Investment in Intelligent Transport Aid Systems and Final Performance

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Abstract

Public transport contributes to the welfare of citizens and improves the social development of cities. Worldwide, local authorities dedicate between 15 to 20 per cent of their yearly budget to urban transport. The intelligent transport aid systems (ITA systems) are integral control systems that, when applied to a transportation network, can offer the required means to know, regulate and manage the available resources in real time. The main objective of this research consists of examining the relationship between investments in intelligent transport aid systems (ITA systems) and the efficiency, effectiveness and improvement of the service quality of firms offering urban transport services in local environments. Results show that the investment in Intelligent Transport Aid Systems generates a better performance in firms operating urban transport along time.

Keywords: Intelligent Transport Aid Systems (ITA), transport industry, efficiencies, structural equation model, performance

Introduction

Urban transport greatly impacts citizen's welfare (OCDE, 2004). Traffic jams greatly impact people working in cities or metropolitan areas situated in the developed countries (Gwilliam, 2002). In addition to being priced competitively, the public transport must offer comfort and security to the passengers. The COTEC Report (1998) indicated that the transport in the twenty first century would be centered on a great demand of service and versatility. In addition, it will need to comply with clear environmental restrictions and budget and competitive exigencies. These requirements lead to a systematic implementation of technological improvements in which telecommunication networks play an essential role. According to the COTEC Report, the number of trajectories at the end of the year 2010 will double the figures reached in the last part of the ninety century. To cover the increase of demand in the transport, the European Union intends to reach the following objectives:

- To increase the levels of security and the creation of value in the transport systems
- To develop and integrate new technologies at an European level, especially in the area of the standard advance transport for telecommunications (ATT)
- To generate economic benefits of the IT implementation, trans-

lated into less traffic jams and savings in accidents

- To create new work opportunities, by promoting the innovation through the use of advanced technologies

The investments in new transport infrastructures need to cover the potential and real mobility demands. The effectiveness in the management of the system is the only option that allows covering the demand of the citizens' movements (Bayliss & Fox, 2000), and is characterized by the following attributes (Segui & Martinez, 2004):

- Security and comfort ability for citizens
- Effectiveness: an exhaustive control in the demand and allocation of the resources is required.

Public Administrations and the public transport companies have developed a group of actions that try to solve these problems. The Public Administrations put into action Acts that affect the ways in which the service is offered. Transport companies implement Intelligent Transport Aid Systems (ITA systems) to improve the management of the systems.

The ITA systems are specific traffic management systems based in an intensive use of information and communication technologies. They allow avoiding the problems associated to traffic jams in urban and inter-urban transports. The application of these systems starts in Europe in the nineties as a sustainable alternative to the problem created by the increasing mobility demand, especially in urban and inter-urban areas. This way the ITA system increases the sustainable mobility by improving the efficiencies in the transport and providing a higher level of security for final users (Seguí & Martinez, 2004).

The main objective of this research consists of examining the relationships between the investments in ITA systems and the improvement in the final performance reached by public or private urban transport companies operating in local environments. The selection of this research in basically inspired in the following reasons:

- The practical nonexistence of studies that put into relation the impact of information and communication technologies (ICT) over public urban transport (Brown, Gatian, & Hicks, 1995; de Pablos Heredero, 2000; Dos Santos & Pfeffers, 1995, Farley, 2007; Floyd & Wooldridge, 1990, Harris & Katz, 1991, Sircar, Turnbow, & Bordoloi, 2000).
- The new trend to dissociate social welfare, in terms of GNP per capita, with the intensive use of private transport in the urban areas of important western cities, as for example, New York or Zurich (Newman, 2000).
- The analysis coming from the ICT industry (AETIC, 2006) that explains the existence of a positive relationship between the use of ICT and sector productivity, especially in the transport industry. However, we cannot find many empirical studies that support these hypotheses.
- The lack of indexes that allow in a satisfactory way to relate, in a concise way, the introduction of ICT and the generation of efficiencies applied to the public urban transport and specifically to the ITA systems.
- The interest coming from the ICT and public transport industries to know if the implementation of the ITA technology is able to offer firms upper returns on investments.

Theoretical and Empirical Background

This section summarizes the most relevant approaches as revealed in our literature. There are generic and theoretical studies that explain some of the impacts of ICT in the improvement of traffic management in big cities (Finquelievich, 1996), or that connect the implementation of ITA systems with increases in firm productivity. Pérez (2001), analyses the impact of telecommunication systems over urban transport in the sector of private transport. He centers his analysis in the management of fleets, the local authorities and the environment. He quantifies the impact in a three value scale: 1) no impact 2) important impact, 3) great impact.

According to Pérez (2001), the implementation of telecommunication applications in the urban transport, would provide of a positive impact in the management of the public transport (management of fleets), in the perceptions of users on local authorities and in the environment. The positive impacts derived of the implementation of telecommunication networks would be related with travel timetables, the operational costs, the quality of the service, the security, the environmental improvement and the decrease in the energy consumption. Berechman (1993) analyses the effects that a group of Acts produce in the public transport efficiency. More precisely, this author analyses the advantages generated by an improvement in the costs of introducing concessions in competence regimes. The World Bank (2002), analyses the effects produced by the introduction of competence in the local transport system in London (Figure 1) in the period from 1984-1985 to 1994-1995. These effects show the improvements in the costs consumed by mile close to a 65%. This effect implies a decrease in the costs of subventions for public urban transport close to a 90%.

Total expenses in British pounds	**1984-1985**	**1994-1995**
Cost per miles run	444	270
Cost by passenger and mile	29	22
Return by bus and mile	263	241
Return by passenger and mile	17	20
Subsidy by bus and mile	182	29
Subsidy by passenger and mile	12	2

Figure 1. Effects of the competence in the public bus transport (London)
(adapted from the World Bank, 2002)

Ongkittikul (2006) indicates that the changes promoted by the implementation of new technologies have a positive influence in the dynamics of the public transport industry. The changes would be determined by a generalized improvement in the quality of the service offered, and the way this public service is offered. These changes should improve the final results of the transport systems, by promoting a change in the sector. Besides there are some specific studies centered on the energy efficiencies reached in the transport industry in general (Kenworthy, Laube, Newman, & Barter, 1997; Newman, 2000).

