DEPARTMENT OF ECONOMICS AND FINANCE
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PUBLIC TRANSPORT: THE CASE OF ATAC

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Introduction

"As public transport forms the backbone of any efficient urban mobility system, adequate public transport provision helps make cities more dynamic and competitive as well as create more jobs." (International Association of Public Transport, 2015)[1]. The social benefits of a well-functioning transportation system are known, while the economic advantages are not always given enough importance.

The increasing use of cars is making urban mobility more and more inefficient. In particular, Italy has one of the highest car to population ratio among EU countries. The problem is particularly acute in Rome where in 2012 there were 71 cars every 100 inhabitants[2]. The situation is not sustainable in the long run in terms of pollution and congestion. In the years to come public transport will have to play an important role in re-designing mobility in the city of Rome. The purpose of this dissertation is to support the subsidisation of public transport and to analyse public transport market in Rome.

The dissertation is organized in two chapters. The first chapter aims at proving that the market alone does not deliver welfare-maximising price and frequency. We will go beyond the traditional argument of natural monopoly by taking a broader view: we will consider not only producers' costs, but also users' time costs. The intuition is that a single operator will provide better-integrated schedules, minimizing users' waiting time and avoiding coordination failures. In addition, we will analyse several market failures connected to public transport, providing further arguments in favour of the subsidisation, such as congestion and pollution. We will aim at proving that incentivising the use of public transport is much more effective than any toll system or "clean vehicles" regulation in reducing congestion and CO_2 emissions. The last part of the chapter will focus on policies that developed countries have adopted in order to deal with all the market failures linked to urban public transport.

The second chapter takes a positive approach: we will make an economic analysis of urban public transport in Rome. Firstly, we will focus on the supply side of the market. We will briefly review the history of ATAC (*Agenzia per i Transporti Autoferrotranviari del Comune di Roma*), the current public transport operator in Rome. Then, we will make an analysis of the latest available income statement in order to highlight the major sources of expenses. In addition, we will present the service provided in 2016 and the current fare system. Secondly we will focus on the demand side of the market. We have chosen three different kind of users: occasional users, tourists and commuters;

[1] http://www.uitp.org/news/monthly-focus-economic-impact-public-transport
[2]ANSA: http://www.ansa.it/motori/notizie/rubriche/industriamercato/2014/10/28/italia-paese-ue-a-piu-alta-densita-auto-roma-al-top_8b10de6b-b4ba-4b17-8945-8903eeb7a64d.html

each of which is associated with a specific fare. We will try to establish the main factors that affect the demand for public transport, then, thanks to the increase of all fares in 2012, we will compute short-term elasticity of each kind of user. The last part of the chapter will be dedicated to current issues concerning public transport in Rome: the arrangement with creditors, the possible bankruptcy scenarios and the referendum.

Chapter 1 – Public Transportation Policy: Optimal Price and Frequency

1.1 Introduction

This Chapter will be dedicated to the normative analysis of public transport. Our aim is to analyse arguments supporting the subsidisation of public transport. First of all, we will introduce some general aspects of transport economics in particular the money value of time. Then we will focus on the cost structure of the public transportation industry, in order to establish whether public transport is a natural multiproduct monopoly. As far as production costs are concerned, public transportation does not seem to exhibit economies of scale for all modes of transport. Empirical studies proved that bus transport is subject to constant returns to scale, thus we cannot conclude that public transportation is a natural monopoly and it needs subsidies to achieve marginal cost pricing. However, if consumers cost, i.e. time costs, are taken into account then public transport has remarkable economies of scale. The intuition is the following: for passengers it may be more convenient to have a single operator who can provide integrated schedules and faster connections, which reduce the average journey time, and consequently time costs. This effect was named after the economist Herbert Mohring who proved the existence of increasing returns to scale and provided the main rationale for subsidisation. After having examined in detail the Mohring effect, we will present a model which includes users' costs and gives policy indication on the size of the subsidy. The model will compare a profit-maximiser monopolist with a welfare-maximaser operator. We will show that unless the price demand elasticity is zero, the monopolist will not provide socially optimal fares and frequency.

The Mohring effect is not the only reason why public transport subsidisation is socially desirable. Most metropolitan areas have to cope with road congestion and public transport can play an important role. It is obvious that buses have a lower vehicle-passenger ratio and therefore occupy relatively less space; underground and tramways carry passengers that would otherwise be on the road. Among all the solution proposed, shifting the demand from private transport to public transport seem to be the one with less transaction and political costs. Glaister (1974) made a case for subsidisation showing that optimal peak fares are below the marginal cost when we take into account the relief to congestion when peak road users shift from car to public transport. An analogous reasoning will be made for pollution.

Lastly, we will consider other issues that planners must take into account such as pollution tourism, and we will analyse the regulations issued by public authorities in order to deal with all the previously mentioned market failures.

