The Impact of Integrated Tariff Systems on Public Transport Demand: Evidence from Italy

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Preliminary draft

Abstract. The increasing problems of pollution and traffic congestion represent a challenge towards the definition of a model of sustainable mobility, in particular in the largest urban areas. An indirect control on these negative externalities associated with private transport may be pursued by means of policies aiming at improving quality and accessibility of public transit networks. In this respect, one popular option is to design an Integrated Tariff System (ITS): the crucial question remains if such a policy can be effective in raising the number of public transport users. In this study we use a ten-years panel of 69 Italian public transit providers (with or without ITS) and estimate alternative specifications of the demand function. Results show that the impact due to the ITS introduction is on average quite small, but it becomes more relevant when the ITS is characterized by specific factors making it more attractive for the potential users, such as large network extension and single ticket option.

Keywords: Public Transit Systems; Tariff integration; Demand function; Dynamic panel models

JEL Codes: C23; D12; Q58; R41; R48

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1. Introduction

Growing concerns about pollution and traffic congestion represent a challenge that calls for the definition of a model of sustainable mobility, which is particularly urgent in the centres of big urban agglomerates. On the one hand, one can try to directly control the congestion and the other private transport externalities, by internalising the associated costs through the introduction of payment mechanisms for users (for example park pricing or road pricing schemes). On the other hand it is possible to have an indirect control of such externalities, by promoting policies aimed at improving the quality and the accessibility of the public transport network. To that regard, the provision of an integrated and high-quality transport system can represent a valid tool. The term integration may refer to *informative integration*, where user has easy access to information about the different networks, timetables and tariffs, *physical integration* among different networks (infrastructures and network design that make it easier for users to change the modality of transport), and *tariff integration*, whose effectiveness is clearly greater when the other two forms of integration are at place.

In the following we will refer to the above aspects jointly considered as Integrated Tariff System (ITS). An ITS allows passengers to utilize several transport modalities (e.g., intercity and urban buses, subway, local railway, ferry boats, etc.) by buying only one ticket, which can be used in a short time period (e.g., two hours, daily ticket) or can well have a seasonal validity (e.g., weekly, monthly or yearly). As such, the integrated travel card allows users to consider the whole public transit system within a specific area (urban, metropolitan or even regional) as if it were organized by a single firm offering a unitary service. ITS have been introduced in many countries and are a subject of explorative studies promoted by the European Commission (NEA, 2003) and by Governments (e.g. for Scotland, see the Scottish Executive Social Research, 2004, while for the UK, see the TRL report, 2004). Notwithstanding this increasing interest, academic research, both at theoretical (Cassone and Marchese, 2005; Marchese, 2006) and empirical level is rather limited. As pointed out by the Scottish Transport Research Planning Group: "*No conclusive evidence was found that integrated ticketing leads directly to patronage or revenue increases, partly because integrated schemes have apparently not been studied or introduced in isolation. However, the many presumed benefits are thought to constitute a reasonable case for introduction*" (Scottish

Executive Social Research, 2004, p. 48). A similar view can be found on the TRL Report: "*Results of studies of the effects of pre-paid ticketing systems (travelcards or season tickets) show no consistent pattern: in some cases elasticities are greater for pre-paid tickets than for cash fares, but in other cases the opposite is found*" (TRL, 2004; p. 18).

The present work contributes to this literature by providing fresh empirical evidence on the impact of the introduction of ITS on patronage. By carrying out an econometric analysis on a panel of 69 local public transport (LPT) Italian companies observed in the period 1991-2000, we study the determinants of the LPT demand by discussing also the effects of various qualitative features of the service (i.e. average speed, frequency and density), with the ultimate goal of evaluating the shifts in LPT demand due to the provision of an ITS. From a methodological point of view, the analysis relies on the estimation of dynamic panel models. To be more specific, the outcomes coming from a fixed-effects model (in which the lagged output variable is affected by an endogeneity problem), are compared with the ones resulting from the estimation of GMM models (Arellano and Bond, 1991; Blundell and Bond, 1998). Moreover, we estimate the LSDV model first introduced by Kiviet (1995) and subsequently implemented by Bruno (2005), that foresees a correction of the bias implicit in the fixed-effects model and, as compared to the GMM specification, is more appropriate in the case of samples which are limited in the cross-sectional dimension.

The remainder of the paper is organized as follows. Section 2 present a selected review of the empirical literature on transport demand and of the very few studies focused on the impact of pre-paid and integrated tickets on patronage. Section 3 describes the data and the construction of the variables used in the demand model. Section 4 presents the empirical methodology and discusses main estimation results. Section 5 concludes.

