A METHODOLOGY FOR OPERATIVE COST AND REVENUE EVALUATION IN TRANSIT SYSTEMS: APPLICATION TO AN ITALIAN EXTRA-URBAN AREA

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1. INTRODUCTION

The introduction of the definition of “minimum services”, to be guaranteed on those relations on which it is not possible to provide a public transport service at accessible prices to the users, allows public financing to maintain a certain level of price for what is considered an otherwise unprofitable activity, as indicated in the EC directives 1191/69 e 1893/91.
It has to be specified that these directives allow public subsidies to guarantee a service of public utilitiy, but it also imposed that the same funding cannot be used by the companies to restore deficits due to bad management on unsubsidised services, practice of common use to the current date, even if not correct on a economic and social point of view.
In Italy, the policies of budget restoring "ad post" is no longer a viable route since the enforcement of the law 422/97, in reception of the EC directives, which imposes a control on the management of the service, aiming to assure the appropiate standards in reliability, safety, efficiency and effectiveness.
To guarantee that the request of a better service at an acceptable cost is satisfied, the law 422/97 sets a series of targets, and particularly:
- the transformation of each transport company, generally publicly owned, in limited companies, independent from the bodies requesting the service;
- the assignment of the management of service calling for tenders or service contracts;
- the institution, within the regional administrations, of mobility observatories.

The transformation in limited company of all the public operators has to be accompanied by their reorganization, and this implies the necessity to have a picture for reference, described by aggregated indicators, which allows the dimensioning or re-dimensioning of the various activities of the companies.
Furthermore, in the view of a rational use of the resources to fulfill the prescriptions given by the quoted laws, the analysis of the economic performance of the service assumes a strategic importance; this can be expressed by means of a difference between costs and revenue in management, essential for the definition of the levels of supply and for the calculus of the public funding necessary to produce the services.
A beforehand knowledge of the economic result of the business, would allow the control Authorities to define the entity of resources to be made available to make up the set of services considered essential for the communities' needs (within the considered basin).

The companies, on their behalf, could calculate the amount of funding needed to produce a given transit programme and evaluate the business convenience, the profit margins, and the investment risks connected to the given activity. Such an analysis, indispensable during the phases of design and project, is relevant during the phase of monitoring of the service, where it is necessary to verify if the given goals of efficiency and cheapness have been obtained, and to what extent.
Several methods concerning cost structures of public transit systems have been proposed in literature, and Oum and Waters (1996) provide an excellent summary of recent works in this area. Essentially those procedures are developed to analyze the production technology of public transit firms and a translog statistical function to approximate transit systems' variable costs is generally adopted (Obeng, 1984, Berechman and Giuliano, 1984, Karlaftis et al. 1999, Karlaftis and McCarthy, 2002)
The purpose of the analysis conducted in this paper is different: as a matter of fact cost functions in the present work are not introduced to find out a production level to compare firm performance but to perform a quantitative analysis that should allow to define the necessary resources to comply a set of services, once known the existing demand and the adopted fare structure and revenue. To obtain those targets, it is necessary to develop a methodology for the aggregated analysis of the performance of the public transport system.
Such an analysis can allow the authorities to determine beforehand the dimension of subsidies needed to guarantee the services as programmed to optimum, that is to harmonise the offered services so to exploit at the best the supplied resources.
This note presents a methodology for the operative cost and revenue evaluation in extra-urban transit systems. This methodology is a part of a general procedure of analysis of the regional transit system (Russo, 2002). The structure of the presented model is based on a procedure developed within the Progetto Finalizzato Trasporti 2 of the National Research Council (De Felice et al., 1995 and 1999) even if it has been developed and integrated to consider the different perspective and peculiarities of the present approach and the new introduced regulations. The whole procedure has been tested on an Italian regional area.
In the following paragraph the proposed methodology will be described, specifying the analysis on the base of costs/revenue and obtaining an evaluation on the economic performance of the single line. Paragraph 3 contains the experimentation of the proposed procedure on the test site and the obtained results are shortly discussed. In paragraph 4 some conclusions and the perspectives for a future development will be outlined.

2. MODEL DESCRIPTION

A streamlining in several phases concerning both planning and management of local public transport systems can be achieved by the opportunity to make valuations on only a part of the programmed service. For this purpose, in the proposed model, a single transit line has been considered as a production unit.

The total economic performance of a service programme is thus valued by aggregating the results given by the whole set of lines which form the programme. This implies the opportunity to calculate the profitability for each line, referring to it specific sales revenue and production costs. This choice offers the opportunity to harmonize the procedures of evaluation here described with the other models used for the analysis of public transport systems. Therefore the method here proposed becomes part of a system of models for the evaluation of a transport system, where the data on which the evaluation is based are congruently obtained from the results of the other models which form the whole methodology.
An indicative scheme of the functional interaction among the cost macro-model and the other models is shown in Fig 1.