1.2 General Features of Transport Economics and Public Transport Policy

Transportation is the movement of persons and goods across space with the aid of facilities and vehicles. Transport economics is a branch of economics, hence it focuses on the allocation of valuable and scarce resources, such as time. However, transport economics has certain unique features. Firstly, demand for transport is always linked to an activity to be carried out at the destination; nobody demands transport for its own sake. Therefore, demand for transportation is said to be a derived demand. Secondly, the consumption of each transportation facility is unique in time and space. In other words, the traditional assumption of a spaceless and instantaneous economy is inconsistent and must be removed. Lastly, different technologies and economies of scale characterise different modes of transportation.

The management of transport system by public authorities is common in all developed and developing countries. The presence of market failures provides a rationale for government intervention in the form of regulations (e.g. car emission standards), public production (e.g. railways) and partnerships with private firms (e.g. motorways).

Also equity is an important factor in the design of public policies involving transport. On 25th September 2015, world leaders committed to the 17 Sustainable Development Goals (SDGs) to reach by 2030. Although transport is not addressed directly of a SDG, it is present across several targets and indicators. Specifically, goal 11, which concerns cities and human settlements, sets the following target (11.2): "By 2030, provide access to safe, affordable, accessible and sustainable transport system for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons."[3] United Nations recognized that transportation plays a crucial role in reducing poverty, fighting inequality and facing climate change.

In this dissertation we limit ourselves in the analysis of urban public transportation. In the following sections, we will examine all the factors that justify the public provision of transportation, focusing on market failures and specific policy design issues.

1.3 The Value of Time

Before dealing with specific public transport related matters, we must clarify a crucial issue concerning transport economics and, more generally, any cost benefit analyses: the evaluation of time. Time cannot be traded on a market, has not a price, but it is a scarce resource and economic agents attach value to it. Therefore, we need a means to quantify time in monetary terms in order to

[3] Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development, Annex, 6 July 2017

consider the full benefits or costs of a project. Two different approaches have been proposed, the income approach and the pure cost approach.

The income approach is straightforward. Assuming only one mode of transport and allowing individuals to choose the amount of working hours, forgone income represents the opportunity cost of time spent travelling. For a given wage rate, an individual chooses according to his preferences, his optimal amount of leisure time and consequently his income. In Figure 1it is shown the optimal choice of an individual who has an amount of time available equal to OB and has a wage rate equal to the slope of AB. Now, consider an improvement of the transportation system which reduces travel time and does not yield extra costs for the individual. Time available increases by the segment BD and, ceteris paribus, the income-leisure constraint shifts up. The new optimum is point F which will be on a higher indifference curve. The result would be the same as if the individual was given a lump sum grant equal to BK, i.e. time saving times wage rate[4].

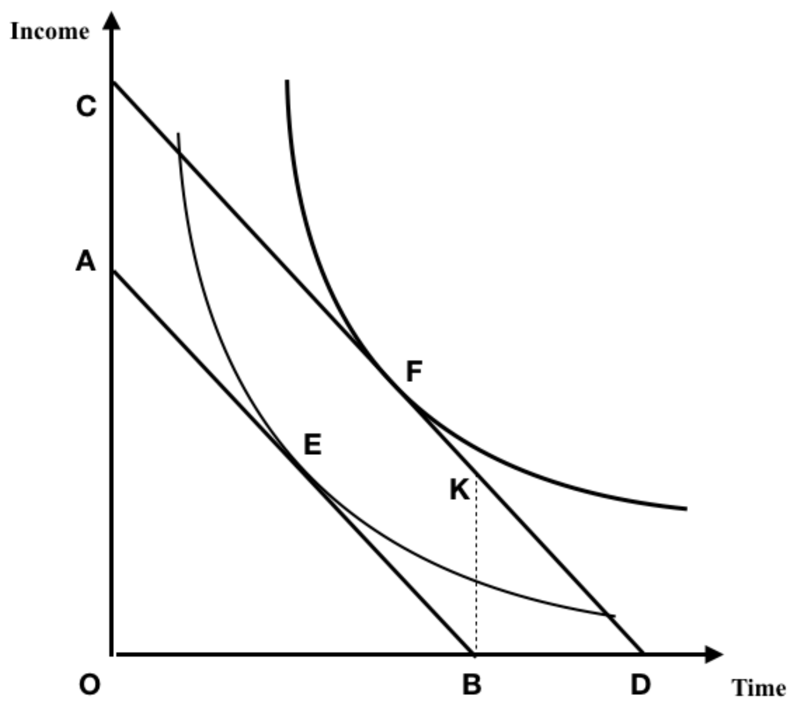


Figure 1.1 *Optimal Income-Time Choice.* ***Source****: L. N. Moses, H. F. Williamson and Jr. (1963) "Value of Time, Choice of Mode, and the Subsidy Issue in Urban Transportation"*

Therefore, the income approach monetizes time saving by multiplying them by the wage rate. The wage rate represents an individual's valuation of his own time: in equilibrium he is indifferent between an additional hour of leisure or an additional hour of work. However, this method presents some pitfalls. Firstly, individuals cannot freely choose their working hours, and likely they will not be in an optimal situation. The wage rate will overstate the value of time for those individuals

[4] BK = BD * tg(D) where BD is time savings and tg(D) is wage.

who would like to work more for the same rate; and conversely, it will understate the value of time for those who would like to work less. Secondly, this approach attaches no value to the time of students, retired or unemployed. Lastly, it does not take into account alternative modes of transport.

