IMPACTS OF REGULATORY SCHEMES ON INNOVATION: THE CASE OF URBAN PUBLIC BUS TRANSPORT IN SANTIAGO

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ABSTRACT

Innovation is a common topic of economic research and it is starting to play an important role in the provision of urban public bus transport. On the other hand, contract theory has focused mainly on the effects of regulation on cost reduction, incentives, efficiency, and level of service, leaving little attention to its impact on innovation. This paper analyses the effects of different regulatory schemes on potential and observed innovation, in the urban bus sector. Specifically, we focus on studying the implications of different contractual interactions, on both technological and service operation innovation, in private procurement of urban bus services. In order to assess the effects of contracts on innovation, we analyse the regulatory reforms implemented in Santiago de Chile in 1979, 1991, 2007, and 2012. In particular we study the implications on service operation, vehicle, and infrastructure innovation capabilities, and whether changes are implemented by the operators, authorities or not implemented at all. In each study case, we also identify the incentives that led public and private parties to engage in innovative initiatives. General conclusions about each regulatory framework are then drawn. Our findings indicate that the contractual framework firmly determines the degree of innovation present in the industry. In particular, limited regulation incentivises strong service operation innovation, while showing negative vehicle innovation. On the other hand, gross cost and fixed payment contracts lead to negative service operation innovation by operators, motivated mainly by cost reduction efforts. Furthermore, introducing revenue risk sharing between authorities and operators is expected to incentivise positive service operation innovation by the latter. Lastly, infrastructure and positive vehicle innovation are generally driven by authority efforts to increase service quality, as there are little incentives for operators to invest in either. Policy-makers should take these conclusions into consideration when designing contracts, in order to achieve the desired outcomes of a reform. Further research is needed to build a formal economic model on innovation in this industry. Lastly, it would be interesting to extend the analysis with data of developed countries, as we expect that significant differences with developing countries may arise.

Keywords: public transport, innovation, bus, regulation, Transantiago

1. INTRODUCTION

Developing countries have experienced strong changes in their cities in the last decades, both in their structure and public transport systems. There is a growing tendency for introducing competition in the urban bus sector and numerous different regulatory schemes had been implemented, with varying degrees of success.

In this context, it has been widely documented in the academic literature that contract design is highly correlated with the outcomes of the implementation of a given bus system, mainly in terms of costs and efficiency (Gagnepain and Ivaldi, 2002, 2010; Roy and Yvrande-Billon, 2007). On the other hand, the effect of regulatory schemes on innovation is a relatively new topic, which has acquired little attention in transportation research (Ongkittikul and Geerlings, 2006). However, innovation's importance in providing a quality system suggests the need for formal studies and a solid theoretical framework for its analysis.

The aim of this paper is to assess the impacts of contracts on innovation, attempting to isolate the effects of a given regulatory scheme on both technological and service operation innovation, in private procurement of urban bus services. Particularly, we study contracts' implications in infrastructure, vehicle, and service operation innovation capabilities. Also, we analyse whether innovations are implemented by the operators, authorities, or not implemented at all. To do so, we follow the classifications and theory presented by Ongkittikul and Geerlings (2006), with a focus on the incentives generated to innovate by each contract type on each party.

In order to assess these effects, we analyse the case of Santiago de Chile and its regulatory reforms implemented in 1979, 1991, 2007, and 2012; these cases represent the transition between public procurement and privatisation, the introduction of limited regulation via competitive tendering for routes, a competitive tendering for gross cost contracts, and the recent adaptation of the previous scheme involving revenue risk sharing with the authorities, respectively. This study case is particularly interesting because of the various frameworks implemented and the numerous modifications in contracts in the Transantiago era (2007 onwards), characterised by the introduction of several compliance measures and their enforcement.

The paper is structured as follows. Section 2 provides the theoretical framework of innovation that will guide our analysis. Section 3 presents a brief history of the evolution of public transport in Santiago, along with the main relevant characteristics and innovative developments of each phase. In Section 4, we analyse each study case, based on the theory and classifications presented in Section 2. Finally, we draw our conclusions and provide suggestions for both policy and further research.

2. THEORETICAL FRAMEWORK

As previously mentioned, public transport service provision and contract design has been generally studied through the scope of economic welfare analysis, with a focus on efficiency and cost structures. However, rather than using that common view, this study focuses on the effects on innovation of each regulatory policy.

The term innovation has acquired both attention and importance in latest research, but many disciplines understand its definition rather differently. Ongkittikul and Geerlings (2006) summarise the contributions of varied literatures and provide a definition to be used in public transport studies.

In order to properly define innovation in public transport, it is necessary to understand its production process first. In this paper we follow the public transport characterisation developed by Ongkittikul (2002), based on the twin characteristics approach (Saviotti and Metcalfe, 1984; Saviotti, 1996). The latter is when each product can be described as the combination of technical and service characteristics, with the technical characteristics being all that is needed to produce the final services.

The modified framework presented by Ongkittikul (2002) reclassifies the technical characteristics into two new groups: pure technical characteristics (**T**) and competences (**C**). The first group includes all the basic tangible goods required in providing public transport services, i.e., vehicles and infrastructure. In the other group, competences comprise all the skills required by operators running the system, i.e., labour division and management, organisational structure, and contractual arrangement and fulfilment, amongst others. The explicit inclusion of the regulatory schemes is not casual, as it is one of the most important factors that determine the behaviour of an operator, and also one of the focuses of this study.