2. Review of the literature

There is an impressive number of papers that investigated the demand on the LPT industry. A recent comprehensive review is contained in the TRL report (2004). As a general result, it is nowadays widely accepted that studies of transport demand that consider the tariffs as the main variable in the process of consumer choice are not very useful. The passenger transport demand is different from the other consumer goods in that, in addition to price, other qualitative factors, such as frequency, commercial speed, network extension, the possibility to have interconnections with nodes of other transport networks (railways, airports), are very important and must be taken into account.

For example, Dargay and Hanly (2002) included among the regressors a variable, bus-kilometers, which is the total number of kilometres covered by the buses in the rolling stock. The elasticity of the demand with respect to this variable was higher than the price elasticity, underlying the important of qualitative aspects of the service. Turning to the traditional estimates of demand elasticities with respect to the price and to the income, the literature shows short-run elasticities ranging from -0.3 and -0.8 and long-run elasticities which are often above 1 (Gilbert and Jalilian, 1991) in absolute value. The income elasticities are in general low (Asensio *et al.*, 2003) and in some studies, after the inclusion of a variable checking for the use of private cars (which is correlated to the income level), they are found to be negative. There is thus some evidence consistent with the fact that bus passenger transport can be considered as an inferior good. A useful review of the results appeared in the empirical literature is provided also by Dargay and Hanly (2002). To summarize:

- The price elasticity is higher in the peak hours and lower in the other periods of the day (Oum *et al.*, 1992);
- The price elasticity is higher for single tickets as compared to multi-ride tickets, and both are higher as compared to an 'average' elasticity, suggesting that single tickets and multi-ride tickets are substitute goods (De Rus, 1990; Dargay and Pekkarinen, 1997);
- The price elasticity for the suburban service is higher as compared to one measured for the urban service (Nijkamp and Pepping, 1998).

To the best of our knowledge, there are only three studies that investigated, either directly or indirectly, the impact of ITS on the bus passenger demand. Fitzroy and Smith (1999) analysed the impact of the introduction of discounted integrated season tickets using a sample of 4 Swiss towns observed from 1971 to 1996. The results from a pooled estimation (including city dummies among the regressors) and from a SUR system show a positive and significant effect of the season-ticket dummy variables on the LPT demand. This effect is different across towns, with the most powerful effects arising in Geneva (15-16%). Moreover, the extension of season ticket validity to all LPT companies in the city of Bern (inter-operator transferability) significantly affected the demand, implying an increase ranging from 14 to 26% (pooled and SUR estimation, respectively).[1]

While the former study only indirectly was providing relevant information concerning the introduction of ITS, the study by Matas (2004) is focusing directly on this topic. The regional government of Madrid created in 1987 an integrated fare system for the whole LPT network based on a travel card. By collecting data for bus and underground trips in the Madrid region for the years 1979-2001, she estimated a two-equations system by applying the SUR method in order to take into account the possible correlation in the errors across the two types of service. The results showed that the introduction of travel cards were leading to a growth in bus and underground patronage of 3.4% and 5.3% in the short run, and 7% and 15% in the long run, respectively. Finally, the study of Dargay and Pekkarinen (1997) is concerned with evaluating the effects of integrated ticket policies on bus use in Finland, but the angle of observation is to estimate the fare elasticities on the demand for bus cards and on the travel demand with these cards. Both demands were found to be highly sensitive to price and income.

For sake of completeness, we report also the results of the already cited study by NEA (2003), that contains some anecdotical evidence on the impact of integrated tariffs. It is shown that the introduction of ITS in a set of European cities induced an increase in transport demand ranging from 4% (Manchester) to 33% (Paris). However, the study does not make use of econometric techniques and relies on a summary index of integration, which includes informative integration, network integration, and tariff integration. For what concerns the Italian evidence, the study shows that the introduction of a new integrated fare system in Rome (Metrobus) had the effect of raising public transport patronage by more of 6% in two years.

In the present work we analyse the evolution of LPT demand for 69 Italian operators which are observed for 10 years. Differently from Matas (2004), and Fitzroy and Smith (1999), we do not have time series data for one region or a small number of towns only, so that panel data econometric techniques can be easily applied. Moreover, the paper is mainly focusing on tariff integration, so that we will try to directly evaluate the impact of the different ITS features that have been introduced (e.g., exclusivity of the integrated ticket, extension of tariff integration outside the municipal boundaries, possibility to buy

[1] In a previous study (Fitzroy and Smith, 1994) the authors analyzed only the demand for public transport in Zurich and found similar evidence on the impact of integrated season tickets.

a single-trip (or short time validity) integrated ticket rather than being obliged to buy seasonal tickets) on public transport patronage.