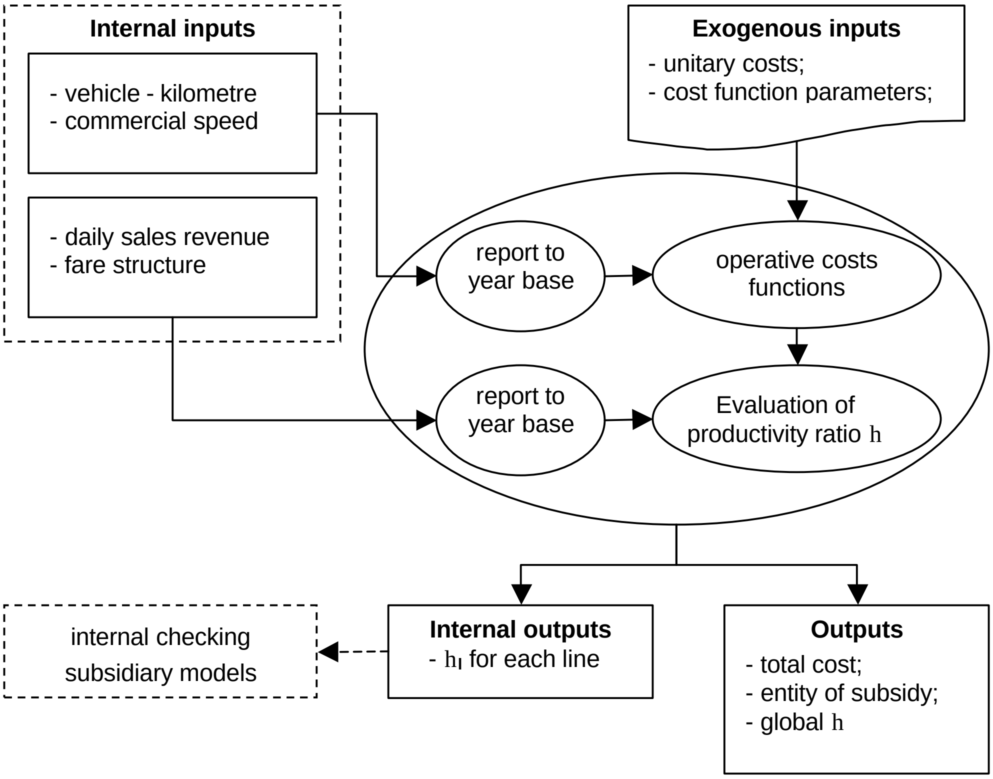

Fig. 1: Structure of the cost macro- model.

As it can be seen, inputs (and outputs) have been subdivided into two classes: *internal* that correspond to outputs of (inputs for) other macro-models within the process of which the proposed model is a part of and *exogenous* that are generated (used) outside the process. A description on the nature of such data is given in the following.
It is worth noting that, within this paper, the proposed application is supposed to work using costs (and sales revenue) considered on average. If this hypothesis cannot be accepted, as in the case where a distribution of services needs to be treated by means of a schedule approach, temporal variability must be taken into account also in the definition of costs, yielding to a specification of cost functions different from the one here introduced, where an interaction among the model including also the temporal dependance should be explicitly included.

2.1. Input data

Internal inputs

As said above, internal inputs are the results of other macro-models within the general procedure to which the one described here belongs. In particular the input used come from:

– Supply model
  - the amount of service produced quantified by means of the amount of vehicle - kilometre [VKM];
  - the commercial speed of each line L [$VCOM_L$].

– Fare and revenue model
  - daily values of sales revenue for each hypothesized fare (and supply) scenario;
  - spatial and temporal structure of the adopted fare.

Exogenous inputs

Exogenous inputs obtained from sources external to the general procedure are:

– Unitary costs
  - the unitary costs of the resources in terms of the current average prices, inclusive of VAT and production taxes;
  - the unitary consumption obtained both on the basis of data given by the Companies, and on the basis of the characteristics of the vehicles;

– Parameters of cost functions
  - estimated both analysing the existing literature and using data obtained by companies.

2.2. Models

Temporal aspects in within-day data

Concerning the temporal aspects connected with the produced service, they must be included if the scheduled service cannot be taken into account in average. To better explain the nature of these effects, two lines (one for each direction) sharing the same terminals and included in the supply system used in the application described in paragraph 3 have been considered. Main characteristics of the two bus lines are shown in Tab. 1 and in Fig. 2 is depicted the within-day distribution in terms of the number of runs leaving each terminal every hour.