The pure cost approach overcomes some of these problems. It considers alternative modes (or alternative routes for the same mode) with different money and time costs. This method is applied when consumers can choose to pay more to use the faster mode or route, for example car vs public transport. The value of time savings is the cost differential between the two modes or routes. However, some commuters may be willing to pay more to use the faster way. Moreover, factors different from journey time and costs may influence consumers' modal choice such as comfort. Therefore, this approach allows us to compute an estimate of lower bound of the monetary value of time.

None of the two approaches provides an unbiased estimate, but the monetary evaluation of time is crucial to evaluate any policy concerning transport infrastructures. Empirical research plays an important role. Several studies have been carried out and some of them led to satisfactory results. In particular, UK transport department succeeded to calculate reliable estimates for the average values of time for travel on various modes of transport. For example, they estimated that the value of travel time (VTT) for commuters is on average 11.21 £/h, meaning that they are willing to pay 11.21£ to make their journeys one hour shorter.

So far we have ignored that the value of time could vary according to the purpose of the journey or to the way in which time is spent. The choice of public transport implies not only greater in-vehicle time (IVT) but also walking and waiting time costs. The value of time spent to go to or to walk from the bus stop is expected to be higher than the value of IVT because of greater physical effort and the possible unpleasant circumstances, e.g. rainy day. Analogously, also waiting cost may be valued at premium because of the frustration caused by the unproductive use of time and, again, the unpleasant circumstances. Quarmby (1967) estimated that "walking and waiting times are worth between two and three times in-vehicle time". Subsequent researches have been done but the results do not differ from Quarmby's findings.

In conclusion, the evaluation of time poses many challenges but what we have said so far is enough for the purpose of this dissertation.

1.4 Economies of Scale and Scope: Is Public Transport a Natural Monopoly?

In this section we start our analysis of the transport industry. Local transport companies usually provide different modes of transport: motor bus, trolleybus, underground, tramway, etc.etc.; thus they can be defined as multi-product firms. Very often there is only one transport enterprise licensed by a public authority which operates in an urban area. We can legitimately ask ourselves whether urban public transport is a natural monopoly. A natural multi-product monopoly can be defined as such if its cost function is sub-additive over the relevant range of output level and if there are sunk costs.

Before starting our investigation, we must give some theoretical background. Consider the vector of output $q^i = (q_1^i, q_2^i)$, a cost function is said to be sub-additive if:

$$C(\sum q_1^i, \sum q_2^i) = C(\sum q^i) < \sum C(q^i)$$

If this inequality holds for all output levels of the demands, then the cost function is globally sub-additive. In economic terms it means that costs are lower if outputs are produced by only one firm instead of two or more firms. In order to satisfy this condition, firm's technology must exhibit economies of scope and some sort of economies of scale, in particular, declining average incremental cost for all products[5].

Economies of scope imply that it is more economical to produce two or more outputs within the same firm rather than producing them separately. Analytically:

$$C(q_1, q_2) < C(q_1, 0) + C(0, q_2)$$

Economies of scope can be achieved through the joint use of factors, assets and know-how in the production of the different outputs.

In a multiproduct context, economies of scale can be defined as declining average incremental cost for each output. We define incremental cost of q_1 keeping q_2 constant as:

$$IC(q_1|q_2) = C(q_1, q_2) - C(0, q_2)$$

And average incremental cost of q_1 as:

$$AIC(q_1|q_2) = [C(q_1, q_2) - C(0, q_2)]/q_1$$

If an increase over the relevant range of q_1 causes a fall of its AIC, then the output q_1 has declining average incremental costs. When this condition holds for each output and there are economies of scope at all relevant levels, the cost function will be globally sub-additive.

Sub-additivity of the cost function could be enough to have a monopoly, but without the presence of sunk cost the monopoly would not be sustainable. Sustainability implies that no firm can enter the market with a lower price a make non-negative profits. Sunk costs are unrecoverable investments necessary to start up a firm and enter the market. Sunk costs resemble a barrier to entry and give the incumbent a strategic advantage in an eventual price war, so that any threat of a new entrant is not credible. The asymmetry created by sunk costs makes the monopoly sustainable. In

[5] This is just one of the set of necessary conditions in order to obtain a sub-additive cost function. Other sets of necessary conditions are out of the scope of this dissertation.

conclusion, a natural monopoly must necessarily show two features: a sub-additive cost function and sunk costs.

We start our investigation with the analysis of sunk costs, which is straightforward. The key characteristic of sunk costs is unrecoverability, meaning that it is not possible to resell or make an alternative use of the asset. For example, the cost of buses is not sunk, because it can be recovered through sale. On the other hand, the cost of building railways for the underground is sunk because there is no alternative use. Other sunk costs faced by the transport industry are publicity, training and acquiring knowledge of the territory.