3. Data and variables

The adoption of ITS in Italy was delayed with respect to other European countries. Except from the first experiences in Lombardy and in the Bozen Province in the second half of the seventies, the majority of operators started to introduce some forms of tariff integration only in the nineties. In 2002, 42% of urban transport systems were fully or partially integrated, with larger percentages recorded in Northern Italy and in big and medium sized towns. Such percentages are constantly growing trough time. As described in detail in Piacenza and Carpani (2003), the ITS characteristics vary from case to case. For example, there are still geographical limitations of validity within some Provinces or Regions, and sometimes the integrated ticket represents an alternative option to buying separated tickets which are issued by single LPT operators. In the empirical investigation such differences can be exploited in order to evaluate separately the effects on public transport patronage of different types of tariff integration.

Our data base is relative to 69 LPT companies which are observed from 1991 to 2000. We gathered information from the annual directories of ASSTRA – the nationwide association of publicly-owned LPT operators – and directly from questionnaires sent to firms, in order to circumvent the problem of missing technical data and to get further information on ITS. The geographical localization of our sample firms fits closely the national distribution of LPT demand: 60% of companies are located in Northern Italy, 17% in Central Italy and the residual 23% in Southern Italy. There are 38 mixed firms that provide both urban and intercity service, while 21 and 10 operators are specialized in the urban and intercity service, respectively. As for the introduction of integrated tariffs, 22 operators (of which 9 urban-type, 2 intercity-type and 11 mixed-type firms) are involved in some form of ITS.

The dependent variable used in the estimation of demand model (see section 4) is the total number of transported passengers per year (Y), which has been preferred to other demand indicators such as passenger-kms (which includes also aspects related to the supply of the service) and traffic revenues (which are affected by the pricing policy).

The public transport tariff (*P*) has been measured in terms of average price using a proxy, i.e. by dividing total revenues deflated by the consumer price index (base year 2000) by the total number of passengers. Unfortunately, given the wide selection of ticket types offered, we were not able to disaggregate data by type of tariff (e.g. number of passengers that use single tickets, seasonal tickets, intercity tickets, and so on), so our empirical strategy is the estimation of a single equation described the demand of an 'average' LPT service.

With respect to service quality, in our study the latter is captured by three indicators usually considered in the literature on LPT demand: average commercial speed (*SP*), route density (*RD*), and service frequency (*FR*). The average speed of LPT vehicles is inversely related to in-vehicle travel time and has been obtained by dividing the total yearly kilometers covered by all vehicles in the rolling stock by the total number of service hours. The frequency, which is a proxy for waiting time costs, is measured as the ratio of total yearly vehicle-kilometers to the network length. Finally, route density has been computed by dividing the network length by square kilometers of served area; a high value of this variable means that users can easily have access to LPT network and consequently face lower walking time costs.

LPT demand also depends on socio-economic and demographic characteristics of the served area. Disposable real income affects transport demand both directly (a higher income level should reflect an increase in working activities and therefore stimulate mobility) and indirectly (through the increased probability to buy and/or use private cars at higher income levels, in such a way reducing LPT demand). Real income (*W*) has been measured as the deflated (using the GDP deflator index) per-capita income at the provincial level. As for the other socio-economic and demographic regressors which are often included in LPT demand estimation, we constructed the following variables for the territorial area covered by each firm[2]:

- general occupation rate (OCC_G), measured by the number of employed people on the total of working age population (15-64 years);
- occupation rate (OCC_{AG}), in the agricultural sector, computed as the ratio of employed people in agriculture to the total number of workers;

[2] The information on per-capita income levels and other socio-economic and demographic characteristics has been gathered from the directories of ISTAT (the Italian National Institute of Statistics) and from data processed by the Istituto Guglielmo Tagliacarne (Foundation of the Italian Chambers of Commerce).

- elderly and female population rate (respectively, POP_{OLD} and POP_{FEM}), measured by the ratios of people with more than 64 years and of women to the total population, respectively;

Apart from occupation rate in the agricultural sector, all the other proxies are expected to exert a positive effect on LPT demand. However, since they are highly correlated to the income indicator (especially the occupational variables) and their within standard deviation is very limited (see table 1), we have finally decided to exclude them from the regressions analysis which is presented below.[3]