Line	Length [km]	Stops	Time	Recovery	Comm speed	Runs	VKM (day)
253	22	5	25’	5’	53	20	440
279	22	5	25’	5’	53	22	484

Tab.1. – Supply characteristics of lines 253 and 279.

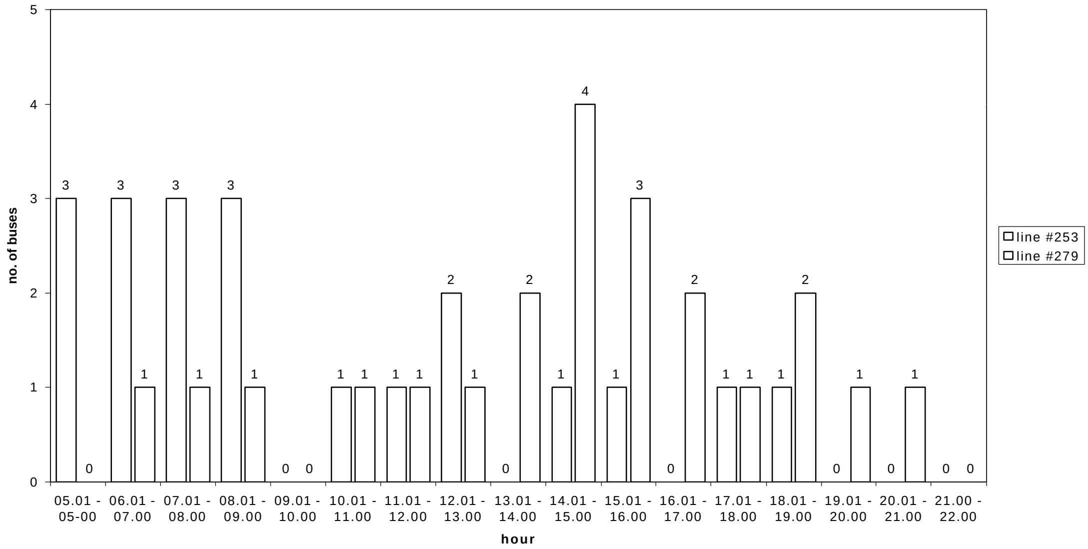

Fig. 2: Within-day distribution of service – lines 253 - 279.

As it can be seen, such distribution cannot be defined uniformly distributed within the day. The differences, in terms of operative costs, will be examined between two approaches: the first one (*aggregate*) considering average values for the produced service, and the second one (*disaggregate*) taking into account also the schedule of the service. The daily produced service is of 924 veh-km, corresponding to an annual service of 304,920 veh-km (see point 3 for more details on annual expansion and cost evaluation). Obtained costs for the two approaches, where, for the sake of simplicity, *only personnel and vehicle costs have been evaluated with the scheduled approach*, are shown in Tab. 2.

Voice	Aggregate	Disaggregate	
TRACTION	152,460.00 €	152,460.00 €	-
MAINTENANCE	60,984.00 €	60,984.00 €	-
PLANT AND VEHICLE	200,071.30 €	203,371.71 €	+ 2.02%
PERSONNEL	181,368.99 €	342,229.63 €	+ 88.69%
GENERAL	48,787.20 €	48,787.20 €	-
TOTAL COSTS	643,671.48 €	804,532.13 €	+ 24.99%
veh-km cost	2.11 €	2.64 €	

Tab. 2: Annual operative costs – lines 253 - 279.

These differences come from the fact that, in disaggregate approach, the number of vehicles to be used in the line and the number of employees do not depend only on the amount of produced service but also on the way this service is distributed within the day. As a matter of fact the number of drivers to be used must take into account both of the number of vehicles contemporary in service and drivers' shifts.
At the time being, specification and calibration of models evaluating the whole set of operative costs following a disaggregate approach, are under development.

Reproducing day-to-day data on year base

Internal inputs (produced service and fare revenue) come from the results of the simulation of a generic day, so they are obtained as daily values. To perform an economic evaluation it is necessary to extend those data to obtain yearly values. In general, if a daily distribution $r_d(t)$, (i.e. a distribution of the amount of service daily produced, as shown in Fig. 3) is known, one way to obtain annual value R_y is to integrate this distribution to the whole year:

$$R_y = \int_1^{N_d} r_d(t)dt$$

where N_d represents the number of considered days.