Trying to find specific research related to the generation of efficiencies derived from ICT investments and the implementation of Intelligent Transport Aid Systems in the public urban transport, it is useful to observe which ones the main relevant objectives for an ITA system are. The paragraph 12 in the "Telecommunication innovations for transport firms" Report, the COTEC Document (1998) and the aspects analyzed by De la Rosa and Núñez-Flores (1993) defend that the implementation of an ITA system would promote a higher operational security in the manage-

ment of public urban transport, an improvement in the customer satisfaction (users) and drivers, and an increase in the real demand, based in a more competitive schema of the final supply. We also collect the essential points of both approaches; according to paragraph 12 in the COTEC Report (1998), the objectives followed by the implementation of a ITA system are the following ones: 1. An increase of the quality in service by improving the times, a better adaptability of the supply and demand, better information "*on line*" to the customer; 2. A decrease in the exploitation costs and the needed investments to optimize the service supply, less buses for the same degree of supply, A decrease in the number of drivers 3. A greater efficiency in the structure of the management of traffic, a decrease in the number of human resources, A greater reliability in the decision making process, greater flexibility and more transparency; 4. Better control of the fleets, a decrease in the number of breakdowns, a decrease in the accidents and a more positive environmental impact. De la Rosa and Núñez-Flores (1993), stress the objectives to reach by implementing a ITA system: 1. An increase in the quality of service by improving the time responses and better adaptation of the demand conditions and supply possibilities; 2 A reduction of the exploitation costs based in a best fit of the fleet in terms of size and service improvement: 3. A decrease in the energy consumption; 4. An increase in the management of traffic; 5. An increase in the reliability in the decision making and the offering of higher degrees of flexibility an transparency in the system; 6. An improvement in the technical control of the fleet; 7. To decrease the number of accidents and provide of better security systems for users and drivers; 8. To decrease the negative impacts in the environment generated by pollution and noise. Bakos and Treacy (1986) and Hitt and Brynjolsson (1996) support that the benefits obtained by implementing ICT in firms were firstly measured by the reduction in operational costs and/or by increases in the production capacity. Today, we consider other kind of benefits, especially those derived from the internal strategy (efficiency, effectiveness, improvements in customer service, a higher quality of products and services, support of the process reengineering and higher degrees of flexibility), those related with the competitive strategy (skills to surpass the competitors) and those in relation with the business strategy (effects on the industry).

The premises cited in points 1, 2, 3 and 4 in the COTEC Report (1988) in one hand, and the ones explained in the points 1, 2, 4, 5, 6 and 7 of the defined objectives coming from De la Rosa and Núñez-Flores (1993) in the other hand, would be congruent with the affirmations coming from Bakos and Treacy (1986) and Hitt and Brynjolsson (1996). Bharadwaj, Bharadwaj, & Konsynski (1999) show in graphic way some intangible values that generate sustainable competitive advantages, coming from ICT investments, as they can be the improvement in the quality of the products or services, the improvement in the service relationship to the customer, the creation of knowledge assets, and lastly the improvement in the co-ordination and potentiating of synergies. These aspects would fit in the same way with points 1, 2, 3 and 4 of the COTEC Document (1988) and with the points 1, 4, 5, 6, y 7 of De la Rosa and Núñez-Flores (1993). According to Porter (2001), to integrate the ICT initiatives in the general business strategy improves the skills in firms when developing different products, proprietary contents, and distinctive processes and produces satisfaction for the potential customer. That it is to say, all those elements that create real value, and have always been defined as competitive advantages. Porter's statements would be also shown as important elements to consider for points 1, 2 and 3 in the COTEC Document (1988) and with points 1, 2, 4, 5 and 6 in De la Rosa and Núñez-Flores (1993). By taking into consideration just the transport industry, Kenworthy et al. (1997), develop a research study in 37 cities in North America, Europe and Asia. Kenworthy et al. (1997) consider as main factor in the firm's productivity the efficiency in energy by passenger (EE/passenger). The energy efficiency would be determined by a group of variables, such as: degree of vehicle occupation. The frequency of tours would be determined by a group of variables, as for example: degree in the vehicle occupation, frequency of runs and mean distance by run. In their own views, an improvement in the energy efficiency would produce a reduction in the coverage of exploitation costs in the

public transport, situated in Europe around a 54% (Newman, 2000). Besides, an improvement in the energy effectiveness would promote a decrease in the emissions of pollution, and therefore it would promote a positive effect in the environment. If we compare the affirmations coming from the Kenworthy et al. (1997) studies with the objectives marked in the COTEC Document (1988) and those indicated by De la Rosa and Núñez-Flores (1993), we observe that there is a clear coincidence between the aims and results obtained. In the cited study Kenworthy et al. (1997) statements would be aligned with points 1,2, 3 and 4 in the COTEC Document (1988) and with the points 1, 2, 3, 4, 7 y 8 in the De la Rosa and Núñez-Flores (1993). According to the previous considerations, we could affirm, taking into account the objectives marked by the ITA system in the COTEC Document (1988) and in De la Rosa and Núñez-Flores (1993), that the implementation of an ITA system:

- would increase the quality of the final service,
- would decrease the exploitation costs,
- would generate a great efficiency in the structure of traffic management and a higher technical control

All these aspects would promote an increase in the real demand, and it would increase the returns of exploitation, all together with a decrease in the costs. In addition, we can also mention the data coming from the Annual Report in 2005 (2006 edition) of the Information and Communication Technology Spanish Association (AETIC, 2006) that establishes that all industries, containing intensive investments in ICT, as it is the case of the transport one, obtain upper profitability over the mean in different industries. This statement is valid through an indirect measure, as their own AETIC index, DMR, which is a ratio that defines the level of implementation of new technologies in firms. Besides, once the ITA systems are implemented and in a similar way as the air flight electronic reservation systems (Duliba, Kauffman, & Lucas, 2001), they would promote high substitution costs, in such a way that once the ITA system is implemented, it would be very costly to change the system. The same way, these systems, could generate more sophisticated specific applications, and offer additional services, as for example the payment by using the intelligent card, future projections for the occupation of vehicles, etc. These continual and additional developments allow to the initiators in technological systems convert these resources in value, few and difficult to imitate or substitute systems that according to Barney (1991) would derive in sustainable competitive advantages.