Table 1. Summary statistics for the variables of the demand analysis

Variable	Mean	Standard deviation			Min	Max
		Overall	*Between*	*Within*		
Y	49,708,000	141,989,000	142,040,000	15,780,000	326834	979,000,000
P (€)	0.52	0.26	0.25	0.07	0.08	1.45
SP	24	9	9	2	10	50
RD	1.39	1.94	1.95	0.15	0.09	16.83
FR	14,218	15,924	15,874	2,209	811	99,064
W (€)	17,775	4,183	4,137	778	9,657	28,026
OCC_G	0.55	0.09	0.08	0.03	0.33	0.87
OCC_{AG}	0.06	0.05	0.05	0.01	0.00	0.22
POP_{OLD}	0.18	0.04	0.04	0.01	0.10	0.25
POP_{FEM}	0.52	0.01	0.01	0.00	0.51	0.54
D_{INTRO}	0.22	0.42	0.34	0.25	0.00	1.00

Since the key issue of the study is the investigation of the impact exerted by integrated tariffs, we constructed also a dummy variable assuming value 1 when the introduction of integrated tariffs is observed (D_{INTRO}), and, most importantly, other four dummies accounting for the presence of specific features of the ITS, namely:

- extension of the integration validity outside the urban area and/or a specific single route (D_{EXT});
- supply of a single integrated ticket (including the daily ticket) together with the classical seasonal ticket (weekly or more), that allows more flexibility for occasional users (D_{SING});

[3] The results relative to our key variables with the inclusion of such additional characteristics in the model are virtually unchanged and are available upon request.

- flexible territorial validity, according to the number of purchased "zones", e.g. urban centre, within a ring of 10 km from the centre, within a ring of 20 km, etc. (D_{ZONE});
- exclusivity of the integrated ticket (D_{EXCLU}), that is, the impossibility to buy alternative less expensive tickets which are valid only on a subset of transport modalities (e.g. subway-only, bus-only, urban-only, etc.).

Table 1 shows summary statistics for all the variables described above.

4. Demand estimation

4.1. Model specification

To assess the impact of ITS on LPT patronage, a demand function model for public transit service provided by the 69 companies in our sample has to be specified and then estimated. As remarked in Oum (1989), one of the most striking features of the transportation literature is the wide variety of demand models proposed, which is mostly linked to the choice of aggregation level of the data and to the choice of functional form. Indeed, differences in types of data and in functional specifications are likely to affect empirical results with relevant policy implications, such as elasticity values and traffic forecasts.

As for the type of data, the choice between *aggregate* – where the basic unit of observation is the aggregate volume of a particular mode in a market – and *disaggregate* modeling approach – where the basic unit of observation is an individual decision maker's distinct choice – largely depends on the goal of the study and the cost of collecting the data. When the purpose of the analysis is to forecast the average behavior of an aggregate group of individuals (e.g. the residents in a given metropolitan area), for instance in response to some changes in LPT policy (e.g. introduction of ITS), then the use of aggregate data is more natural end even preferable, although it introduces certain restrictive theoretical assumptions about the consumer behavior.[4] As Winston (1985) underlines in a survey paper highlighting advantages and disadvantages of the two approaches, a disaggregate model requires an extensive data base and the data are often difficult to obtain, due to the confidentiality of private information, and even when data collection is feasible, the process could result very expensive. Therefore, following the previous studies by Fitzroy and Smith (1999) and Matas (2004), we have decided to rely on the estimation of an aggregate demand function, that allows us to provide an

[4] See Berechman (1993, chapter 2) and Gagnepain and Ivaldi (2002, appendix).

approximation of the underlying factors behind the observed changes in public transport demand and of the corresponding elasticities.

The functional form mostly used to estimate aggregate transport demand models are the *linear* and *log-linear* specifications. The linear function has been extensively used in early studies (e.g. Bates, 1982; Benham, 1982) because it is simple to estimate and the empirical results can be easily interpreted. It presents the advantage that each demand elasticity depends on the value of the variable, but for many variables the assumption of a linear effect may not be realistic. On the other hand, the log-linear (or *double-log*) model specifies the logarithm of traffic volume as a linear function of the logarithms of potential determinants, such as prices and quality attributes. Since it is capable of modeling nonlinear effects and the coefficients themselves directly represent the demand elasticities with respect to the different explanatory variables, at present the log-linear specification is the most widely used form in transport demand analysis (e.g., for public transit systems, Fitzroy and Smith, 1994 and 1999; Gagnepain and Ivaldi, 2002; Matas, 2004). The main drawbacks of this model is that each elasticity is invariant across all data points and not dependent on the location of the demand curve. However, the assumption of constant elasticity specification has been tested by the estimation of both a linear and a log-linear model. The procedure used to compare the different functional forms is based on the respective likelihood values according to the Box-Cox (1964) metric[5]. The selection indicated the double-log as the specification best fitting the data, so we finally decided to adopt this model in our econometric analysis.