Furthermore, Ongkittikul and Geerlings (2006) divide the final transport service (**Y**) into two main categories: core and supplementary activities. As their names suggest, core activities are the main part of the service, in this case, transporting people from an origin to a destination; while supplementary activities includes all the other tasks performed by the operator (e.g., travel and user information, ticketing, marketing, buses maintenance, etc.). Figure 1 summarises this new characteristics-based approach of public transport service.

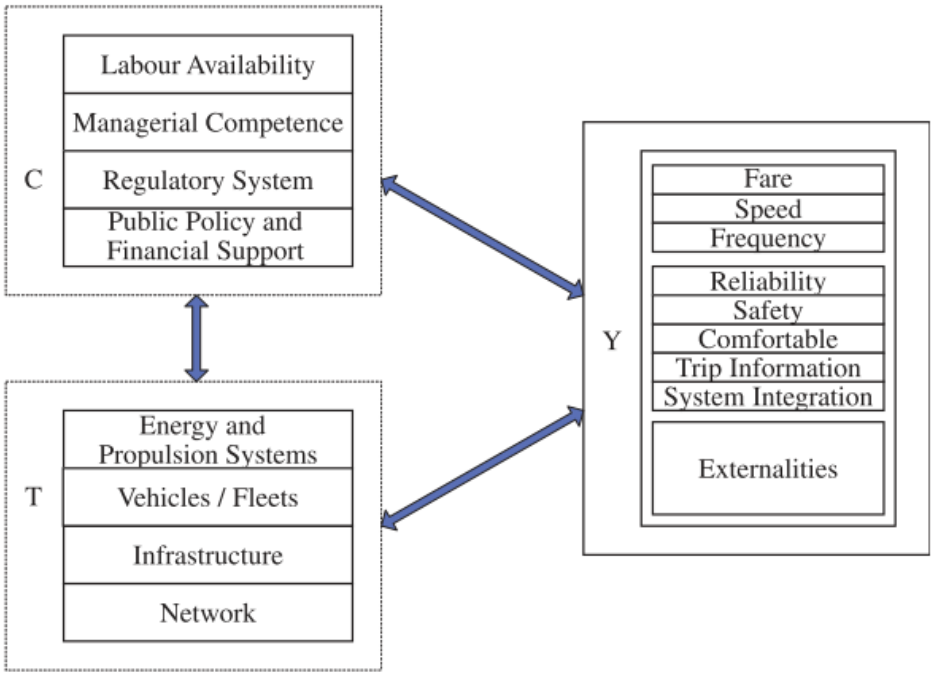

Figure 1 - Characteristics-based approach of public transport service. Source: Ongkittikul (2006)

Taking this new characterisation as a basis, we will follow Ongkittikul and Geerlings (2006) definition, which states that innovation is any change affecting one or more terms of one or more vectors of characteristics (i.e. technical characteristics vector (**T**), competences vector (**C**), or final transport service vector (**Y**)). It is important to note that, under this definition, all changes in the service provision process are classified as innovation, whether they are considered beneficial or harmful to the users of the system; we will call the former positive innovation and the latter negative innovation. For instance, fleet modernisation is classified as positive innovation while an increase in the average vehicle age is considered negative innovation. We are aware that this is a simplification and in a complex transport network grey areas may appear.

Additionally, Ongkittikul and Geerlings (2006) focus in the service characteristics vector (**Y**), and further classify its innovative developments as endogenous or exogenous. Endogenous service innovations are produced by changes in the technical characteristics (**T**) and/or competences (**C**) vectors, while exogenous innovations comes from external forces and constraints (i.e. basically, regulation imposed by public authorities). Although both endogenous and exogenous service innovations finally produce changes in the technical characteristics (**T**) and/or competences (**C**) vectors, the logical consequence in which they occur is different and thus should be analysed as separated classifications.

Finally, innovative developments are classified by Ongkittikul and Geerlings (2006) in three categories: infrastructure, vehicle, and service operation innovations. Examples of innovations in each classification are presented in Table I. These are simple categories, and prove to be more operational than the previously introduced when analysing a real study case. However, all of them are relevant and thus are considered in this investigation.

Table I – Examples of innovations in each category, of the bus industry.
Developed from Ongkittikul and Geerlings (2006), using Chilean examples.

Innovation related to infrastructure	Innovation related to vehicles	Innovation related to service operation
- Bus corridors - Pre-board payment bus stops - Camera control system - Bus terminals modifications	- Fleet modernisation - Environmental friendly engines - Low-floor buses - Changes in vehicle size - GPS equipped buses	- Services modifications - New services development (e.g., express and short route variants) - User information webpage

Furthermore, as one of the contributions of this work, we also identify different incentives that may lead authorities and operators to innovate. This consideration is especially relevant since, as shown by Ongkittikul and Geerlings (2006), it is common to observe great differences between potential and observed innovation, explained by lack (or wrong set) of incentives. Thus, the observed innovation in a system is determined by the incentives that each regulatory scheme provides to both authorities and operators, urging contract design to take this sphere into consideration. Lastly, it is important to note that our enumeration is not necessarily exhaustive, as it is only a practical simplification of a more complex set of interactions amongst numerous actors.