Hypotheses

Taking into consideration the different approaches generated in the previous paragraph, along with some additional points of view, that follow, we offer to the effects of this research the following hypotheses,

H1. *The implementation of an ITA system improves the efficiency in the firms operating public urban transport by bus*

This hypothesis is sustained in the objectives established in the COTEC document (1988) and in de la Rosa and Nuñez-Flores (1993): a decrease in the number of buses for the same level of demand, a decrease in the number of drivers, a decrease in the operational costs, a decrease in the energy consumption. Bakos and Treacy (1986) support that the implementation of ICT in the organizations improves the operational efficiency and the functional effectiveness. Hitt and Brynjolsson (1996) stress how the ICT increases the productive capability and therefore the efficiency in the organizations. Kenworthy et al. (1997) and Newman (2000) confirm that an increase in the use of public transport decreases the consumption of energy in the cities. Pérez (2001) in his research on public transport states that the introduction of ICT in transport firms increases the quality of service and the regularity and punctuality of the runs. Thatcher and Oliver (2001) affirm

that ICT have an impact in the final profitability and productivity in the organizations. Sieber and Valor (2005) proof how the implementation of ICT decreases the operational costs in firms.

H2. *The implementation of an ITA system improves the quality of service in public urban transport by bus*

The objectives appeared in the COTEC Report (1988) and in de la Rosa and Nuñez-Flores (1993) in which this hypothesis would be sustained are the following ones: an improvement in the times of the service, best information for the final user on public transport, best adaptation of the supply to the demand, a positive perception by users (less number of accidents and breakdowns). The following studies would support the results in the empirical study: Mukhopadhyay, Rajiv, and Srinivasan (1997) defend that ICT increases the quality of the service. Bharadwaj et al. (1999) also show in an illustrative way, that some intangible values, coming from ICT investments, would have an impact in the improvement of some aspects: in the quality of products and services, in the relationship with the final customer. Porter (2001) stresses how the implementation of ICT improves the quality and service by promoting a differentiation in the customer. Pérez (2001) affirms that the implementation of ICT in transport firms improves the quality of the service, and the regularity in the frequencies pre-established for the transport. García-Canal, Rialp-Criado, and Rialp-Criado (2007) sustain that the introduction of ICT in firms improves the relationship with customers.

H3. *The implementation of an ITA system improves the effectiveness in the personal of firms operating in the public transport by bus.*

The objectives offered in the COTEC Report (1988) and in the de la Rosa and Nuñez-Flores (1993) sustain this hypothesis: it improves the productivity in the human resources and produces and optimization of services. The following studies would in principle support the results in the empirical study: Harris and Katz (1989) defend the theory that the investments in ICT improve the productivity in the organizations. Dedrick, Gurbaxani, and Kraemer (2003) support in their study that the most important effects of ICT in firms consist of the decrease in the coordination costs of the economic activities in the organizations, and the improvement of processes in firms. Sircar et al. (2000) affirm that the investments in ICT and human resource training actions produce competitive advantages in the organizations. Gargallo and Galvé (2005) check how the qualification of the workers constitutes a key aspect to achieve a best profit in ICT investments.

H4. *The implementation of an ITA system improves the information related with data of business interest in firms operating public transport by bus.*

The objectives appeared in the COTEC Document (1988) and in the de la Rosa and Nuñez-Flores (1993) in which this hypothesis would make sense are the following ones: a higher reliability in the decision making process, more flexibility and transparency and a better technical control in the fleet, an increase in the efficiency in the management of traffic. The following studies would support *a priori* the results of the empirical study: Ragowsky, Stern, and Adams (2000) affirm that the investments in ICT produced in specific processes in the organizations are potential sources of competitive advantages. Siau (2003) proofs how ICT promote the achievement of competitive advantages by putting together the flows of information amongst organizations or amongst different administrative units inside the organizations. Hu and Quan (2003) indicate in their research that ICT are a potential source for generating competitive advantages since they improve the existent processes. This improvement is translated into best precise and updated information. The OCDE (2004) in the report "Information Technology Outlook" indicates how ICT offer a level of relevant information for the business of all the firms. Seguí and Martínez (2004) affirm how the introduction of ITA systems collaborate in all the managerial and distribution processes in the transport of people, by offering instant information related to traffic and travels,

management of the public transport, management of the urban transport, management of the demand, assistance to the driver and planning the journeys.

H5. *The implementation of an ITA system improves the final performance in firms operating urban public transport by bus*

The checking of this hypothesis would be a consequence of the previous proof of the hypothesis H1, H2, H3 y H4.

The Intelligent Transport Aid Systems and Urban Transport

According to Rubio (1993) the ITA systems constitute a group of *hardware and software elements* that include the most advanced techniques in the fields of computing and telecommunications. They are then, integral control systems that applied to the public bus network offer the tools to manage on real time the working of the available resources. Its effectiveness explains that it is one of the most extended applications in public transports.

The first ITA systems were implemented in Japan in the seventies. Their introduction in Europe took place in the nineties (Seguí & Martínez, 2004). By using the available regulation tools, the ITA system allows acting in a continuous way over the bus lines with the main objective of maintaining a high quality in the service. The collected data help to inform customers, managers and people responsible for the public transport. The ITA systems are composed by other different systems, user information system on board, UIS; the driver information system, DIS; the information points for the user in the stops, IPU; the emergency systems, SOS; The vehicle location systems, VLS; Expedition of tickets and communication systems, GPS. The following figure presents the main elements of an ITA system.