As for the determinant to be included in the demand function, we follow the classical guidelines and assume that the aggregate consumption of local public transport, Y, depends on transit fare level, P, other variables representing service attributes denoted by Z, and a vector S of socio-economic characteristics of served population (Berechman, 1993). Thus, we can write the general expression for the demand function as follows:

$$Y_{it} = D(P_{it}, Z_{it}, S_{it}) \qquad [1]$$

with $i = 1, \ldots, 69$ denoting the firm and $t = 1991, \ldots, 2000$ the year being observed.

[5] Both linear and log-linear specifications are nested in the more general Box-Cox (1964) model with λ transformation of the dependent and independent variables, where the transformation for the variable x is defined as follows: $x = (x^{\lambda} -1)/\lambda$. Indeed, the linear and log-linear forms can be obtained by setting the value of the Box-Cox parameter λ to one and zero, respectively. For more details on this issue, see Oum (1989) and Benfratello *et al.* (2007).

According to the variables selection described above (section 3), the vector Z includes: average commercial speed (SP), route density (RD), service frequency (FR); the dummy capturing the impact of the ITS introduction (D_{INTRO}) or, alternatively, the set of dummies reflecting the presence of specific features of tariff integration – namely, extension (D_{EXT}), single ticket option (D_{SING}), flexible territorial validity (D_{ZONE}) and exclusivity (D_{EXCLU}) – interacted with a set of *service-specific* dummies – namely, urban (D_{URB}), intercity (D_{INT}) and mixed (D_{MIX}).[6] As for the socio-economic characteristics, in the final specification of [1] the vector S reduces only to a real income indicator (W) measured by the deflated per-capita provincial income. A lagged value of the dependent variable (Y_{t-1}) is included to capture potential lags in the adjustment of LPT demand to changes in the right hand side determinants.

Given the adopted log-linear form, the demand equation to be estimated for the BASIC MODEL according to the procedure discussed in the next section is the following:

$$\ln Y_{it} = \alpha + \beta_1 \ln Y_{i,t-1} + \beta_2 \ln P_{it} + \beta_3 \ln SP_{it} + \beta_4 \ln RD_{it} + \beta_5 \ln FR_{it} + \beta_6 \ln W_{it} + \delta D_{INTRO} + \varepsilon_{it} \quad [2]$$

In the EXTENDED MODEL, δD_{INTRO} is substituted with $\sum_r \sum_s \delta_{rs} D_r D_s$ where r = EXT, $SING$, $ZONE$, $EXCLU$ and s = URB, INT, MIX. ε_{it} is an error term including a random noise and unobservable effects which are firm-specific but may be fixed over time (see section 4.2.1).

4.2. Econometric analysis

4.2.1. Methodological issues

As already mentioned, one peculiarity of our study with respect to the previous literature on LPT demand is given by the possibility of exploiting the advantages of econometric techniques developed for the estimation of dynamic panel data.

Let us first briefly review some of the main econometric concerns when we have to estimate model [2] and we can assume the error term as being composed by a random noise (u_{it}) and a firm-specific unobservable effect (γ_i).

$$\varepsilon_{it} = \gamma_i + u_{it} \quad [3]$$

γ_i captures the heterogeneity of the sample and may be correlated with the observable variables used as regressors, making OLS estimates biased and inconsistent. In our

[6] We discuss the reasons for such a specification in section 4.2.2.

dynamic model, the problem in applying OLS is immediate, since the lag of the demand is endogenous to the fixed-effects in the error term. Suppose for example that a firm faces a reduction (or increase) of passengers due to some specific environmental factors which are not modeled (e.g. downward trend in population, factors affecting the quality or the cost of alternative mode of transports, etc.). This fixed-effect is positively correlated with the lagged variable, thus the downward (or upward) trend in demand due to the fixed-effect will instead inflate the OLS coefficient for the lagged variable (Roodman, 2006).

With panel data, unobserved heterogeneity bias can be handled by introducing firm-specific dummy variables, leading to the LSDV (Least Square Dummy Variables, or fixed-effect) estimator. However, LSDV does not eliminate *dynamic* panel bias.[7]

One way to deal with the problem is provided by the DIFFERENCE GMM (Arellano and Bond, 1991), which removes the fixed-effects by transforming the data and estimating equation [2] in *differences*. In the model in difference, the lagged dependent variable remains endogenous, but deeper lags are orthogonal to the error and can thus be used as instruments (as long as the error term u_{it} is serially uncorrelated).