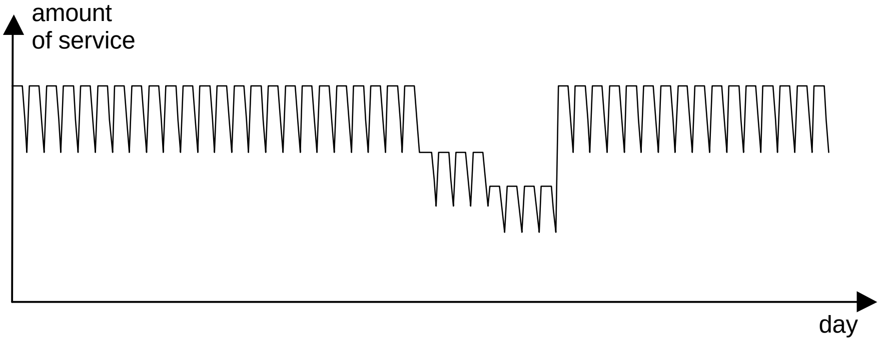

Fig. 3: Example of a day-to-day distribution of service.

In general both supply and fare revenue distributions can be hierarchically sub-divided in some classes (i.e. winter / summer and, within each one of these, working days / holidays) making feasible the hypothesis that, within a class *c*, the amount of supplied service / fare revenue r_c is constant.
The annual value can be evaluated then as:

$$R_y = \sum_{c=1}^{N_c} r_c \cdot d_c$$

where N_c represents the number of classes and d_c the number of days belonging to class *c*. It is not necessary to adopt the same classifications for supplied service and fare revenue.

Operative costs

The proposed method of analysis refers to the operative costs, that are those costs generated by the activities directly made for the service of the lines; the result is expressed in terms of the contribution offered by each line to the covering of the general costs.
Line operative costs can be divided in two classes (De Felice et al., 1995):
- costs whose total value in the short term depend from the volume of activity, that is the quantity of service supplied, these costs are no longer generated in the moment in which the service is no longer produced;
- costs for the production of resources used on more than one line, lines on which the cost has to be re-divided; to this aim appropriate parameters can be used which represent the size of the service produced on the lines (n° of runs, n° of vehicles, etc.).

A general formulation for an operative cost function can be expressed as:

$$C(\boldsymbol{S}, \boldsymbol{D}, \boldsymbol{T}, t) = K + C_{ad}(\boldsymbol{S}, \boldsymbol{T}, t) + C_{na}(\boldsymbol{S}, \boldsymbol{D}, \boldsymbol{T}, t)$$

where ***S***, ***D***, ***T*** are vectors of attributes depending on the produced service, the overall dimension of the programme (to capture scale effects), technological aspects respectively; t takes into account of all the temporal aspects connected with the produced service; K is a constant value, C_{ad} represents the additive component of cost varying with the amount of produced service and C_{na} represents the rigid component of cost eventually varying with the size of produced service. In the formulation making up the proposed model, not necessarily all the addends should appear.

The adopted methodology can be summarized in the following phases:

a) identification of the activities done for the production of the service;
b) definition of the kind of resources used for the development of the single activities;
c) definition of the acquisition cost of these resources;
d) definition of the quantity of resources used by the line;
e) prevision of the operative costs of line for activity;

As stated above, since disaggregate approach in cost evaluation is under development, aggregate approach has been adopted for the application here described. In this context, the criterion generally used for the quantification and the evaluation of the resources is that of associating, to each one of the selected cost items, a function having as dependent variable a proxy of the amount of service produced. The parameter chosen as indicator of the amount of produced service is the amount of vehicle-kilometre [VKM].

So, for the time being, temporal effects are not considered. The total operative cost [*TOC*] is evaluated as:

$$TOC = TC + MC + PVC + PC + GE$$

where *TC* is the traction cost; *MC* is the maintenance cost; *PVC* is the cost for plant and vehicles; *PC* is the personnel cost; *GE* are general expenses.

In some cost functions a structure which allow to take into account the variation of the cost as the dimension of the service changes has been introduced. It has the structure of a step function assuming an unique value within some defined intervals of produced service. The adopted expression is:

$$a_x \cdot b_x^{-MIN\{INT(VKM/KMS),\, d_x\}}$$

where a_x and b_x are parameter expressing the level of increase for the cost function x, *VKM* represents the amount of produced service; *KMS* expresses the range of each interval in terms of veh-km; δ_x is a parameter taking into account the number of intervals to be introduced for the cost function x.

In the following the relationships adopted for the considered cost items will be described.

