehicles entering the city with non-local plates. In addition, instructional measures can also help in reducing the number of movements in private vehicles. That is the case of transit free rides for passengers holding a ticket for any game or activity.

In the case of Rio de Janeiro, the revision of current regulation determines that from June 2011, taxi drivers will need a special authorization from the taxi regulator to stop at any taxi stand of the city. The authorization will be delivered only to drivers that go through a registration process in which drivers` licenses and vehicle maintenance conditions will be checked.

The registered drivers could apply for a parking space at any stand, but only one taxi stand could be selected. The taxi regulator had previously developed a field survey to identify the main taxi drivers parking at main taxi stands in the city. Those professionals will have priority to choose the taxi stand they would like to stop, based on their professional record.

In the case of taxi stands located in tourist areas of the city, drivers will be requested to have an English or Spanish language certificate. Those without any certificate will have a one year period to get it. After this period that they will have their parking permit at that taxi stand revoked. The forecast is to have all taxi stands operating under the new regime until 2012. The beginning of this process will focus on airports taxi stands and on the main city bus station, where most taxi violations are registered. Those taxi stands will be electronically monitored 24 hours a day.

Under the new regulation taxi drivers will also be ranked according to the certificates obtained and municipal record. Defense-driving and a foreign language certificates besides having an adapted vehicle to carry special needs passengers, will be advantageous in the ranking system. The regulation will also define new provisory taxi stands, to be located close

to areas where specific events, such as musical shows, special celebrations, specific sport games, will be held in the city. Taxi drivers better ranked under the new regulation will get a special parking permit to stop at those stands. During those events they will be able to stop at their designed taxi stand and also at those provisory ones.

The Master Plan of the Municipality has fixed a goal to reduce the current taxi fleet. It was established that the ideal fleet size will be based on the relationship of 1 vehicle to 700 inhabitants. According to the 2010 demographic census, the city of Rio has a total of 6.3 million inhabitants and the taxi fleet is expected to be reduced to some 9,000 vehicles. There is no timetable to reach this figure and the forecast is that at least 30 years will be necessary to reach this figure, based on the current taxi permit regulation.

All changes in the new regulation are focusing on improving taxi services until the 2014 and 2016 events (FIFA World Cup and Olympic Games). Thus, the municipality is trying to increase the number of traffic inspectors and also the oversight service. It is likely that trying to reduce the taxi fleet will not result in better quality services. Training adequately taxi drivers and improving vehicle inspection will possibly be an important strategy to support the required changes on service levels.

6 CONCLUSIONS AND RECOMMENDATIONS

In this paper we have examined some of the most relevant aspects of the taxi industry, in order to provide a comprehensive and systematic analytical overview of existing global taxi schemes. We specifically discussed regulation and management strategies usually applied in taxi systems, presented a review of the literature regarding energy and sustainability issues, and briefly discussed the conditions of Rio de Janeiro for hosting the FIFA World Football CUP - 2014 and the Olympic Games of 2016. Some of the main conclusions referring to those aspects are summarized in the sequence.

According to OECD (2008), taxi services are subject to a variety of potential limitations of competition. They include entry restrictions, which can take the form of limits on the number of licenses available or of rules that impose quality standards applied to cars or drivers. The rules restrict the total number of suppliers, with two consequences: an undersupply of services and an increase in the acquisition value of the limited number of licenses. Another form of

government control over the taxi sector is price regulation. However, there is no agreement on the effectiveness of those measures to ensure the quality of the service.

Schaller (2007) reviewed the effectiveness of regulatory approaches for the telephone order (dispatch) market and for the cab stand/street hail market and for cities with substantial trip volumes in both markets. A final conclusion of his study was that entry policies must be carefully tailored to market needs and local conditions. The availability and quality of taxi services are also affected by local factors that cannot be controlled through regulation. Therefore, even if we learn from the experiences applied in other places, we must always look at the specific conditions of each city.

Deregulation is not the ultimate solution for all cities. As observed by Gwilliam (2005), total deregulation can even increase fares. In addition to those already discussed in section 3, the following suggestions regarding regulation are given by Gwilliam (2005) for developing countries: *i)* where quantity control is deemed necessary to reduce congestion, tight price control and/or competitive tendering of annual operating licenses should also be implemented; and *ii)* the position of shared taxi services should be assessed in light of a broader public transport regulatory strategy, allowing for the benefits of a differentiated supply, but full taking into account the external congestion costs. OECD (2008) suggests that most important is not to block innovation which may give rise to new services. One factor is to ensure price differentiation is not prevented by regulation.

Regarding energy and sustainability issues, a statement found in World Bank (2002) somehow summarizes the main findings of this paper. Although local air quality can be improved in the long run, there is no quick technological fix for developing countries, due to the existence of a large number of old vehicles. That refers to vehicles in general, but also applies to taxis. Therefore, taxi regulation strategies in developing countries should be used to improve the environment conditions of the fleet and, if possible, to change the sources of energy used in the vehicles.

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