Now, we will investigate on the sub-additivity of the cost function. The first condition to obtain sub-additivity is the presence of economies of scope. Economies of scope result from the joint utilisation of inputs such as capital, labour and energy. Different transport modes can share the same scheduling and ticketing system, or the same network maintenance. In 2007, Farsi et al. carried out a study on the cost structure of the Swiss urban transport sector in order to assess economies of scope and scale. They used panel data set for companies providing the most common transport modes in Europe: motor bus, trolleybus and tramway or a subset of them. Results show that global economies of scope decrease as output increase, but they remain statistically different from zero at all relevant output levels.

As to economies of scale, many empirical studies led to the conclusion that bus transit companies are characterized by constant return to scale (Oram, 1979; De Boeger et al., 2002). But when bus services are combined with the provision of trolleybus and tramway, the global production function show increasing returns to scale (Farsi et al., 2007). Other studies point out that urban rail transport (underground, light railway) is not characterized by increasing returns to scale, as one could have expected, but by increasing returns to density. Returns to density describe the relationship between inputs and outputs but, differently from returns to scale, the size of the network is held constant. This is probably due to all fixed and semi-fixed costs in the railway industry.

While we can be confident enough about the presence of economies of scope, statements on returns to scale are very weak, there is no clear evidence that confirms or rejects the hypothesis of increasing returns to scale. Therefore, we cannot conclude that the urban transport cost function is sub-additive and, as a consequence, we cannot prove that urban transport is a natural monopoly.

However, an important case study suggests that urban bus services may be a natural monopoly. In Britain bus routes were operated by licensed monopolists and their fares were approved by a public authority. In 1986 Britain deregulated its local bus services (with the exception of London) leaving them open to competition. Surprisingly, the general structure of bus services did not change significantly, indicating that monopoly may be the most efficient market structure. The key to the problem is integration. So far we have considered just producers operating cost. We must add to our analysis costs borne by consumers who have to supply an irreplaceable input: their time. For passengers it may be more convenient to have a single operator who can provide integrated schedules and faster connections, which reduce the average journey time, and consequently time costs.

In conclusion, a monopoly, even if it has not lower producer's costs, involves lower users' costs, suggesting that bus routes are characterised by economies of scale. This is the so called Mohring effect, which will be discussed in details in the next section.

1.5 The Mohring Effect

As we have already mentioned, transport differs from other commodities in the fact that consumers have also a producing role. They have to supply a scarce and valuable input: their time. In precedent sections we have discussed how time can be evaluated, in this section we are going to analyse how these time costs affect the market structure. Mohring (1972) argues that when travellers' journey time is included in the cost function, transport services are characterised by significant economies of scale; therefore, subsidies are required in order to achieve marginal cost pricing.

Assuming that bus operations are subject to constant returns to scale, if the demand for public transportation doubles and the transport operator costs responds to this change by doubling the number of buses on the route, then average operating costs and average travelling time remain the same, while the waiting costs halves, suggesting an overall decreasing average cost function. Consequently, price and frequency will be respectively higher and lower than the social optimum, unless urban transport was subsidized.

Mohring's paper represents a milestone in the economic theory of urban transportation. His claim was challenged by van Reeven (2008) who argued that if the operator takes this frequency effect into account then the profit-maximizing frequency is socially optimal.

In his model van Reeven considers the case of a monopolist supplier who decides frequency and fares. In unitary time interval T=[0,1), each departure is denoted by y_i. The number of departures in the interval T, the frequency, is f and c is the operating cost of each departure. X is the number of travellers whose utility is given by $U = v - p - \tau$; where v is the reservation price, p is the fare charged and τ represents waiting costs. Waiting costs are given by $\tau = t * \overline{w}(f)$, where t is the valuation of time and $\overline{w}$ is average waiting time which clearly depends on frequency. The demand depends both on price and frequency, $D(p, f)$. On the other hand, profits will be given by $\pi = D(p, f)p - cf$. Assuming that consumes arrival times are uniformly distributed, equidistant departures minimize average waiting time which will be equal to $1/2f$. Total welfare is equal to consumer surplus minus the production costs, therefore $W = vX - tX/2f - cf$. Thus the welfare maximizing frequency is

$$\frac{\partial W}{\partial f} = \frac{tX}{2f^2} - c = 0 \Rightarrow f^* = \sqrt{\frac{tX}{2c}}$$

Therefore the welfare created will be $W = vX - \frac{tX}{2f^*} - cf^* = vX - \sqrt{\frac{tc}{2X}}$, provided that the reservation price is $v \geq \sqrt{2tc/X}$. The fare does not have an impact on total welfare because is simply a transfer of money from consumers to producers, as long as the expected utility of consumers is positive:

$$u^e = v - p - t\overline{w}(f^*) = v - p - \sqrt{\frac{tc}{2X}} \geq 0 \implies p^* \leq v - \sqrt{\frac{tc}{2X}}$$