Traction cost [TC]

Traction cost is here referred to the unitary cost [*UTC*] and the supplied service, in terms of veh-km, produced in the entire year. The unitary cost is obtained on the basis of the fuel consumption, unitary cost of fuel, type of vehicle, type of the line mileage (congested, urban, extra-urban).

On the base of the operational context, only the service consumption, relative to the mileage on line, has been considered; it has supposed negligible (thus not considered) the off duty consumption, relative to the run between the depot and the bus stop from which the service begins. The expression used to define the traction cost is then:

$$TC = UTC \times VKM$$

Maintenance costs [MC]

The maintenance of the vehicles is represented by a cost assumed variable under the hypothesis that maintenance cycles are operated every a fixed mileage interval. The relative unitary cost [*UMC*] is comprehensive both of labour and spare parts and considers also the incidence of accidental extraordinary servicing. The expression adopted to define the maintenance cost considers also the entity of the programme introducing a pair of parameters b_{cm} and KMS which allow the variation of the cost function introduced as the dimension of the service changes. The expression of the maintenance costs function is:

$$MC = UMC \times VKM \times [1 + b_{cm} \times INT\ (\ VKM\ /\ KMS\ )\ ]$$

Plant and vehicle costs [PVC]

Referring to the plant, cost [PVC_P] has been considered dependent on an unitary redemption cost [UR] and on the amount of produced service using the expression above specified:

$$PVC_P = UR \times VKM \times \alpha_{PL} \times b_{PL}^{\ -\ min\{INT(VKM/KMS),\ dPL\ \}}$$

Referring to the costs dependent on the use of the vehicles [PVC_V], it is useful to outline that the redemption years, correspond to those of actual running life of the vehicle, which has to be considered a variable dependent from the yearly mileage of the vehicle; i.e., if a vehicle has an average running life [*VUA*] of 500.000 km, and a yearly mileage [*PMA*] of 50.000 km, a period of conventional depreciation of ten years will be considered, over which the cost of the new vehicle will be spread.

In the application described, where bus lines are extra-urban, it has been hypothesized the use of coaches with seating space of 50, and the redemption cost, as the depreciation share of life of the vehicle “used” in the year, is calculated in reference to the average of the purchase prices [*CUA*] of those vehicles; the period of redemption, that is the number of years on which the purchase cost [*PA*] is spread, depends on the average yearly mileage which the vehicle runs on the different lines [*PMA*]; on this last parameter depends also the number of vehicles necessary to produce the service [*NA*]. Annual taxes and insurances [*CTA*] are also taken into consideration. The expressions of the vehicle costs function and of the other related ones are:

$$PVC_V\ =\ NA \times [\ (\ CUA\ \ /\ PA\ ) + CTA\ ]$$

where:

$$NA = INT\ (\ VKM\ /\ PMA\ ) + 1$$

$$PA = INT\ [\ VUA\ /\ (\ VKM\ /\ NA\ )\ ]$$

thus:

$$PVC = PVC_P + PVC_V$$

Personnel cost [PC]

For the prevision of the personnel cost, two kind of employee qualification have been considered: on board and administrative. Personnel cost depends on the unitary driving costs [*UCPG*] (function of salary [*SALD*], working hours [*HOUY*] and commercial speed [*VCOM*]), the unitary administrative costs [*UCPA*] (function of salary [*SALA*], size of supplied service [*KMS*]) and the supplied service. The expression of the function of the personnel costs is:

$$PC = VKM \times (UCPG + UCPA)$$

where:

$$UCPG = SALD / (VCOM \times HOUY)$$

$$UCPA = (SALA / KMS) \times \alpha_P \times b_P^{\,- \min\{INT(VKM/KMS),\, dP\}}$$

General expenses [GE]

The general expenses [*GE*] have been evaluated in function of an unitary cost [*UCG*] and the size of supplied service [*KMS*]:

$$SG = UCG \times VKM \times \alpha_{GE} \times b_{GE}^{\,- \min\{INT(VKM/KMS),\, dGE\}}$$

2.3. Output data

The outputs of the described model can be used for the evaluation of the considered service programme. As a matter of fact internal outputs can be used as feedback for the other macro-models whilst exogenous outputs can be used as data for a general (and external) evaluation procedure to define the feasibility of the examined programme and to compare, in economic terms considering other socio-economic indicators (i.e. carrying out a multi-criteria analysis), the considered programme with other feasible ones, as sketched in Fig. 4. This aspect, at the time being under development, will be the subject of forthcoming works.