On one hand, when service provision is delegated, private operators may involve in innovation by their own initiative (i.e., endogenous innovation) or by following impositions

made by authorities (i.e., exogenous innovation). Endogenous innovative behaviour can be explained quite simply, as it is widely accepted that private parties' main motivation is to maximise their expected profits (Varian, 1992; Laffont and Martimort, 2002). Therefore, the incentives that may lead operators to innovate are aligned with profit maximisation, for instance; cost reduction efforts, which can be the result of modifications on vehicles or timetables' structure; increasing patronage, resulting from marketing campaigns or improving service quality; increasing incomes by a direct fare raise; or improving market position, which can be achieved by predatory behaviour against smaller firms, pressuring authorities into giving the firm benefits (Tullock, 1967), or even allying with other operators to create monopoly power.

On the other hand, authorities may impose modifications in the service provided by private operators in an exogenous way. In this respect, the incentives that explain the logic of innovation are more varied and complex, as they are the result of the interactions of numerous agencies and political actors. However, we identify and present some general motives. First, authorities may introduce innovations to the system as an effort to improve it, in order to obtain political support from citizens or fulfil campaign promises, as transportation is a major concern in any urban city. Secondly, public authorities can be also motivated to reduce the amount of subsidy given to private operators, and consequently implement reforms aiming at improving the efficiency of service provision. Finally, it is also important to identify situations in which the authorities may act as the result of external pressures. As Tullock (1967) explained, firms may be interested in promoting regulations and laws that allow them to obtain monopoly power or increase their profits in other ways, which can be done by pressuring and lobbying key political actors. This process, called rent-seeking, is prejudicial to society as inefficient legislation (that favours some specific interest-groups) can be passed as the result of the lobby process. Resources expended in this manner are considered wasteful as they are not invested to increase social welfare, but only to transfer part of it to the lobbying firm. Additionally, the pressure can also be applied by other public agencies or companies. For instance, attempts to introduce competition by deregulating a bus system currently in charge of a public company may be hindered by the present operator, in order to retain jobs and/or political power.

Having presented the theoretical framework for our study, we proceed to analyse the history of Santiago's bus system, assessing the effects of the different regulatory schemes on both potential and observed innovation.

3. SANTIAGO'S BUS SYSTEM: A BRIEF HISTORY

In this section, we present the evolution of the public transport system in Santiago. To do so, we divide the system history in five phases and present their main relevant characteristics along with the changes brought by each regulatory reform.

3.1 Public procurement (until 1979)

Until 1979, the state-owned company *Empresa de Transportes Colectivos del Estado (ETCE)* was in charge of supplying bus services and regulating fares, routes and operation

licenses of private operators. This period was characterised by a supply shortage and low quality of service. The scarce competition put relatively low pressure on efficiency and the number of buses, and therefore frequency were below acceptable standards (Díaz et al., 2005).

Despite a high innovative potential, the weak institutions in charge and lack of incentives resulted in a relatively stable phase. Vehicles and infrastructure remained practically unchanged and service design did not responded to demand in time, meaning that there were fewer buses and routes than needed.

3.2 Deregulation (1979-1991)

As a response to the declining conditions of the public transport system, authorities decided to introduce competition by deregulating entry, fares, and route structure. This process started in 1979 and was completed in 1983, by then the *ETCE* was dissolved, leaving in its place a large number of informal operators.

The reform was expected to increase service supply and quality, along with a fare reduction effect, as a result of competition's pressure on efficiency. The two first objectives were indeed achieved. In less than ten years bus supply was doubled, which decreased waiting times and increased service coverage. However, this large number of old buses highly increased congestion and pollution in the centre of the city, where most routes concentrated and overlapped. Also, during this period fares almost doubled in real terms, even while the main input prices were actually decreasing, as a result of the imperfect competition that characterises deregulated bus service provision (Díaz et al., 2005). Namely, each bus does not face a totally elastic demand at a bus stop, as passengers waiting cannot access all bus services simultaneously. Consequently, declining to ride a bus results in an extra (and unknown, since passengers do not have perfect information) waiting time, generating a pseudo-monopolistic situation from which operators can profit by raising their fares (Fernández and Muñoz, 2007).

Services were provided by a large number of informal operators, where the owners of the vehicles were often also their drivers, meaning that their income depended directly on the number of passengers and fares they collected. This situation led to fierce on-street competition, with negative effects in safety and quality of service along with discrimination against schoolchildren (who paid a reduced fare without any subsidy) and people with reduced mobility, amongst other problems (Muñoz and Gschwender, 2008).

Regarding innovation, the results were varied. Authorities became practically inactive as they delegated the service provision to private operators and focused their efforts on building a subway system instead. Therefore, authorities showed virtually no signs of innovative initiatives in the bus sector. However, at the end of this period authorities developed the *Metrobús* system. This scheme was launched in 1987 and consisted in tendered bus routes that served as feeders to the subway, and users of the *Metrobús* could ride the latter paying a reduced fare, much smaller than the sum of a regular bus and subway ticket.