Now we want to compare these results with the choices of a profit-maximiser monopolist. The operator faces a demand D(p, f) = X as long as $\overline{w}(f) \leq (v - p)/t$, i.e. the expected utility is positive; otherwise D(p, f) = 0. Profits are equal to π = pD(p, f) – cf, and it is easy to see that they are decreasing in frequency. The monopolist will try to minimize frequency subject to the constraint of the demand.

$$\overline{w}(f) \leq \frac{v-p}{t} \Rightarrow \frac{1}{2f} \leq \frac{v-p}{t} \Rightarrow f \geq \frac{t}{2v - 2p}$$

Therefore, the minimum frequency that the monopolist can provide is f^M = t/(2v-2p). Now we plug f^M into the profit function and we maximize with respect to the fare.

$$\frac{\partial \pi}{\partial p} = X - \frac{tc}{2(v-p)^2} = 0 \; and \; \frac{\partial^2 \pi}{\partial p^2} < 0$$

The profit maximising fare is $p^M = v - \sqrt{tc/2X}$. Substituting p^M into f^M we obtain $f^M = \sqrt{\frac{tX}{2c}} = f^*$. In this way van Reeven showed that socially optimal frequency is equal to profit-maximiser frequency, thus the Mohring effect does not subsist and transportation systems are efficient without any subsidy.

However, van Reeven makes a strong assumption on the demand. For any frequency $f \geq$ t /(2v-2p) all passengers travel regardless of the fare charged, in other words, the demand is completely inelastic. This assumption seems quite unrealistic given that close substitutes are available, e.g. car, bike, walk. Therefore, if we model the demand realistically as we will do in details in the next section, the Mohring effect holds.

The Mohring effect provide a rationale for heavily subsidisation of public transport industry. This policy indication found many supporters in the United States where the Federal Transit

Administration invests more than $ 12 billion annually to support public transport, and in Europe where the fare revenues are on average 48% lower than operational costs.

1.6 Welfare Maximisation

In this section we are going to model the Mohring effect and we will establish the size of the subsidy needed in order to maximise welfare. We will use a traditional measure of welfare, the total surplus. First of all, we will examine all tools available to the government in order to regulate public transport. Secondly, we will establish a framework within which we can develop our model. Then, we will analyse both sides of the market, and lastly, we will draw our conclusions on the social optimal equilibrium.

1.6.1. Policy Instruments available

Once the government recognizes the need to intervene, variety of actions are available to public authorities. They have to identify all market failures, establish their magnitude, design and implement the most appropriate policy.

The first important choice is the structure of the industry. The World Bank identified three general models, which differ for the degree of influence of public authorities. In the "Unified Public Model" a publicly owned firm controls all the steps of the provision of the service, from planning to operations. This model is very common in the United States. The second model is the "Closely Supervised Private Model". With this structural organization planning and operations are separated. The welfare-maximiser public entity makes the most important decisions on the level of subsidies, coverage and frequency; whereas the operator, subject to a public contract, takes the day-by-day decisions. This system has been adopted by the city of London. The last model is the most market-oriented, the "Loosely Supervised Private Model". This model does not reckon on a legal monopoly, but on the contrary on multiple licensed operators. The licensing authority acts in the public interest. Generally, this structure favours competition but hinders integration. This model is widespread in Asia and Africa.

After having chosen a model, another structural decision must be taken: which kind of technology to adopt. There is a wide range of technologies for public transport, from the bus on a shared right of way to trolley bus to underground system. The choice of course depends, among other factors, on the structure of the city, the density of the population and on the costs. For example, monorail systems and buses on a separated lane would be a good solution for a city affected by congestion, however planners have to take into account road constraints: if a street is narrow, the creation of a bus lane could even worsen the problem of traffic. In metropolitan cities where the density of population is the most important factor, planners should opt for mass transit technologies, such as underground systems. Other factors that may influence the choice of technology are preferred fuel, which depends on the resources of the country, and environmental-friendliness.

The choice of technology is closely linked to the issue of coverage. It has been estimated that on average people find it unpleasant to walk for more than 500 meters to reach a station or a bus stop. Improving the coverage of the systems means reducing the average walking distance of users, bus this clearly implies higher costs. The same reasoning can be applied to frequency. Higher frequency means on the one hand, reducing users' waiting costs but on the other hand, it requires more vehicles and higher producers' costs. There is a clear trade off between the quality and the costs of the service.

Last but not least, the most obvious and powerful policy instruments that public authorities can use is the fare scheme. There is wide variety of fare schemes, they range from simple ones, such as a fare per ride, to complex ones, such as zone-based fares, subscriptions, tourist tickets, etc. etc.. To keep things simple, we focus on the fare for a single ride. The choice of pricing is equivalent to the choice of subsidy level. The charged authority will decide the share of the costs covered by fares revenues and the share repaid by subsidies. For example, fares revenues could cover operating costs but not capital costs.