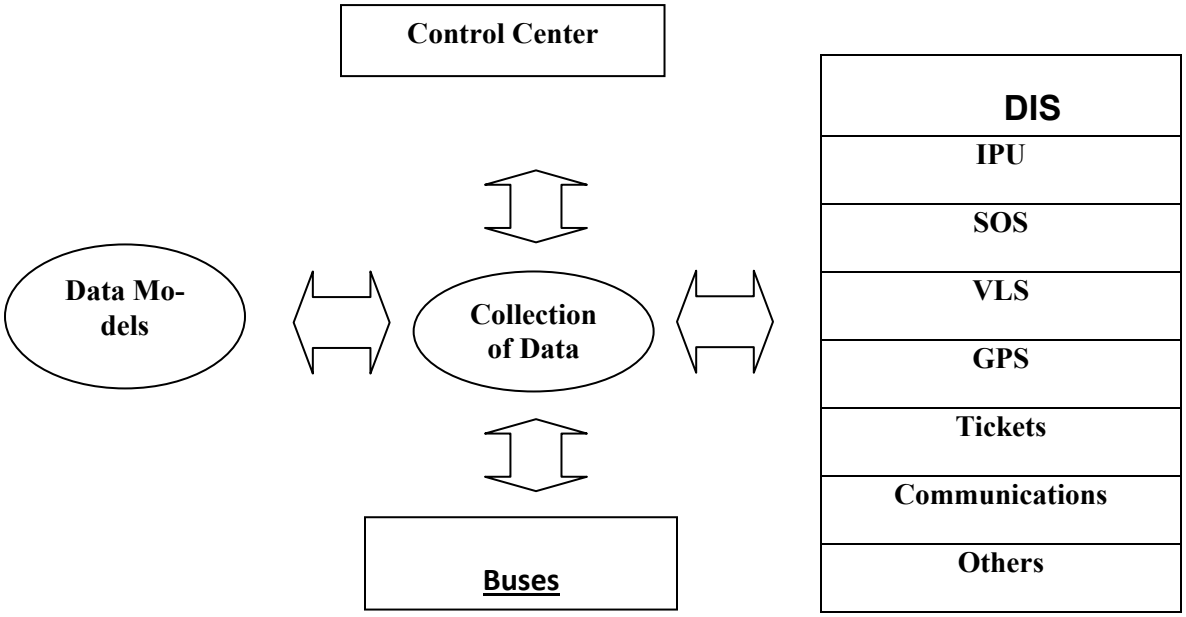

Figure 2. The Intelligent Transport Aid System for the Transport
(adapted from Escobar, 2007)

The ITA system is a system that combines the computer abilities embarked in each of the buses and a communication system, with capacity to send in a cyclic way a great volume of information

process it in a Control Centre. This way the management of time in real time is assured in the transport network. The way an intelligent transport system works is as follows: the network of buses is continually localized via the GPS (satellite systems), the communication systems "via radiofrequency" send the position of the bus that has been previously determined by the GPS system to the central control place. In the central control place, the regulation and exploitation of the whole network of buses is performed. The working of the system, as we have previously indicated, is based in four processes: localization, communication, regulation and information. The location is a basic function of an ITA system. This function takes place via a GPS that transmits its position through a communication system to the central host, where the needed fits in the exploitation system are executed, in case they are needed. Today the ITA systems are used, apart from the public passenger systems, in other areas as in the logistic ones (for national and international transports), security bodies (policy, civil protection, and private security companies), money transport, dangerous merchandise transport, transport of perishable products, boats and maritime services, etc. The ITA systems allow the control of all the areas related with the fleet of vehicles in a firm. The main objectives, that firms operating in public urban transport and Public Administrations try to cover by the implementation of an ITA system are the improvement of the service offered to the users, the improvement of the management in the firm and the modernization and improvement of the image in the Public Administration in general and in the firm in particular.

Empirical Study

The technique for the analysis applied to the empirical study is based in the use of structural equations containing latent variables and errors of measure. In the proposed model, we consider the efficiency reached (ER) the result of a series of factors that appeared measured through effi-

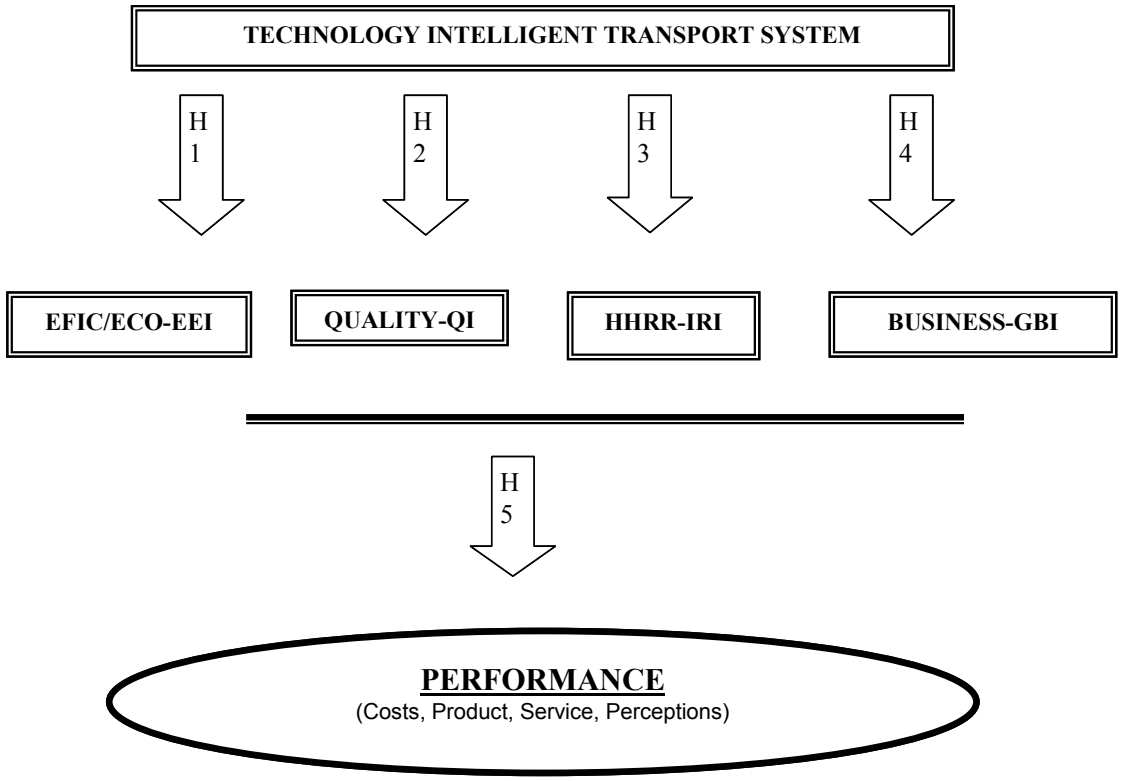

Figure 3. The proposed model

ciency and economic indicators (EEI), indicators of quality (QI), Human Resource indicators (HRI), and general and business indicators (GBI). Figure 3 expresses in a graphical way the proposed model.

As it has been explained in the explanation of the hypothesis, we defend that the ITA system produces a group of efficiencies that can be measured by a group of economic indicators (H1), quality indicators (QI), Human Resource Indicators (HRI) and business indicators (H4): At the same time, they promote better performance (costs, differentiation and perception) (H5).

Methodology Applied to the Empirical Study

The data base applied in this research comes from a survey realized in all the firms that operate urban public transport by bus in the main cities of Spain. In Figure 4 we offer the most important attributes that we have taken into account: the universe, the geographic area, the sample size, and other characteristics that constitute the technical fiche.