On the other hand, operators developed both vehicle and service operation innovation. As it has been documented by Díaz et al. (2005), during this period some operators started to use low capacity vehicles. This minibus effect was also present in the bus deregulation in the United Kingdom, as explained by Ongkittikul and Geerlings (2006), and Mallard and Glaister

(2008), amongst others. This result, along with the ease of entry to the bus market, allowed the creation of a great number of new services, and the supply shortage of the public provision era was solved.
Moreover, some drivers associated and created a simple yet effective way of controlling headways, the *sapos* system, which worked with observers positioned along the route who informed drivers on the other buses passage times (Johnson, Reiley, and Muñoz, 2006).

3.3 Competitive Tendering: first attempts (1991-2007)

The large number of old buses with low average load factors was a symptom of a clearly inefficient system with high pollution externalities. This, along with the relatively high fares being charged (taking purchasing power parity into account), led to the introduction of regulation as a government effort to improve service quality.
In 1991, authorities restricted maximum vehicle age and bought a large number of buses from operators in order to take them out of the streets, which contributed to importantly reduce the number of buses circulating. Also, several rules were established regarding vehicle characteristics and air pollutants emissions, which became stricter over the years. In addition to the new rules, market entrance became regulated via competitive tendering for routes in a net cost contract scheme[1], but without any level of subsidy. In other words, operators competed in fares, average vehicle age, and other variables for the right to operate a defined route service (Díaz et al., 2005).
In the beginning, fares decreased along with congestion and pollution externalities. However, subsequent tendering processes were not as successful as the first ones. There is evidence that operators colluded in 1998, as shown by Sanhueza and Castro (1999). As Muñoz and Gschwender (2008) indicate:

> The bus companies were organised into powerful owner cooperatives that almost always coordinated their members' bids in the route tendering processes, and attempts by the Ministry of Transport to modernise the system were often obstructed. In 2001 the companies brought Santiago to a standstill by blocking major intersections with their vehicles. On this occasion, however, the cooperative leaders were jailed and the government regained the upper hand.

The beneficial initial effects of the reform were fading, and some main problems were never directly attacked as they were inherent from the service and ownership structure of the industry, which promoted on-street level competition.
As World Bank (2009) indicates, the main problems of Santiago's urban transport system were, amongst others; a steady decrease of public transport modal share, high level of traffic

[1] Net cost contract: in this type of contract, the total operating cost and revenues are estimated in advance, and their difference determines the price the local authority pays to the transport company (i.e., the subsidy level). Both production and revenue risks are thus borne by the transport company (Roy and Yvrande-Billon, 2007).

congestion and air pollution, increasing road accidents involving buses, inefficient route design, and low passenger satisfaction.

In this scheme, regarding service operation, innovative potential was high for authorities and moderate for operators; however, in practice there were no major changes in this respect. Authorities tendered basically the same routes from the end of the deregulated era. On the other hand, operators did not have the incentives to invest in developing new services as there were no insurances that they could capitalise their investment later, due to the lack of road space exclusivity. Adding the small average firm size (in 2005, each firm had an average of only 2.11 vehicles (Díaz et al., 2005)), and the complicated procedure for changing routes, the service structure remained virtually unchanged.

Regarding vehicles, the minibus effect initiated during deregulation was considered negative, due to the high pollution and congestion externalities, and thus was eliminated by the new regulation, which restricted the minimum vehicle capacity. The restriction imposed to the maximum vehicle age fostered the renovation of the fleet, and the public had access to better and newer vehicles. For instance in 1998, seven years from the reform, average vehicle age in Santiago was only 5.21 years.

Lastly, there wasn't much bus infrastructure investment these years. On one hand, operators had neither the incentives nor the power to do so. On the other, authorities considered it more important to invest in expanding the subway system, rather than building bus infrastructure.

3.4 Transantiago: the beginning (2007)

The previous scheme had a bad perception amongst citizens and the former operators had problems with the authorities, as shown by the strike mentioned in the preceding section. Adding the other problems already discussed, the system was prime for major changes. The proposed solution was Transantiago, one of the most ambitious transport system reform projects in not only Latin America, but the whole world.

The Transantiago plan consisted in a complete restructuration of the public transport system of the city. It involved a new route design organised in a trunk-feeder network where operators competed for a gross cost contract[2] in 9 feeder zones and 5 trunk corridors. This design, along with a new payment method where operators and drivers practically no longer received money per passenger collected, intended to end on-street competition, discrimination to students and other problems with the previous system. Also, it included a reduction in the number of buses circulating and fleet modernisation, to ensure an environmentally sustainable system and the inclusion of people with reduced mobility. The system also incorporated a smart-card payment method, which allowed fare integration between different lines and access to the subway without the need to pay an extra full fare.

[2] Gross cost contract: in this type of contract, authorities and operators estimate and agree upon a price that will be paid for the production of a fixed amount of services, while all revenues are accrued by the local authority. Therefore, production risk is borne by the transport company and revenue risk is taken by the public party (Roy and Yvrande-Billon, 2007).

The introduction of the new system finally took place in 2007 and solved some of the major problems with the previous scheme, such as unsafe driving and discrimination to students and elderly people. However, many key elements of the design were not ready at the time Transantiago was launched and there were also some short-sighted design considerations. For instance, the GPS and bus fleet control system were missing and planned bus infrastructure was incomplete (World Bank, 2009).

The absence of incentives for operators to collect passengers and authorities' inability to control them at the time of the launch, added to the lack of infrastructure needed to support such a network design, resulted in numerous problems for the system: waiting times and perceived travel time increased dramatically, buses were overcrowded, the subway system collapsed because of the new passengers attracted, the general public perception of the reform was negative, and high levels of fare evasion were observed (Muñoz and Gschwender, 2008).