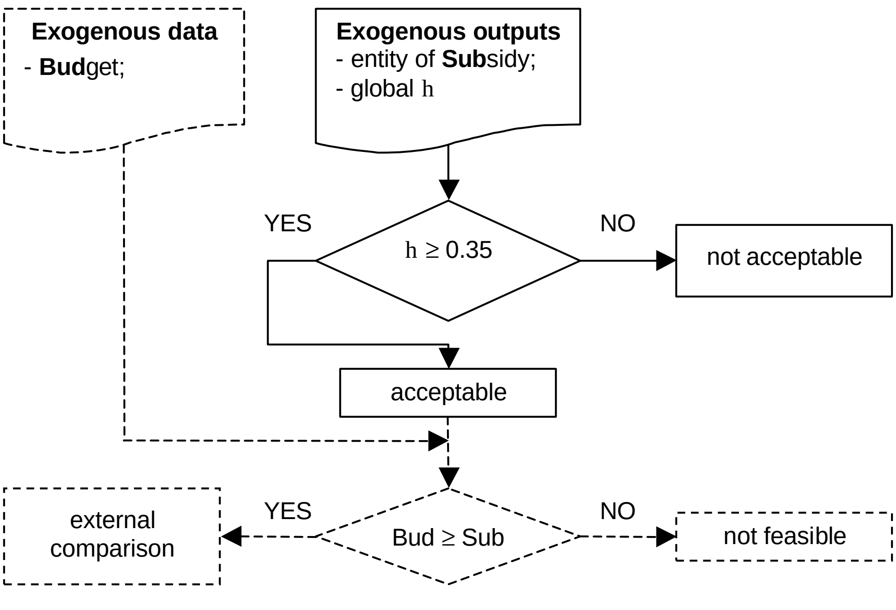

Fig.4 – Scheme of a possible usage of output data for programme evaluation.

Internal outputs

– Line productivity ratio h_l
  It is defined as the ratio between fare revenue and operative service cost referred to a single line. Such indicator is useful since it can give information on the productivity of a single line and can be used in the subsidiary models such as supply design, demand models, fare models to increase the productivity of the transit system.
  It can also be used, (i.e. within supply macro-model), to distinguish those lines that, because of a low value of revenue, can more efficiently substituted by alternative transit systems.

Exogenous outputs (indicators)

– total cost
  - mean veh-km cost
  - entity of subsidy
  - global productivity ratio η. This indicator has been introduced by Italian regulations and is given by the ratio between fare income and operative service costs. In order to consider a service programme as feasible, its value must not be minor than 0.35.

3. EXPERIMENTATION

3.1 The test site

The methodology for the evaluation of costs have been applied for the simulation of the extra-urban transit services of the provincia of Reggio Calabria. This territory is disaggregating, in Regional Transport Plan of Calabria Region, in 3 traffic basins (Tirrenico, Reggio Calabria, Jonico) collecting the 97 traffic zones corresponding to the communalities of the province. The province is poor in infrastructures, with a ratio of 54,4% to the national average. It is a due consequence that also the mobility infrastructures are underdeveloped, due to the lack of support services to the enterprises.

3.2 Input data

Internal inputs

Supply model
Some data relative to the system of the extra urban bus public transport supply is given in Tab. 3. It shows that the system consists of 428 lines, run by 25 Companies, for a total of 1132 daily runs (from 4:00 to 22:00). The total amount of service produced daily, quantified by means of the amount of veh-km [VKM], is equal to 38161.

Fares and revenue model
The data consist in daily values of sales revenue for each line and for each hypothesised fare (and supply) scenario. Revenue are the output of fare and

revenue model (Gattuso et al., 2002) and a short description of scenarios and aggregated values of fare revenue are shown in Tab. 4. It is worth noting that daily sales revenue given by fare and revenue model have been reported to the calendar year. For the sake of simplicity, in this particular application, this has been done by using an expansion coefficient whose value has been supposed equal to the one used to expand daily supply, as described in the next point.

Operator	no of lines	Length	Runs	VKM	Operator	no of lines	Length	Runs	VKM
1	22	526	71	1839	14	2	58	12	348
2	8	114	22	304	15	10	346	14	518
3	6	100	8	120	16	6	126	12	228
4	10	274	17	410	17	26	1084	74	2521
5	4	254	6	328	18	6	106	16	318
6	56	2458	139	6800	19	11	429	47	1795
7	55	2739	94	4211	20	11	209	52	984
8	14	304	18	434	21	12	532	24	844
9	10	250	21	452	22	2	52	6	156
10	13	153	39	611	23	10	183	23	357
11	112	4613	343	12504	24	8	260	40	1452
12	4	100	12	286	25	6	170	12	236
13	4	42	10	105	**TOT**	**428**	**15482**	**1132**	**38161**

Tab.3. – Daily supply of road public transport in the province of Reggio Calabria.