An alternative approach is given by the SYSTEM GMM, which can greatly increase the efficiency of the estimates as shown in Blundell and Bond (1998). Instead of transforming the regressors to get ride of the fixed-effects, the SYSTEM GMM transforms (by taking differences) the instruments to make them exogenous to the fixed-effects. This methodology requires the additional assumption that changes in any instrumenting variable are uncorrelated with the fixed-effect, and it is particularly suitable for estimating process which can be considered closed to a random walk.

Both DIFFERENCE and SYSTEM GMM are valid tools when the database has large cross-sectional units ($N \rightarrow \infty$) with respect to a short time extension (T), otherwise the number of instruments, which grows prolifically in the time dimension, would increase too much leading to a problem of over-identification. In fact, finite samples may lack adequate information to estimate the variance matrix of the moments, which is quadratic in the instruments. Over-identification is quite difficult to detect, since the unique tool is represented by the Sargan test, whose reliability weakens as the number of instruments grows. One minimum (but insufficient) caution is to have a number of instruments

[7] Actually, the bias of LSDV has opposite sign with respect to the OLS, and thus the range between these two estimates obtained for the lagged variable coefficient provides a useful check on results from theoretically superior estimators (Bond, 2002).

lower then the cross-sectional dimension, however, in finite samples the bias is present to some extent even when instruments are few, as shown in Windmeijer (2005).[8]

For balanced finite sample panel data, however, there exists another way to obtain unbiased estimates of a dynamic model, that is performing LSDV estimator and then correcting the results for the bias, which can be predicted with surprising precision (CORRECTED LSDV; Kiviet, 1995). This procedure, which seems to have been quite unexploited so far, has been extended to the case of unbalanced panel data by Bruno (2005), which also implemented it as a new STATA routine.

Table 2. Estimates of model [2] from alternative panel data approaches

Regressor [a]	LSDV		DIFFERENCE GMM		SYSTEM GMM		CORRECTED LSDV [b]	
	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value
Y_{t-1}	0.606	(0.000)	0.555	(0.000)	0.942	(0.000)	0.785	(0.000)
P	-0.259	(0.000)	-0.438	(0.000)	-0.090	(0.000)	-0.218	(0.000)
SP	0.094	(0.003)	0.095	(0.031)	0.134	(0.000)	0.088	(0.016)
RD	0.047	(0.141)	-0.023	(0.623)	0.015	(0.061)	0.049	(0.206)
FR	0.039	(0.096)	0.013	(0.680)	0.041	(0.003)	0.048	(0.076)
W	-0.141	(0.049)	-0.087	(0.336)	0.007	(0.579)	0.024	(0.753)
D_{INTRO}	0.021	(0.101)	-0.002	(0.915)	0.070	(0.000)	0.027	(0.081)
Constant	6. 987	(0.000)	-	-	-	-	-	-
Nr. observations	690		552		621		621	
R^2 *Within*	0.672		-		-		-	
R^2 *Between*	0.981		-		-		-	
R^2 *Overall*	0.978		-		-		-	
AR(1) test	-		-5.03	(0.000)	-5.64	(0.000)	-	
AR(2) test	-		1.47	(0.641)	-0.14	(0.892)	-	
Sargan test	-		72.63 [c]	(0.000)	33.13 [d]	(0.861)	-	
Nr. instruments	-		42		51		-	

[a] The dependent variable *Y* is the total number of transported passengers.
[b] Bootstrapped standard errors are based on 200 replications. Coefficients from the Blundell-Bond (1998) approach are used as initial parameter estimates.
[c] Statistical distribution: $\chi^2_{(35)}$.
[d] Statistical distribution: $\chi^2_{(43)}$.

In table 2, we compare the results from alternative panel data estimators applied to our basic model, where integrated tariff is represented by a single dummy variable without

[8] Windmeijer (2005) runs a simulation for a panel with N = 100 and T = 8, showing that reducing the number of instruments from 28 to 13 decreased the average bias by 40%, but did not eliminate the bias completely.

details about its characteristics. As it can be seen for the case of the DIFFERENCE GMM, the problem of over-identification is serious since it does not pass the Sargan test. While the SYSTEM GMM seems to overcome this problem, we need to take into account the weakness of the Sargan test considering that our number of instruments nearly approximates the number of firms (51 with respect to 69). We can note that coefficients obtained from the CORRECTED LSDV procedure with respect to the SYSTEM GMM have some relevant differences in the magnitude, even if the sign of coefficients are all confirmed. Moreover, the difference in the lagged variable tend to attenuate the long-run impact of the variables in a more credible range (the coefficient in SYSTEM GMM would imply that the long-run effect is approximately 20 times the short-run effect, while results from CORRECTED LSDV reduce this multiplicative impact to about 5). Next section will focus on the parameter results obtained from the CORRECTED LSDV procedure.