One important reason for the above problems was that the number of buses circulating was substantially lower than the contracts stipulated, but it was not until the implementation of the GPS control system and the first compliance measures that this situation could be properly controlled and punished (Beltrán et al. 2011).

Transantiago brought along many innovations, in all of the three categories analysed. Service structure was radically changed, a webpage with information about the different routes was created, which also allows users to obtain the shortest route between two points of the city (using buses and/or subway), amongst other innovative developments. Regarding vehicles, the entire fleet was to be replaced by quality low-floor and low-emissions buses; also, three-axle high capacity buses were introduced in crowded lines. Finally, bus infrastructure was also improved; proper bus stops were built with some of them involving pre-boarding fare collection, some bus exclusive lanes were created, and operators were demanded to build proper bus terminals.

However, these innovative initiatives were part of a transport plan built practically from scratch and thus were not really effects of the regulatory scheme imposed with Transantiago. In this sense, this period may seem to lose some interest for this study, which focuses on how different regulatory schemes induce diverse innovative behaviours. Nevertheless, it is interesting to analyse the initial problems and the lack of adaptability of the system, which is a direct consequence of its regulatory design, and how these flaws are being corrected with the reforms subsequently introduced.

Finally, one important innovation not included in the original plan was the introduction of express routes variants (which skip many bus stops and benefit from the urban highways of the city) and short routes variants (which run only on the most loaded parts of the service), allowing lower travel times and more efficient fleet use, respectively. Yet, these developments were mostly an authority's effort to improve the system, as the gross cost contract did not provided private operators the proper incentives to invest in designing new services.

3.5 Transantiago: following modifications and development (2007 and further)

As previously discussed, Transantiago's situation improved over the years, due to contract improvements, creation of new compliance measures, the application of an important

subsidy not considered in the initial plan, and other management measures driven by the authorities.

The initial business model was designed to ensure a low-risk business, in order to attract new and foreign investors to the tendering process. As mentioned above, the actual number of passengers carried had very little influence in each operator's payment. Instead, payments depended mainly in the scheduled number of bus-kilometres, but not on the actual performance or service quality. Consequently, operators faced in practice a fixed payment contract, rather than the gross cost contract originally planned. This design was swiftly proved incomplete, as operators could reduce their operational costs by running fewer buses than programmed, without significant effects on their revenues. For instance, as Beltrán et al. (2011) indicates, in July 2007 there were about 4,600 buses circulating, in contrast with the theoretical number of 5,600.

This behaviour had devastating effects in service quality and authorities decided to prevent it by modifying the contracts in a way that operators' payments were directly impacted by the actual number of buses circulating. Due to technological constraints, a first compliance measure was introduced at a company-level in August 2007. The result was an indicator of the number of seat/standing places per hour fulfilled, the so called ICPH (*índice de cumplimiento de plazas-hora*), and had a remarkable impact; in only a few months, the programmed number of buses was almost equal to the observed in the streets (Beltrán et al., 2011).

Despite this initial success, there was evidence that some lines' operational programs were not being fulfilled, and instead operators ran more buses than stipulated in lower-cost lines, obtaining a perfect ICPH company-wide while leaving some users unattended. In addition, irregular headways and bus-bunching were major issues in the system, and this first index was not providing the correct incentives to solve them. Consequently, in mid-2008, two more compliance measures were introduced; a frequency fulfilment index (ICF: *índice de cumplimiento de frecuencia*), and a regularity fulfilment index (ICR: *índice de cumplimiento de regularidad*). Both indexes are calculated at route level, solving the company-wide aggregation problem of the ICPH. Also, it is important to note that instead of directly correcting each operator payment like the ICPH, both the ICF and ICR considered fines for companies that failed to achieve predefined service level standards (Beltrán et al., 2011).

As stated above, Transantiago introduced three-axle high capacity buses, intended to be used in high demand lines and periods. However, operators had freedom to assign them wherever they preferred, and some lower-demand lines users could experience higher waiting times if the specified offer was achieved by using larger vehicles at lower frequencies. Hence, the ICF was designed accordingly to solve this issue by requiring the fulfilment of the specified frequency (Beltrán et al., 2011).

Later, the previously introduced ICPH was modified and improved, in order to provide better incentives to operators. The result was a new index that measures the number of seat/standing places-kilometres per hour fulfilled (ICPKH: *índice de cumplimiento de plazas-kilómetro-hora*). This new compliance measure is more demanding than the ICPH, and it also takes in account the number of kilometres run by each bus, in order to prevent operators from running buses during only a small fraction of each measure period and still fulfilling a perfect ICPH. Interestingly, the ICPKH has been further improved by the conclusions of a joint authority-operators analysis (Beltrán et al., 2011).

Although the introduction of these first compliance measures had important beneficial effects, some issues still remained unsolved. Companies adapted to each change in a way that allowed them to maximise their incomes by providing the least level of service possible. This behaviour forced authorities to constantly change contracts in order to overcome the negative innovation by operators to get around the intent of each compliance measure.