Frequency and pricing are the most powerful tools available to policy makers because they are less subject to the constraints imposed by the structure of the city, while structural decisions, such as technology, must be made at the inception of the transport network and are very difficult to modify. This is the reason why in our model the two optimization variables will be price and frequency.

1.6.2. The framework

In the next sections we will try to optimise the price and the frequency for a bus route in absence of congestion. Our aim is to prove that public transport must be subsidised, otherwise socially optimal frequency and price would be unachievable if the market was left to an unregulated monopoly. The decision to focus on buses is justified by at least two reasons: firstly, it is the most widespread public means of transport; secondly, it is the most relevant in terms of users' waiting costs. We will use as a reference model the one developed by Leonardo J. Basso and Sergio R. Jara-Diaz (2010).

1.6.3. Public Transport Operator

In this analysis we will continuously compare a welfare-maximiser operator to a profit-maximiser operator, who, given their different objective functions, will make different choices. We assume that the public and the private enterprise are the same in terms of technology and cost efficiency. As we have discussed in previous sections, data show that bus operations are subject to constant returns to scale. Thus the cost function is C(*f*) = c*f* where *f* is the number departure in one hour, namely the frequency. For a given frequency, the timing of departures does not affect monopolist's profit, but it affects consumer surplus through average waiting costs. For the sake of simplicity, we assume that preferred departure times are uniformly distributed, but we will drop this assumption later to make the model more realistic. The welfare-maximiser operator will opt for equidistant departures in order to minimise the average waiting time. The proof is the following: y_i indicates each departure timing and we consider all users with preferred departure time x belonging to the interval $[y_{i-1}; y_{i+1}]$. The operator must choose the y_i which minimises the average waiting costs. Then, the average waiting time is

$$\bar{w} = \frac{1}{y_{i+1} - y_{i-1}} \sum_{k=i}^{i+1} \int_{y_{k-1}}^{y_k} (y_k - x)\, dx$$

If we compute the integral, we obtain

$$\bar{w} = \frac{y_i^2 + \frac{1}{2}(y_{i-1}^2 + y_{i-1}^2) - y_i(y_{i+1} + y_{i-1})}{y_{i+1} - y_{i-1}}$$

and we minimise with respect to y_i though FOC and SOC

$$\frac{\partial \bar{w}}{\partial y_i} = \frac{2y_i - (y_{i+1} + y_{i-1})}{y_{i+1} - y_{i-1}} = 0 \;\Rightarrow\; y_i^* = \frac{y_{i+1} + y_{i-1}}{2}$$

and

$$\frac{\partial^2 \bar{w}}{\partial y_i^2} > 0$$

Therefore, equidistant departures minimise the average waiting time. In particular, if we fix the number of buses per hour *f*, a bus will run every 1/*f* minutes.

This choice is optimal is terms of welfare. On the other hand, the monopolist can choose any departure scheme since waiting costs do not affect his profits. In order to keep things easy to compare, we will assume that the monopolist will choose the equidistant departure schedule.

1.6.4. Demand for Public Transport

As we have pointed out before, consumers incur into two kind of costs: monetary costs, resembled by the price of the fare, and time costs. Thus, consumers face a generalised cost of p + τ where p is the fare charged and τ is the waiting cost. Knowing that preferred departures x are uniformly distributed, the expected waiting time is $E[\bar{w}] = \frac{y_i - y_{i-1}}{2}$; but we also know that the time distance between two departures is $1/f$, therefore $E[\overline{w}] = \frac{1}{2f}$. Expected waiting costs τ are equal to $t/2f$ where t is the money value of an hour spent waiting. Each of the consumers has his own reservation price v. The reservation price generally depends on income, price of the best alternative (e.g. the price of oil) and preferences. We assume that reservation prices are uniformly distributed along the interval [a; b]. All consumers that have a reservation price v above $v^* = p + \frac{t}{2f}$ will use public transport. In an economy with X individuals the demand for public transport, or traffic, is given by $D(p, f) = X \cdot P(v \geq v^*)$, where

$$P(v \geq v^*) = \int_{v*}^{b} \frac{1}{b-a} dv = \frac{b-v^*}{b-a} = \frac{b-p-\frac{t}{2f}}{b-a}$$

Now it is easy to notice that as one could have expected the demand depends positively on frequency and negatively on fare. In order to make computations easier we substitute $Y \equiv \frac{X}{b-a}$ and we obtain:

$$D(p,f) = Y\left(b-p-\frac{t}{2f}\right) \qquad \Rightarrow \qquad p(D,f) = b - \frac{D}{Y} - \frac{t}{2f}$$

1.6.5. Optimal Price and Frequency

First of all, we can already prove that the Mohring effect is valid. If we consider a cost function that includes both consumers' time costs and producers' costs, we obtain:

$$TC(f) = \frac{t}{2f} + c \cdot f$$

Hence the average cost function is

$$ATC(f) = \frac{t}{2f^2} + c$$

It is clear that as the number of operating bus per hour increases, the average total costs decreases implying that there are economies of scale, thus the Mohring effect applies.