4.2.2. Estimation results

We estimate 3 models accounting for alternative treatments of information on the type of integrated tariffs. In line with the evidence from the wide literature on LPT demand estimation, short-run price (*P*) elasticity ranges from –0.22 to –0.24, with long run elasticity around –1. Thus, reducing prices is hardly an effective policy to induce users to choose public transport, and it is also hardly feasible from a financial point of view, given that it would produce a serious shortcoming of revenues at least in the short run. Income (*W*) is not significant in our regressions, indicating that public transport cannot be considered as an inferior good; this result is probably driven by having in our sample several big cities where the problem of congestion is serious and hinders private mobility. Another peculiarity of Italy is given by the characteristic geographical density of relatively low-scale and interconnected cities, which has lead to the definition of the Pianura Padana as a "megalopolis", where traffic is increasing in an exponential way such that there are 20 millions of inhabitants covering on average 20 kms every day. In such a congested context, a development of qualitative public transport can be considered as a valid alternative to private modes, independently of the income.

We consider quality by trying to separately assess the impact of 3 supply characteristics which reflect in a better experience for the public transport user from different points of view. All these factors showed the expected positive sign, though in some cases they did not reach a satisfactory level of significance, probably due to correlation problems among covariates and to the limited time-series variability of our variables. However, it is important to control for all these factors to distinguish between qualitative aspects which require modifications in the supply level (thus having a huge impact on costs) and the eventual user preference for integrated tariff policies, which is indeed the focus of our work. In particular, the commercial speed (*SP*) directly impacts on the time of travel and can be promoted by the regulatory authority through the introduction of reserved bus lanes or by developing modes of transport which represents a valid alternative to road transport (i.e. underground, rail). An increase in service frequency (*FR*), which means an increase of the supply over a given network, can capture several aspects from the user's perspective (a reduction of the waiting time, an increase in the timetable flexibility, a reduction of crowding). Finally, the density of the service (*RD*) requires the extension of the public network by the introduction of new routes, and can impact on demand since it improves the accessibility of LPT services. The estimated (short-run) elasticities of demand with respect to each of the qualitative factors are immediately given by the coefficients reported in table 3.

4.2.2.1. The impact of integrated tariff systems

The role of ITS was firstly investigated including in the model a dummy accounting for the introduction of any form of tariff integration (BASIC MODEL). The evidence of a positive impact on LPT demand could not be rejected considering a 10 per cent level of significance. In particular, our results indicate that the introduction of an integrated tariff system can increase the number of passenger-trips by 2,72% in the short-run and by 12,65% in the long-run (see table 4).[9] Even if this result may appear mild, it must be noted that it simply reflects the introduction of a different price policy over a given LPT network, with given quality attributes and keeping constant the average price for passenger-trips. As a consequence, the estimated impact is not affected by eventual quantity discount policies, such as season tickets, which are often associated with integrated tariffs. Moreover, this evidence does not take into account the characteristics of integrated tariff system, whose design can be very heterogeneous (as described in section 3) and can seriously affect its effectiveness. Therefore, keeping in mind that the desirability (in terms of promotion of LPT demand) of specific ITS characteristics – i.e.,

[9] To compute the percentage impact on *Y* of each dummy variable *D* we adopted the formula in Kennedy (1981): $E_{Y,D} = 100\{\exp[\delta - \mathrm{Var}(\delta)/2] - 1\}$, where δ and $\mathrm{Var}(\delta)$ are the estimated coefficient and related variance for the dummy.

extension, single ticket option, flexible territorial (zonal) validity and exclusivity – can vary according to the type of LPT service provided – i.e., urban, intercity or mixed, we estimated EXTENDED MODEL 1, where each type of LPT service has been interacted with each type of the observed ITS characteristics. Unfortunately the estimation of such a model is problematic due to the limited (or absent) number of positive observations for some of the specific combinations and to the high correlation between some features (e.g. between zonal pricing and network extension).[10] Therefore, we relied on the more parsimonious EXTENDED MODEL 2 in which explanatory variables have been progressively eliminated via a stepwise procedure.