Consequently, in June 2012 a major contract change was introduced. The former practical gross cost contract with compliance measures scheme was replaced by a mixed model in which fares collected became a crucial part of each operator's payment. This model also comprises the application of new compliance measures, including proper bus maintenance, stopping for passengers in all bus stops, and running with doors closed, amongst others service quality indicators enforced by a newly installed camera system. Along with the contract modifications, each company was assigned a representative colour with which they had to paint all of their buses, in order to make the firms more visible to the public and improve their accountability. The new colours are intended to incentive a better service provision as companies now are more recognisable by their users and attempts to improve each firm's corporative image are already being made. For instance, one operator installed televisions on-board of a fraction of its buses, in order to provide a better travel experience to their passengers (while regaining part of the investment by including advertising on the shows).

Although recently introduced, the new contracts already show signs of fostering innovation by private parties. For instance, efforts to reduce fare evasion have been successfully employed; operators have hired guards in peak periods to enforce user payment. Previously one operator added turnstiles to their buses for the same purpose; however, now, reducing fare evasion is a more generalised concern. Additionally, service operation innovation has seemed to increase, as there have been numerous routes and services modifications resulting from joint authority-operators effort.

Finally, regarding infrastructure innovation, bus corridors, exclusive lanes, and bus stops (with and without pre-board payment) have continued to be built by authorities. Additionally, cameras have been placed in some key bus corridors and lanes, as means to deter car users from entering them, by applying fines to infringers. On the operators' side, there was also a proposal of a terminal built in a concession contract, currently under revision.

4. CASE ANALYSIS

In this section, we analyse the previously presented history of urban public bus transport of Santiago, with a focus on the incentives that each regulatory framework provided to both public and private parties to involve in innovative developments.

Table II presents a summary of the innovative capabilities and observed innovative behaviours for each party and period, classified in service operation, vehicle, and infrastructure innovations. The table is structured so as each entry states the innovative potential for each period, party (authorities or operators) and innovation classification (service operation, vehicle or infrastructure), and then explains whether the potential was met by observed innovation.

Table II – Innovative capabilities and developments of the Santiago case.
Developed from Ongkittikul and Geerlings (2006) for the case of Santiago.

Period	Service operation innovation		Vehicle innovation		Infrastructure innovation	
	Authority	Operator	Authority	Operator	Authority	Operator
Public Procurement (until 1979)	High potential. Not exploited by the weak institutions in charge.	Non applicable (complete public provision).	High potential. Not exploited by the weak institutions in charge.	Non applicable (complete public provision).	High potential. Not exploited by the weak institutions in charge.	Non applicable (complete public provision).
Deregulation (1979-1991)	Low potential. Service provision was delegated to private operators.	High potential. High levels of innovation, including new services and the *sapos* system.	Low potential. Operators had freedom to decide which vehicles they would use.	High potential. High levels of innovation (minibus effect and vehicle age increase).	High potential. Low levels of innovation, authorities became practically inactive and focused on the subway system.	None. Operators had no power to invest in this respect.
Competitive Tendering: First attempts (1991-2007)	High potential. Low levels of innovation, authorities tendered the same routes from the previous period.	Moderate potential. Low levels of innovation, due to the atomised industry and the complicated procedure for changing routes.	High potential. Authorities imposed several rules to the vehicles, regarding vehicle age, capacity, and emissions.	Low potential. Operators had to adapt to the requirements imposed by the local authorities.	High potential. Low levels of innovation. The limited public transport budget was mostly expended in the subway system.	None. Operators had no power to invest in this respect.

Period	Service operation innovation		Vehicle innovation		Infrastructure innovation	
	Authority	Operator	Authority	Operator	Authority	Operator
Transantiago: The beginning (2007)	High potential. High levels of innovation, short and express route variants were developed, along with user information systems.	High potential. High levels of negative innovation, focused mostly in cost reduction attempts.	High potential. Authorities demanded high standard vehicles from operators.	High potential. Operators had diverse incentives to modernise the fleet, with varying success between operators.	High potential. High levels of innovation (bus corridors, exclusive lanes, pre-board payment bus stops, etc.).	Low potential. Operators were demanded to build proper bus terminals.
Transantiago: Following modifications (2007 and further)	High potential. Innovation continued the trend installed with the introduction of Transantiago.	High potential. Positive innovation in this respect has seemed to increase, as firms now share revenue risk with authorities.	High potential. Contracts were modified to provide better incentives to renovate the fleet.	High potential. In a few years, practically the entire fleet was renovated.	High potential. Infrastructure investment continued, and more corridors and stops were built.	Low potential. However, there was a terminal proposal in a concession contract scheme.

Although this is not an exhaustive list and many innovations are omitted, it is sufficient to provide some lights on how the process of innovation takes place and thus how it can be influenced to induce the desired results of a reform. Lessons drawn for each innovative capability classification are presented next.

4.1 Service Operation Innovation

During the public provision era, despite a high innovative potential, the observed innovation was low and the service structure did not respond to demand in time. These low levels of service operation innovation can be explained by the weak institutions in charge of the system and their limited budget and information, which hampered a correct adaptation to the transport needs of a fast growing city.

Once deregulation came into effect (1979-1991), this situation rapidly changed. Observed service operation innovation rose and many new services were created, catering to demand

and solving the supply shortage of the public provision era. The supply shortage and the almost non-existing regulation regarding vehicles allowed an easy entrance to the market and incentivised lots of small informal operators to register new services.