Now, we need to build our welfare function. We defined welfare as total surplus. The first element is the consumer surplus (CS), which we will compute as the area between the inverse demand curve and the price line.

$$CS = \int_0^D p(D,f)\, dD - pD = \frac{1}{2}\frac{D^2}{Y}$$

The second element is producer surplus, i.e. profits. Hence, we obtained our welfare function, which has to be maximised with respect to D and f

$$\max_{D,f} \frac{1}{2}\frac{D^2}{Y} + p(D,f) \cdot D - c \cdot f$$

FOC leads to the following optimal frequency and traffic

$$f^*(D) = \sqrt{\frac{Dt}{2c}}$$

$$D^*(f) = Y(b - \frac{t}{2f})$$

While the profit-maximiser operator will maximise with respect to traffic and frequency p(D, *f*)·D – c*f* and he will obtain:

$$f^M(D) = \sqrt{\frac{Dt}{2c}}$$

$$D^M(f) = \frac{Y}{2}(b - \frac{t}{2f})$$

We notice that the frequency rules are the same, however monopolist optimal traffic is the half of the socially desired one. Hence the monopolist will induce a contraction in in the demand through pricing and the optimal frequency will result lower than the welfare maximising one. To see this clearly we plug optimal traffic conditions into optimal frequencies.

$$f^* = \sqrt{\frac{\left(b - \frac{t}{2f^*}\right)Yt}{2c}}$$

$$f^M = \sqrt{\frac{1}{2}}\sqrt{\frac{\left(b - \frac{t}{2f^M}\right)Yt}{2c}}$$

The profit-maximiser monopolist will not provide the first-best frequency even if the frequency rule is the same.

As already anticipated, the monopolist will charge higher fares. Specifically, we plug D* and D^M into the inverse demand function in order to show the different pricing of the two operators.

$$p(D, f) = b - \frac{D}{Y} - \frac{t}{2f} \Rightarrow p^* = 0 \; and \; p^M = \frac{1}{2}(b - \frac{t}{2f})$$

The first best pricing implies that fares do not cover costs at all. In other words, they require a subsidy of the size c·*f** in order to cover all operating costs.

If we drop the assumption of uniformly distributed preferred departures time and we admit the possibility of on-peak and off-peak periods, the derivation of the demand function is a little bit more complex, but the conclusions are the same. The average waiting time depends on the distribution function of preferred departure times g(x).

$$D(p,f) = Y\left(b - p - t\int_0^{\frac{1}{f}} (\frac{1}{f} - x)\, g(x)\, dx\right) = Y(b - p - t \cdot H(f))$$

$H(f)$ is such that $H(f) > 0$, $H'(f) < 0$ and $\lim_{f\to\infty} H(f) = 0$. In words, the expected waiting time must be greater than zero, as frequency increases expected waiting time decreases, and as frequency tends to infinity the expected waiting time tends to zero; $H(f)=1/2f$ is just a specific case, but it easy to see that everything we showed for $1/(2f)$ holds also for a general $H(f)$.

One of the classical counter argument made to the Mohring effect is that users know the departure schedule or learn it so that in the long run their average waiting time is close to zero. Even if we assume that the transport operator is highly reliable, this is not true. Unless it happens by chance, the preferred and the actual departure time do not coincide, therefore the consumer still face the cost of a departure delay. If users know the departures schedule they will wait in more comfortable places, e.g. home/office. Average cost may decrease through a reduction in the premium money value of time due to unpleasant condition. In other words, it is plausible to imagine that in the long run the coefficient t will decrease but it will never be zero, since it would mean that consumers do not attach any value to their time.

In sum, if we assume that reservation prices are uniformly distributed and that average operating costs are constant, a monopolist provides lower frequencies than socially desired and charges a higher fare. Thus, subsidies are needed to achieve the socially optimal equilibrium. This result confirms that if users are heterogeneous in reservation prices, i.e. own demand elasticity is different from zero, the Mohring effect is valid.

The model concludes that subsidies should cover the entire production costs, implying a fare equal to zero. This statement is very strong and we have to bear in mind that we have ignored several issues in the development of our model. Firstly, we have not put any constraint to the capacity of buses and we have not considered any disutility derived from the discomfort in overcrowded buses. In the long run the operator can adjust by increasing the size of buses, however it may cause an increase in the average operating costs and consequently in the size of the subsidy. Secondly, time employed by the bus to make stops and board other passengers has not been included in users' time costs. These costs become relevant in high demand density areas. Lastly, we did not deal with the issue of raising funds to finance the subsidies. The government is often subject to budget constraints and the introduction of a distortive tax may result in a welfare loss greater than the one gained.

In conclusion, this model proves that the subsidisation of the transport industry is socially desirable. As far as the size of subsidy is concerned, many variables must be taken into account and a case-by-case analysis is needed.