Table 3. Estimates of model [2] from alternative specifications of ITS effects

Regressor [a]	BASIC MODEL		EXTENDED MODEL 1		EXTENDED MODEL 2	
	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value
Y_{t-1}	0.785	(0.000)	0.751	(0.000)	0.775	(0.000)
P	-0.218	(0.000)	-0.238	(0.976)	-0.232	(0.000)
SP	0.088	(0.016)	0.048	(0.000)	0.071	(0.056)
RD	0.049	(0.206)	0.152	(0.231)	0.092	(0.030)
FR	0.048	(0.076)	0.094	(0.001)	0.056	(0.037)
W	0.024	(0.753)	-0.003	(0.001)	0.015	(0.834)
D_{INTRO}	0.027	(0.081)	-	-	-	-
$D_{SING} D_{URB}$	-	-	0.128	(0.139)	0.058	(0.043)
$D_{SING} D_{MIX}$			-0.055	(0.137)	-	-
$D_{EST} D_{URB}$			-0.011	(0.755)	-	-
$D_{EST} D_{INT}$			0.056	(0.296)	-	-
$D_{EST} D_{MIX}$			0.290	(0.000)	0.104	(0.003)
$D_{ZONE} D_{URB}$			0.029	(0.680)	-	-
$D_{ZONE} D_{MIX}$			-0.150	(0.082)	-	-
$D_{EXCLU} D_{URB}$			-0.075	(0.411)	-	-
$D_{EXCLU} D_{INT}$	-	-	-0.043	(0.422)	-	-

[a] The dependent variable *Y* is the total number of transported passengers.

[10] Over the total of 690 observations, we have only 152 cases of presence of integrated tariffs, thus it is hard to create many sub-samples.

Table 4. Impact of ITS: short-run and long-run elasticities

	BASIC MODEL		EXTENDED MODEL 2	
	Short-run	Long-run	Short-run	Long-run
D_{INTRO}	2.72%	12.65%	-	-
$D_{SING} D_{URB}$	-	-	5.88%	26.14%
$D_{EST} D_{MIX}$	-	-	10.82%	48.11%

Results from EXTENDED MODEL 2 highlight the impact of two specific characteristics of ITS. In particular, within the urban LPT networks it seems important to give the users the opportunity to choose an integrated ticket for a single trip. This is coherent with the possibility of having in urban centres several occasional users moving within the city for a very specific reason (e.g. a particular event, a one day touristic visit, etc.), while intercity travelling may be more correlated with usual commuters, which are more keen to buy seasonal tickets. The estimated effect of urban integrated tariffs allowing for single tickets is around 6% in the short-run and over 26% in the long-run. When considering mixed networks, as expected, the most important characteristic of the integration appears to be the extension of the integration outside the urban area, which can induce an immediate shift of demand of almost 11%, and can in the long-run produce an increase of passenger-trips by 48%. This results is also coherent with Marchese (2006), which emphasizes the role of integrated tariffs as the extension of the network increases.

5. Final remarks and policy implications

The increase of mobility needs associated with economic development progressively raises concerns about pollution and traffic congestion, inducing policy makers to adopt measures to control the use of private transport modes. Solutions such as parking pricing or road pricing aimed at internalising the cost of private transport as well as the introduction of limited traffic zones have become popular. The focus on negative incentives to private transport has sometimes put on a second place complementary policies aimed at improving the public transport service, thus directly trying to capture users' preferences. In this paper we focus on this second type of measures by investigating how much qualitative factors can affect public transport demand.

Our findings show that the introduction of Integrated Tariff Systems (ITS) exerted a positive impact on passenger demand for a sample of 69 Italian LPT operators which are observed in the 1991-2000 period. On average, the estimated effects of integrated tariffs on patronage are 3% in the short run and 13% in the long-run. Moreover, focusing the attention on urban operators, the provision of a single integrated ticket in addition to the usual season ticket has a larger impact (6% in the short-run and 26% in the long-run) on public transit demand. In a similar vein, for mixed-type operators providing both urban and intercity service, the extension of the area of validity of the integrated ticket has an estimated effect of increasing the number of passengers by 11% in the short-run and 48% in the long-run. Such results, which are robust to different panel-data estimators (LSDV, DIFFERENCE and SYSTEM GMM and CORRECTED LSDV), highlight that not only a shift towards integration but also the specific features of ITS which is implemented should be properly taken into account by Local Authorities in order to increase passenger transport demand.

As compared to other public interventions aimed at directly reducing private car circulation, the adoption of ITS implies a much more structural change, in the sense that, differently from simple monetary (dis)incentives, it can modify the consumer behaviour permanently in favour of the use of public transport services. Of course, these positive effects are more likely to emerge the higher is the quality of the LPT service, in terms of network density, frequency, inter-modal coordination, and if parallel policies aimed at increasing the circulation speed of buses, such as reserved lanes, traffic-lights preferential arrangements, etc., are put forward.

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