Later, with the introduction of limited regulation in the competitive tendering scheme (1991-2007), service operation innovation reached a standstill. Despite the potential that both authorities and operators had to innovate in this respect, there were no major changes regarding service structure. On the operators' side, the atomised informal industry and lack of road space exclusivity, added to the complicated procedure for changing routes, did not provide the correct incentives to develop new services, as this can prove to be a difficult task for small operators (with poor information on the demand structure of the city and a limited investment budget).

As previously stated, Transantiago reform brought a complete restructuration of the service design in the city. Discarding the initial changes, authorities involved in many innovative initiatives (e.g., short and express route variants, route modifications, new service developments, etc.) as an effort to improve the system. This intensive work is explained in part by the poor system performance during its beginning, considered one of the biggest failures of the previously in charge political coalition, that had to be solved. Besides, Transantiago was an important part of their political promises and the public expected immediate actions in order to provide them the high quality system promised.

Nevertheless, it is worth noting that although the pre-Transantiago system had also a bad perception amongst citizens, there were not as many authority efforts (in the shape of innovation related to service operation) to improve it. One possible explanation is that the previous scheme was perceived as an external agent from the government, and the problems of the system were blamed by the public on its operators and drivers. In contrast, Transantiago was an emblematic political project and thus the public demanded from authorities a higher level of responsibility with its results.

Regarding operators, it can be argued that Transantiago's initial contracts were not enough to properly incentivise positive service operation innovation. Since the payment method (practically independent of the number of passengers served) did not foster the development and tuning of services, operators' efforts were instead focused in reducing operational costs and avoiding fines. However, with the introduction of the new contracts, this condition changed and an important part of each operator's payment now depends on fares collected, encouraging firms to innovate in this respect. Consequently, service operation innovation has apparently increased, evidenced by the numerous routes modifications being lately implemented, although the contract modification is too recent to be certain.

Finally, it is interesting to analyse some differences between the current system and the one introduced in the 90's. In both schemes, revenues are directly related to the number of passengers collected, but the observed innovation levels related to service operation are very different. This can be clarified taking into consideration the ownership structure of the industry. Previously, the system was run by a large number of small informal operators competing amongst themselves in the street and, as explained above, the development of new services implies a risky investment whose profits would be divided between all operators exploiting the new route (as there was no road exclusivity). In contrast, currently there are only 7 operators with a certain exclusivity in their operation areas. Therefore, each operator can potentially capitalise its investment in developing a new service. These powerful firms

are also capable of bigger investments, and hold better information about the demand patterns of the city (explained by the new technologies and the joint work with authorities), which eases the innovation process.

4.2 Vehicle Innovation

Vehicle innovation during the public provision period was also low, despite its high potential, because of the weak institutions and their limited budget. Later, when deregulation was implemented, there were many changes in the system and vehicles were not an exception. As observed in many countries facing this same transition, there was a decrease in the average vehicle capacity (known as the minibus effect), and an increase in the average vehicle age. Both effects are explained as cost reduction initiatives. One possible explanation of the minibus effect is the significantly lower cost of purchasing a lesser capacity vehicle, easier affordable by small operators. On the other hand, the increase in the average vehicle age is explained as there are practically no incentives to renovate the fleet in a deregulated system. This is a consequence of the pseudo-monopolistic situation in the bus stop, which implies a lower elasticity of demand not only to fares, but to other variables such as comfort. Therefore, each bus demand is hardly affected by its vehicle age and maintenance, and costs can be reduced with no impact on revenues.
In our study case, because of the high congestion and pollution externalities in Santiago, authorities considered both effects to be negative and thus they were explicitly eliminated by the new regulations, which restricted vehicle age and capacity.
In the Transantiago era, in contrast, other incentives to modernise the fleet were considered in the contracts. Instead of demanding a complete renovation of the fleet from the beginning (which would raise the costs of the reform), replacing a stipulated amount of old buses resulted in concession extensions. These incentives proved to be effective and Transantiago now has a modern high quality fleet with low emissions (Gómez-Lobo and Briones, 2013).

4.3 Infrastructure Innovation

As usual, operators always had few faculties and capabilities to innovate in infrastructure, especially in an atomised industry with small operators, unable to make major investments. On authorities' side, there were few innovations in bus infrastructure until the implementation of Transantiago. There are a number of possible explanations for this behaviour. First, Chile has rapidly grown in the last decades, strengthening its public institutions' budgets and allowing greater investments in this respect. Also, as stated above, electors' pressure to maintain a high level of service has increased as now the bus transport system of the city is considered a government responsibility, rather than blaming most problems on operators. Lastly, a formal industry facilitates joint authority-operators work, which can ensure a correct planning and using of the infrastructure.
Moreover, we highlight the mentioned operator terminal proposal, currently under revision, which is an innovation aiming at reducing costs, but it is nevertheless interesting and could be socially rentable.

5. CONCLUSIONS

Our analysis shows that the contractual framework firmly determines the degree of innovation present in the industry. Each regulatory scheme provides different potentials and incentives to both authorities and operators to innovate, which can also differ in each innovative capability classification (namely; service operation, vehicle, and infrastructure). Consequently, policy-makers should consider this dimension when evaluating different regulatory schemes, as each of them imply different innovative behaviours, which can be fundamental in providing a high quality and swiftly adaptable system.