TECHNICAL FICHE
UNIVERSE: Operators of urban public transport by bus in main cities in Spain
GEOGRAPHIC AREA: all the national territory
DESIGN OF THE SURVEY: The researchers by making use of deep interviews, the World Bank Report and the Report of the Andalucia Region chamber of commerce
SAMPLE SIZE: 53 firms operating urban public transport
SAMPLE ERROR: +/- 10% (P=Q=50)
LEVEL OF TRUST: 95,5% (2 sigma)
SAMPLE DESIGN: A survey by firm
WORK OF FIELD: The researchers
DATES: January – July 2007

Figure 4. The technical fiche

1) **Survey,** in the questionnaire questions related to the following variables are included
   - General information. The main motives for the decision of implementing an ITA system, and the time for implementation.
   - General data. Data related to the name of the firm, location, and information related to the city and the duration of the concession.
   - Efficiency indicators. Indicators related to the increase of decrease of the speed, personal, energy consume, etc.
   - Economic and quality indicators. Increases or decreases in the number of customers, satisfaction degrees, increases or decreases of the number of passengers transported, etc.
   - Human resources indicators. The decrease or increase of the human resources in the firm, costs of personal, etc.
   - Specific data on the SAE. The specific contributions of the ITA system to the business, such as flexibility, implementation costs, observed benefits, etc.

Results

We offer a summary of the results obtained for each of the hypotheses offered in our analysis. Figures 5 through 13 show the results and validations.

H1. ***The implementation of a ITA system improves the efficiency in firms operating public urban transport by bus:***

RESULTS IN THE ESTIMATIONS FOR THE IEE INDEX

	Estimation	P-v		Estimation	P-v
IE10 <= LIEE	1.000	0.000	IE5 <= LIEE	1.293	0.006
IE9 <= LIEE	0.949	0.114	IE4 <= LIEE	1.211	0.014
IE8 <= LIEE	0.903	0.051	IE3 <= LIEE	0.752	0.071
IE7 <= LIEE	1.046	0.025	IE2 <= LIEE	0.575	0.105
IE6 <= LIEE	1.173	0.018	IE1 <= LIEE	1.632	0.005

IEE = EFFICIENCY INDICATORS

Figure 5. Results of the estimations in the index EEI

The obtained value for the parameter that relates the EEI indicator (efficiency and economic index) with efficiencies is 0,127 positive and, one of the highest values of the four obtained in the hypothesis testing. Empirically it is verified that there is a positive association between the implementation of an ITA system and the improvement in the efficiency of public urban transport by bus. The result of this relationship coincides with some studies that relate information and communication technology investments (ICT) with final results, and with the main objectives searched by the implementation of an ITA system. The obtained results in the empirical analysis will be aligned with other previous pieces of research (Bakos & Treacy 1986; Hitt & Brynjolsson, 1996; Thatcher & Oliver, 2001; Sieber & Valor, 2005). They all show that the implementation of ICT in organizations improve the operational efficiency and the functional effectiveness and increases the capacity of production and therefore the final efficiency and profitability of the organizations. Besides some other papers exclusively centered in public transport (Kenworthy et al., 1997; Newman, 2000; Pérez, 2001) would be aligned with the obtained results. Kenworthy et al. (1997) and Newman (2000) conclude that specifically for the public transport industry, the increase in the number of users decreases the energy consumption in cities, and Pérez (2001) affirms how the implementation of ICT in transport firms increases the regularity and punctuality of the paths. Besides, this result matches the objectives pursued for the implementation of an ITA system defined in the COTEC document (1988) and in the de la Rosa and Nuñez-Flores (1993). According to both reports, the implementation of an ITA system would imply a decrease in the number of buses for a same level of the demand, associated to a decrease in the number of drivers and to a reduction of operational and energy consumption costs.

VALIDATION OF THE HYPOTHESIS (H1)

The implementation of an Intelligent Transport System improves the efficiency of firms operating public transport by bus

The value obtained (standardised weight) for the parameter relating the variable IEE with the generation of efficiencies is 1.635.

Hypothesis (H1) = validated (p<0,001)

The continous fit between supply and demand, according to the data offered by the system, implies an increase in the number of passangers and threfore in the results, that associated to a decresase in coordination costs will offer an increase in the firm's effectiveness and profitability.

Figure 6. Validation of hypothesis 1

H2. ***The implementation of an ITA system improves the quality of the service in firms operating urban public transport by bus***

RESULTS IN THE ESTIMATIONS OF THE IC (QUALITY INDEX)

	Estimation	P-v		Estimation	P-v
IC10 <= LIC	1.000	0.000	IC5 <= LIC	1.397	0.041
IC9 <- LIC	1.089	0.056	IC4 <- LIC	0.717	0.115
IC8 <= LIC	1.197	0.062	IC3 <= LIC	1.013	0.119
IC7 <- LRH	1.442	0.054	IC2 <- LIC	0.917	0.061
IC6 <= LIC	1.524	0.037	IC1 <= LIC	0.986	0.052

IC = INDICATORS OF QUALITY

Figure 7. Results in the estimations of the quality index

The value obtained for the parameter that relates the variable IC, (indicator of quality) with efficiency is 0,099, also positive and of small value in relation with the parameter related to the efficiency in the H1, previous hypothesis. Empirically we verify that there is a positive association between the implementation of an Intelligent Transportation Aid System (ITA system) and the improvement in the quality of service of the firms operating public transport by bus. The result of this relationship matches different studies related with the investments in ICT, and with the main objectives pursued by the implementation of an ITA system. The obtained results in this empirical study would be identified with a group of previous literature as for example. Mukhopadhyay et al. (1997) that state that ICT increases the quality, and this increase offers at the same time an increase in productivity, and Bharadwaj et al. (1999) that state how some intangible values, coming from ICT investments have a tendency to improve the quality of products, services, and customer attention. Porter (2001) also stresses how the implementation of ICT in organizations improves the quality and the service differentiated to the customer and Pérez (2001) in a specific work on public transport affirms that the implementation of ICT in firms improves the quality of service. Lastly, Garcia-Canal et al. (2007), confirm that the implementation of ICT in organiza-

tions improves the attention to the customers. Besides this results are congruent with the objectives followed by the implementation of an ITA system defined in the COTEC Document (1988) and by de la Rosa and Nuñez-Flores (1993). According to both reports, the implementation of an ITA system would promote a higher and better information to the user of public transport, a better adaptation to the supply and demand, and a positive perception by users in all respect to public transport (less number of accidents and breakdowns).