Fare scenario	Sales revenue [Year]
#0 - current fare structure	11,619,687.05 €
#1 - kilometric integrated fare structure	18,090,600.00 €
#2 - zonal integrated fare structure	11,354,640.00 €

Tab.4 – Aggregated revenue for each fare scenario

Exogenous inputs

Unitary costs

The values of the unitary costs, described in Tab. 5., have been estimated on the basis of survey data. It seems necessary to put in evidence that:

– the unitary costs of the resources, given by the Companies, are relative to the current average prices, inclusive of VAT and production taxes;
– the unitary consumption have been estimated from data obtained by the Companies on the basis of the experience of the technical staff;

Parameters of cost functions

The values of the parameters used in the cost functions described up to now are shown in Tab. 6. They have been estimated both analysing the existing literature and using data obtained by companies.

Voice	Initials	Unit	Value
Unitary traction cost	UTC	€ / VKM	0.50
Unitary maintenance cost	UMC	€ / VKM	0.30
Mean vehicle purchase price	CUA	€	242,735
Taxes and insurance	CTA	€	826.33
Mean vehicle life	VUA	Km	500,000
Mean vehicle mileage (per year)	PMA	Km	36,000
Unitary plant redemption cost	UR	€ / VKM	0.06
Commercial speed of services	VCOM	Km/h	20.0
Working hours per year	HOUY	h	1,250
Mean cost of driving personnel unit (per year)	SALD	€	32,278
Mean cost of administrative personnel unit (per year)	SALA	€	32,278
Unitary cost for general expenses	UCG	€	0.08

Tab. 5. – Estimates of unitary costs

Parameter	Initials	Unit	Value
Supplied service threshold	KMS	VKM	600,000
Parameter of maintenance cost function	β_{cm}	undimensioned	0.03
Parameter of plant costs function	α_{PL}	undimensioned	2.0
Parameter of plant costs function	β_{PL}	undimensioned	2.0
Parameter of plant costs function	δ_{P}	undimensioned	2.0
Parameter of personnel costs function	α_{P}	undimensioned	2.0
Parameter of personnel costs function	β_{P}	undimensioned	2.0
Parameter of personnel costs function	δ_{P}	undimensioned	2.0
Parameter of general expenses function	α_{GE}	undimensioned	2.0
Parameter of general expenses function	β_{GE}	undimensioned	2.0
	δ_{PL}		
Parameter of general expenses function	α_{GE}	undimensioned	2.0

Tab. 6. – Estimates of the parameters of cost functions

3.3 Model application

For this experimentation the proposed model has been implemented using a commercial worksheet (Microsoft Excel©); to the authors' knowledge there is also the possibility of using commercial software (i.e. NeMESys©, produced by CSST S.p.A., a Decision Support System for the economic evaluation of public transport systems) where obviously operative costs functions are defined in a different way.
It is important to stress that this particular application has been implemented using the aggregate approach, as described in point 2.2, thus costs (and sales revenue) have been considered on average and within-day variability in schedule has not been taken into account.

Reproducing daily data on year base

In order to report the service produced daily, the 6 classes described in Tab. 7 have been considered and, comparing the different scheduled services, a weight for each class have been defined.

	Class	Weight
1	Winter, working day	1
2	Winter, holiday	0,70
3	July, working day	0,75
4	July, holiday	0,53
5	August, working day	0,65
6	August, holiday	0,45

Tab. 7. – weights given to the different days for the expansion of the service to the year

Considering the simulated day belonging to the first class, an expansion coefficient Y for the daily service has been computed as:

$$Y = \sum_{c=1}^{N_c} w_c \cdot d_c$$

where N_c represent the number of classes, w_c the weight of class c and d_c the number of days belonging to class c. The value obtained for the expansion coefficient is Y = 330. For the sake of simplicity, in the current experimentation, the same value has been also adopted to expand the daily fare revenue to the year.

3.4 Output data

Internal outputs

Line productivity ratio h_l

A classification of the line productivity ratios for the considered application concerning fare scenario #0 is depicted in Fig. 5. From an analysis of the disaggregated values on the single lines, it can be seen some differences in terms of economic performance; about the 19% show a productivity ratio greater then the one requested by Italian regulations, this result is originated from a more equilibrated ratio between revenue and costs for these lines, due to a good level of effectiveness. About a 7% of the lines are on the border line and about a 7% does not originate any sales revenue that means that these lines with the actual fare structure are not competitive for the considered demand. The remaining 67% of the lines show not acceptable values of productivity ratio and participate in a consistent form to the constitution of the general deficit of the system and to its not acceptability. The obtained information could allow the Authorities and the programmers in charge of the service, to produce decisions concerning either the repartition of the resources among the different lines or a re-design of the service.