Regarding service operation, our study case shows that a deregulated system is likely to present high levels of innovation, while a fixed payment or gross cost contract will incentivise operators to focus their efforts only in cost reduction attempts, considered mostly harmful to the users of the system. Moreover, introducing revenue risk sharing and authority-operators cooperation may result in higher positive service operation innovation.

Additionally, we conclude that operators have few incentives to innovate in vehicles, except for cost reductions efforts, which can prove to be prejudicial to the transport system users. Therefore, vehicle innovation must be fostered by public initiative, either by demanding high standard vehicles from operators or by providing them with incentives to renovate the fleet, as occurred in Transantiago. Likewise, infrastructure development should be driven by authorities or explicitly included in operators duties, as the latter do not have sufficient incentives (and often neither faculties) to invest in this respect.

Furthermore, we highlight that the regulatory scheme is not the only variable which affects innovation, as it is also important to consider the public perception of the transport system (which can influence authorities to innovate) and the ownership structure of the industry (as small informal operators may exhibit different innovative behaviours than large firms).

Concerning the limitations of this study, we are aware that the institutional design of the public sector can be determinant in the outcomes of any policy, and should be more explicitly included in further research. It is also pertinent to clarify that each city is different and many of the lessons drawn for Chile may not be directly applicable in other countries. In this respect, it would be interesting to extend the analysis with data of other countries, especially developed nations, as we expect that significant differences with developing countries may arise.

Finally, the development of a formal economic model is needed in order to further comprehend innovation in urban public bus transport systems.

ACKNOWLEDGEMENTS

This research was supported by the Across Latitudes and Cultures - Bus Rapid Transit Centre of Excellence funded by the Volvo Research and Educational Foundations (VREF). The authors are also grateful for the help given by Julio Briones and Laurel Paget-Seekins who helped us improve this paper.

REFERENCES

Beltrán, P., Gschwender, A., and Palma, C. (2011). *The impact of compliance measures on the operation of a bus system : the case of Transantiago*. Thredbo 12 Conference Proceedings, Durban, South Africa.

Díaz, G., Gómez-lobo, A., and Velasco, A. (2005). Micros en Santiago: De Enemigo Público a Servicio Público, *Estudios Públicos 96* (primavera) pp. 5-48.

Fernández, J. E., and Muñoz, J. C. (2007). Privatisation and Deregulation of Urban Bus Services : An Analysis of Fare Evolution Mechanisms. *Journal of Transport Economics and Policy*, Vol. 41 (January), pp. 25–49.

Gagnepain, P., and Ivaldi, M. (2002). Incentive Regulatory Policies: The Case of Public Transit Systems in France. *The RAND Journal of Economics*, Vol *33* (4), pp. 605-629. doi:10.2307/3087477

Gagnepain, P., and Ivaldi, M. (2010). Regulatory Schemes and Political Capture in a Local Public Sector. *Working paper 10-158 Toulouse School of Economics*.

Gómez-Lobo, A. and Briones, J. (2013) *Incentive structure in transit concession contracts: The case of Santiago, Chile, and London, England*. Clean Air Institute, Washington D.C.

Johnson, R.M., Reiley, D.H., and Muñoz, J.C. (2006), *The War of the Fare: How Driver Compensation Affects Bus System Performance*, Working Paper 11744, National Bureau of Economic Research, Cambridge.

Laffont, J.-J. and Martimort, D. (2002) *The Theory of Incentives: The Principal-Agent Model*. Princeton University Press, Princeton.

Mallard, G. and Glaister, S. (2008). *Transport Economics: Theory, Application and Policy.* Palgrave Macmillan, New York.

Muñoz, J. C., and Gschwender, A. (2008). Transantiago: A tale of two cities. *Research in Transportation Economics*, Vol *22* (1), pp. 45–53. doi:10.1016/j.retrec.2008.05.010

Ongkittikul, S. (2002). Technological innovations in urban public transport: the twin characteristics approach as a new analytical framework. In*: Colloquium Vervoerplanologisch Speurwerk*, Amsterdam, The Netherlands, pp. 671-690.

Ongkittikul, S., and Geerlings, H. (2006). Opportunities for innovation in public transport: Effects of regulatory reforms on innovative capabilities. *Transport Policy*, Vol *13*(4), pp. 283–293. doi:10.1016/j.tranpol.2005.12.003

Roy, W., and Yvrande-Billon, A. (2007). Ownership , Contractual Practices and Technical Efficiency : The Case of Urban Public Transport in France. *Transport Economics*, *41*(May), pp. 257–282.

Sanhueza, R., and Castro, R. (1999). Conduciendo el transporte público: la licitación de recorridos en Santiago. *Perspectivas en Política, Economía y Gestión*, vol 3, pp. 217–230.

Saviotti, P. (1996). *Technological Evolution, Variety and the Economy*. Elgar, Cheltenham.

Saviotti, P.P. and Metcalfe, J.S. (1984) A theoretical approach to the construction of technological output indicators. *Research Policy* Vol. 13, pp. 141-151.

Tullock, Gordon (1967). The Welfare Costs of Tariffs, Monopolies, and Theft. *Western Economic Journal* Vol 5(3), pp. 224–232

Varian, H. (1992) *Microeconomic Analysis*, 3rd Edition, W. W. Norton & Company, London.

World Bank (2009). *Transantiago Implementation Report*. Sustainable Development Department, World Bank. Washington, D.C.