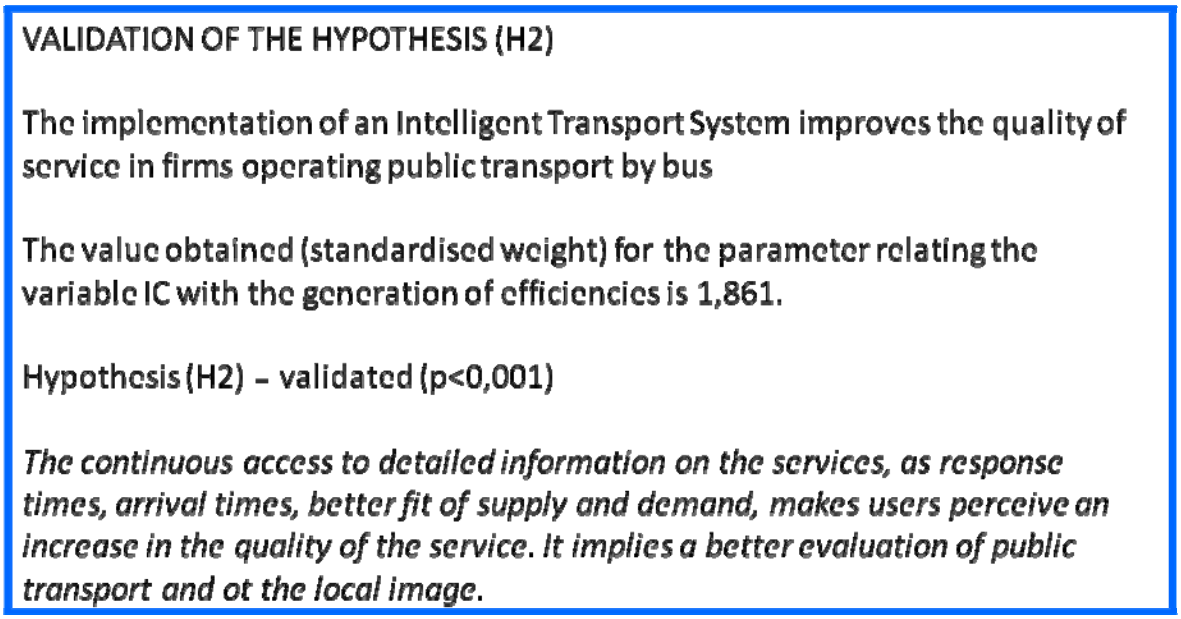

Figure 8. Validation of hypothesis 2

H3. ***The implementation of an ITA system improves the efficiency of the human resources in firms operating public urban transport by bus***

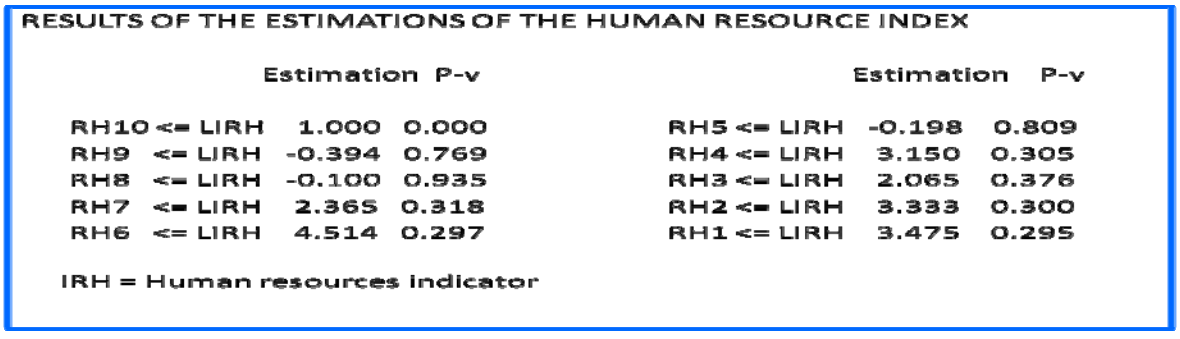

Figure 9. Results of the estimations in the Human Resources index

The value obtained for the parameter that relates the variable HRI (human resource index) with the efficiencies is 0,134. Positive and the most elevated of the four obtained related to the hypotheses. As we have shown, we can empirically verify that there is a positive relationship between the implementation of an Intelligent Transport Aid System (ITA system) and the improvement of the efficiency of human resources in firms operating urban public transport by bus. The result of this relationship fits with a group of studies related with investments in ICT, and with the main objectives pursued in the implementation of an ITA system. The results obtained in this empirical study would match with different previous empirical studies, as the ones coming from

Harris and Katz (1989) that check how the investments in ICT improve the productivity in organizations, or Dedrick, Gurbaxani and Kraemer (2003) that affirm that the most important function in ICT is the reduction of the coordination costs coming from economic activities inside the organizations and improve the processes and the organization of firms. Apart from this, Sircar et al. (2000) affirm that together the investments in ICT and the training of people offer efficiencies in the organizations. Gargallo and Galvé (2005) also proof that the training efforts in the workers is a key aspect to get a best profiting of the investments in information and communication technologies. Apart from this, this result is congruent with the objectives followed by the implementation of an ITA system defined in the COTEC Document (1988) and in the de la Rosa and Nuñez-Flores (1993). According to both reports, the implementation of an ITA system would lead to an improvement in the productivity of the personal and to an optimization of the final services.