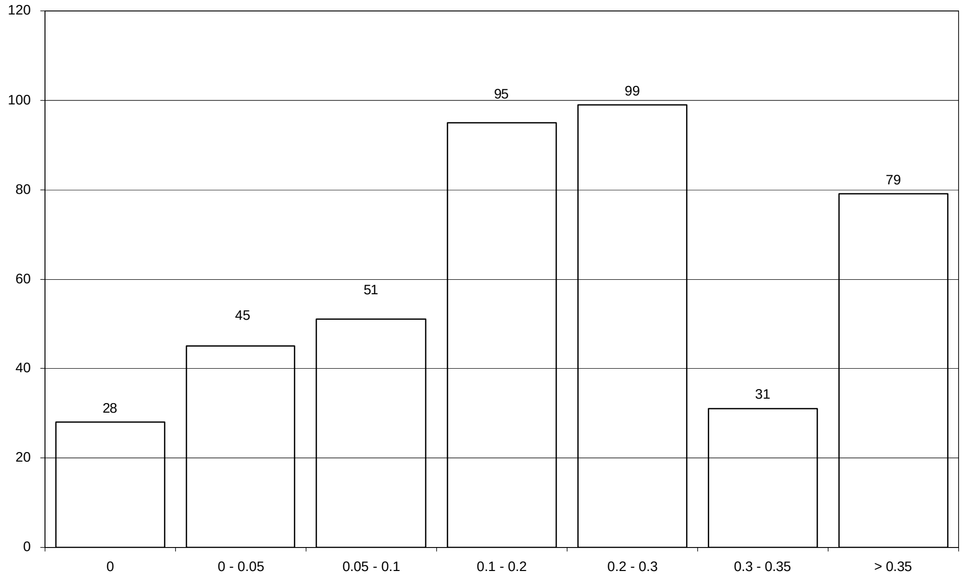

Fig 5. – Disaggregated analysis of the economic count per line: classification of line productivity ratio for fare scenario #0.

Exogenous outputs (indicators)

total cost

The results in terms of annual operative costs are reported in Tab. 8. Analysing in detail the different cost items, it can be seen how the personnel cost is preponderant on the others, while more contained appear the traction and maintenance costs of the vehicles. The resulting mean cost for each produced veh-km is equal to 3.71 €.

Voice	Amount	Voice	Amount
TRACTION	6,296,565.00 €	PERSONNEL	28,647,235.91 €
MAINTENANCE	4,029,801.60 €	GENERAL	503,725.20 €
PLANT AND VEH	7,202,182.48 €	**TOTAL COSTS**	**46,679,510.19 €**

Tab. 8 – Aggregated annual costs of bus lines

entity of subsidy and global productivity ratio h

For each fare scenario it is then possible to forecast the amount of the subsidies that should be provided to ensure the service and define the global productivity ratios. Results for each fare scenario are given in Tab. 9.

Fare scenario	Sales Revenue	Productivity ratio	Subsidy
#0	11,619,687.05 €	0.25	**35,059,823.14 €**
#1	18,090,600.00 €	0.39	**28,588,910.19 €**
#2	11,354,640.00 €	0.24	**35,324,870.19 €**

Tab.9. – Amount of global productivity ratio and annual subsidies for each fare scenario

4. Conclusions

In this paper a procedure has been proposed that allows, through a quantitative analysis, to define the necessary resources to comply a set of services, once known the existing demand and the adopted fare structure.
Such an analysis can allow the authorities to determine beforehand the dimension of subsidies needed to guarantee the services as programmed to optimum, that is to harmonise the offered services so to exploit at the best the supplied resources. The knowledge of the economic conditions in which the service is run can be crucial for the Public Administration, since it is possible to have a quantification of the resources to assign, distinguishing, on the total of the services to be provided, the incidence in terms of operative costs due to each of the different lines.
The model has been implemented, at the time being, by means of a commercial worksheet and has been tested on a real size area showing how, at the time being, law prescription, for the considered area, are not yet respected.
It has been also pointed out how not taking into consideration the effects due to within-day distribution of service can lead to appreciable differences in the estimation of operative costs. For these reason the definition of more accurate cost functions taking into account these effects is under development.
In the development of the research, the specifications here proposed will be recalibrated using the data collected from a selected set of Companies and these data will also be used in order to take into account temporal dimension in schedule with a new specification of cost functions, different from the one here introduced, including also the temporal dimension.

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