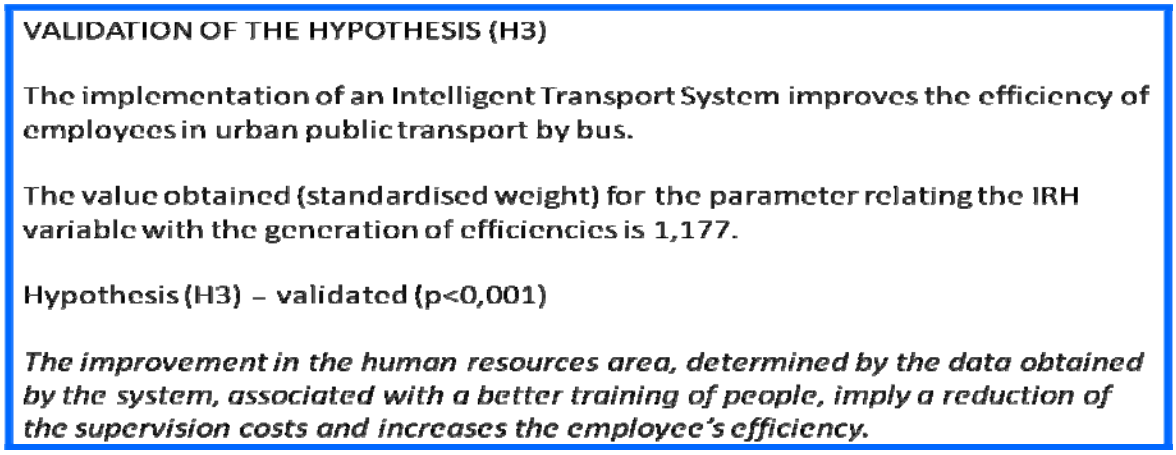

Figure 10. Validation of hypothesis 3

H4. ***The implementation of an ITA system improves the information related to the data of interest in the business of firms operating urban public transport by bus***

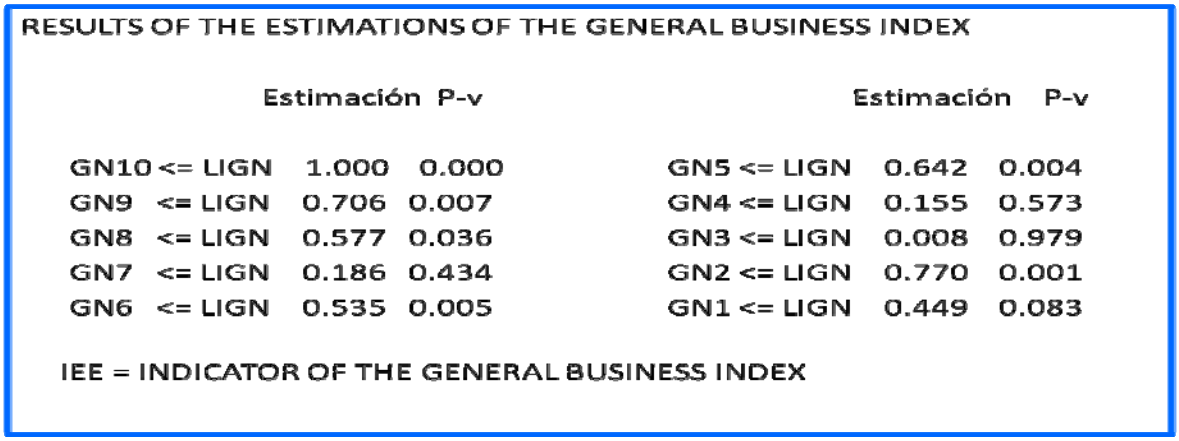

Figure 11. Results of the estimations of the global business index

The value obtained for the parameter that puts into relation the variable Global Business Index, GBI with efficiencies is 0,087. Positive and the smallest of the four obtained for this hypothesis. Empirically we can verify that there is a positive relationship between the implementation of an Intelligent Transport Aid System (ITA system) and the information related to the data of interest on the industry of firms operating urban public transport by bus. The result in this relationship

matches a variety of research analyzing the final firm's results dealing with ICT investments, and with the main objectives followed by implementing an ITS. The results obtained in the empirical study would be supported by the previous literature review, as Ragowsky et al. (2000) who affirm that the investments in ICT centered around specific processes in the organizations are potential sources for the generation of competitive advantages, or Siau (2003) who states that ICT generates competitive advantages by linking the processes of the flows of information amongst different administrative units inside the organizations. Hu and Quan (2005) also validate in their research that ICT are potential sources for competitive advantages since they have the power of improving the existent processes. This improvement allows the obtaining of more precise and updated information. Apart from this, the OCDE (2004) in the "Information Technology Outlook" Report indicates how ICT offer a level of relevant information for the business in all the firms. Seguí and Martínez (2004) support that the implementation of ITA system in all the management processes related to the travelers transport, offer real time information on traffic paths, for the management of the traffic and the planning of the routes. This assumption is also congruent with the objectives followed by the implementation of an ITA system defined in the COTEC Document (1988) and in the de la Rosa and Nuñez-Flores (1993). According to both reports, the implementation of a ITA system would drive to a higher reliability in the decision making processes, more flexibility and transparency, a better technical control of the fleet, and as a result of all of them, an increase in the efficiency achieved in the management of the traffic.

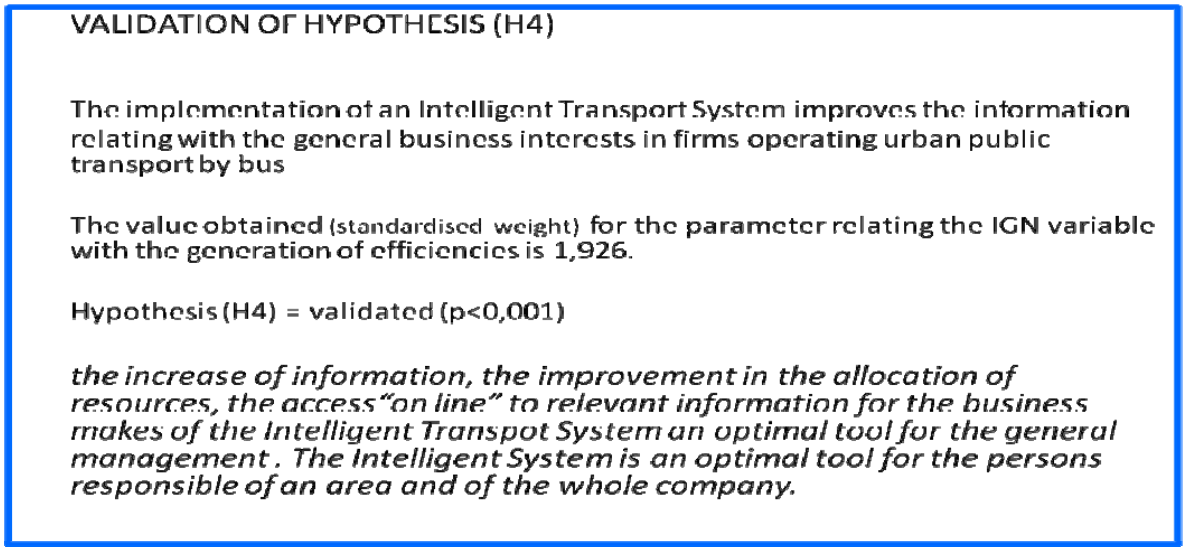

Figure 12. Validation of the hypothesis 4

H5. ***The implementation of an ITA system produces a better performance in firms operating urban transport by bus***

RESULTS OF THE ESTIMATIONS OF THE GENERAL MODEL

	Estimation	P-v
IC <= EFFICIENCIES	199.353	0.000
IRH <= EFFICIENCIES	2.905	0.000
IGN <= EFFICIENCIES	1.000	0.000
IEE <= EFFICIENCIES	1.853	0.000

Figure 13. Results coming from the estimations in hypothesis 5

The verification of this hypothesis is a consequence of the verification of the hypotheses H1, H2, H3 y H4. The four indexes considered present positive values, validating hypothesis H5, the main objective of this research. So the implementation of an ITA system generates a better performance in firms operating public urban transport by bus. Then, according to all the discussion previously presented we can confirm that ***the investments in Intelligent Transport Aid Systems (ITA systems) in firms operating public urban transport by bus in main cities in Spain generate a better performance along time.***

Conclusions and Future Research Areas

Conclusions

According to updated data related to the air pollution and cost of energy ratios, it is urgent to count on with a sustainable, effective and efficient public transport today. This is the reason why Public Administrations and sectors related to transport and new technologies are performing important efforts to promote the citizens mobility, based in a higher use of public transport, especially in cities

To increase the use of public transport in an urban environment, it is needed to count on with an optimal level of supply, combined with a government support, and desired levels of quality. The transformation of the model or behavior of people in relation to transport in cities can be reached by improving the profitability of firms operating urban public transport.

Our research tries to empirically explore and validate if the use of a certain technology, *Intelligent Transport Aid Systems (ITA systems),* in the public transport is source for the generation of a better performance in a regulated scenario, as it is the case of public urban transport by bus in main cities in Spain.

This kind of analysis is important since there are not concrete pieces of research that put into relation and validate from an empirical point of view the effects of ICT applied to the management of public transport in general, and in particular the implementation of Intelligent Transport Aid Systems (ITA systems) in firms operating urban buses.

The results of this research matches with a group of studies that put into relation ICT as source for the creation of efficiencies in other industries (bank, insurance, etc.).

The results of the analysis in this research show empirical evidence that are congruent with the hypotheses related with efficiency and profitability, quality and relevant information for the business and less important in comparison with the hypothesis related with the effects produced in the efficiency of human resources

The results in this research are important for both, the ICT and the urban bus public transport industries, since they support and justify the increase experienced in the implementation of these systems in firms operating urban public transport by bus.

For this research we have chosen a sample composed by all the firms operating local urban public transport by bus in cities in Spain. We have asked to 53 firms and we have received an 81% of response rate.

The basic conclusions for this study, supported in different kinds of hypotheses, are the following ones:

- The Intelligent Transport Aid Systems improve the efficiency and the profitability of firms operating urban public transport by bus (H1)
- The Intelligent Transport Aid Systems increase the quality of the service and the image of public transport in firms operating urban public transport by bus (H2)
- The Intelligent Transport Aid Systems improve the efficiency in the management of human resources in firms operating urban public transport by bus (H3)
- The Intelligent Transport Aid Systems increase and improve the information relevant relating to the exploitation for firms operating urban public transport by bus (H4)
- And last, as a result of our empirical validation, we can affirm that the investment in Intelligent Transport Aid Systems in firms operating urban public transport in the main cities of Spain generate a better performance along time.

  For all that, the improvement in the effectiveness, the increase in the number of passengers, the decrease of the coordination and supervision costs, the continuous access to the specific relevant information, the adjustment of the supply to the demand, the improvements in the human and material resources allocation and the improvement of the personal efficiency imply that the implementation of an ITS generates better performance along time.

Barriers of the Study

Due to the recent worldwide implementation of the first Intelligent Transport Aid Systems (ITA Systems) and the time this research is offered, we could stress that the most important barrier to this research has been the lack of publications (books, doctoral dissertations, articles, etc.) on this kind of systems.

It is quite obvious to indicate, that since there is not a research relating efficiencies achieved as a result of an ITA system implementation, the process of collecting information on this kind of systems has been quite difficult.

Also, and due to the lack of studies related to this issue, it has been especially difficult the elaboration of a survey that could help in the empirical part of the analysis. We could overcome this obstacle by using the "*continuous approach"* method. That it is to say, first we developed a deep interview with a manager in an urban public transport company. As a consequence of it, and oriented by *"the general indicators of transport"* published by the World Bank (1986, 1996) and the Report of control coming from the Andalucia Chamber of Commerce (Colinas, 2005), we have elaborated a wider survey and we have sent it to three Chief Executive Officers (CEO) in other three companies operating urban public transport. Finally and once the previous survey has been

improved due to the feedback received from the managers, the survey has been sent to all the companies operating urban public transport in Spain. Another barrier in our study has been the number of surveys received. Although in percentage, the number of response rate is relatively high, (81%), the whole number of valid responses has been reduced to 26. It also serves to indicate that the indexes related to the questions in the survey are more qualitative (we try to collect perceptions) than quantitative, determined by a *likert scale (1-5)*.We have tried to solve this limitation by applying the statistic method of structural equations containing latent variables and errors of measure.

Future Areas of Research

Being aware of the barriers found in our study and considering the obtained conclusions, we consider of interest to suggest some future areas of research,

- To go deeper in the analysis by using quantitative methods
  - It would be interesting to analyze the increase experienced in the number of passengers by studying the concrete paths, before and after having implemented the ITA system.
  - It would be also suitable to analyze the increase of the variation of the income produced by the transport activities before and after the implementation of an ITA system has taken place.
  - To analyze the variation in the subsidies needed would be another index that could offer concrete knowledge to the study.
- To analyze the possible reduction in the energy consumption by passenger, exclusively due to the optimization of paths and fleets.
- To widen the sample of the study by including other less important cities and the inter-urban transport.
- To perform comparative analysis or apply" *benchmarking"* efforts with other European cities, where the implementation of this kind of systems has already taken place.

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