1.7 Congestion

After having analysed the Mohring effect, which is the main rationale for public transport subsidisation, we will turn to another issue that justifies the use of subsidies. Public Transport is naturally connected to the use of roads. In general terms, road is a public good, however, when the number of vehicles exceeds road capacity, the consumption becomes rival but still non-excludable. Congestion is a negative externality inevitably linked to the use of road, it is the result of overconsumption due to non-excludability. When the road is congested, i.e. peak periods, the presence of an additional vehicle increases road users' journey times. This implies an increase of time costs and operating costs. In other words, an extra car imposes additional costs on other travellers.

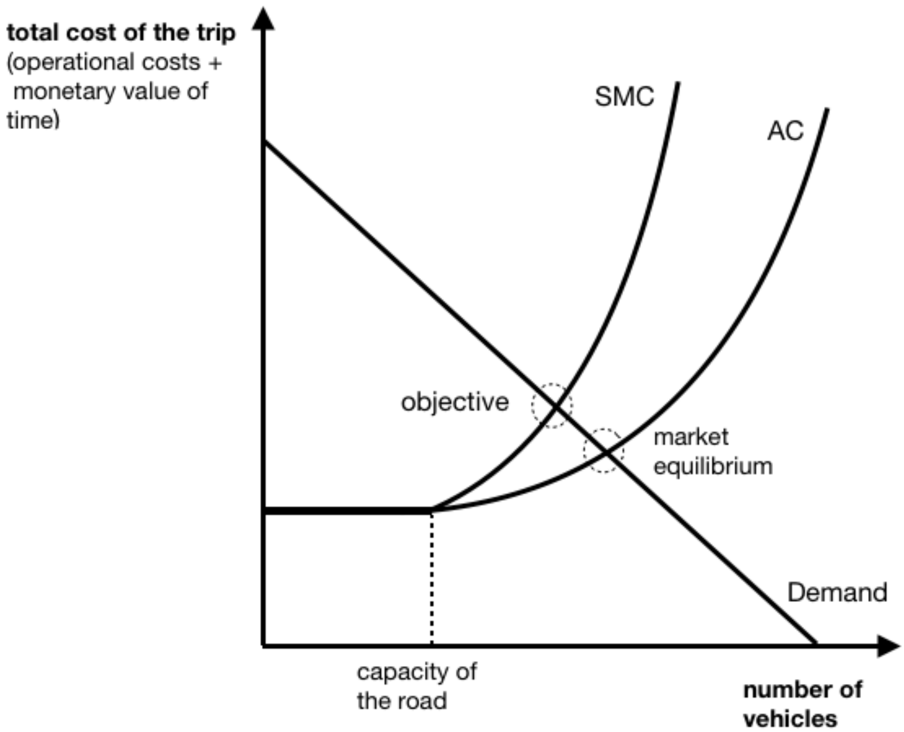


Figure 1.2 *Optimal Congestion* ***Source:*** *David Fetting (1996) "Primer on Congestion Pricing"*

Total journey times (total social cost) increase with the number of cars, but more than proportionately, so that the average cost per vehicle increases as the number of vehicles increases (Fig.2). The private cost that accrues to an additional individual deciding whether or not to drive his car, is simply the average cost, which is lower than the social marginal cost. Thus while the private market equilibrium entails demand equal to average cost, i.e. the price of the trip, social efficiency requires demand to be equal to social marginal cost.

The easiest solution would be increase road capacity. However, this is not always possible, especially in urban contexts. Another common solution proposed by the literature is congestion pricing. Starting from Vikcrey's idea of a toll system dependent on space and time, a large body of literature have been produced.

This policy is frequently implemented for motorways and sometimes it worked also in urban areas (Singapore Area Licensing Scheme, Gothenburg Congestion Tax). This method makes it possible to isolate a specific area, such as the city centre, but it has some limits. Consider a long route which connects the suburbs to the city centre: it is very likely that this road is subject to congestion. However, if the road has many accesses, which is often the case, transaction costs may offset, or even exceed, the benefits of tolling.

Eventually, the last solution we want to consider is the one proposed by Glaister (1974): set public transport fares in order to shift demand from private to public transport and from peak to off-peak periods. Consider four possible modes of transport: (1) on-peak private transport (2) off-peak private transport (3) on-peak public transport (4) off-peak public transport.

Differently from other authors, Glaister considered the interdependencies among the demands of these four modes of transport and he came to the conclusion that optimal fares fall below marginal social costs both in the peak and in the off-peak period. Firstly, optimal peak fares are below the marginal cost when we take into account the relief to congestion when peak road users shift from car to bus. Secondly, optimal off-peak fares are also below the marginal cost price because even if there is no congestion, it is possible to switch peak car users demand to off-peak buses and to draw peak bus users out of the peak.

In conclusion, congestion alone provides a rationale for the subsidization of urban public transport.

1.8 Other Public Transport Related Issues

The Mohring effect and congestion are the most relevant market failures related to public transport; however, there are other issues, such as pollution and tourism, which are worth to analyse.

The relationship between transport and sustainability is quite obvious. The majority of transportation modes rely on non-renewable resources and create noise and air pollution; because buses and undergrounds carry many passengers per vehicle, public transport can reduce the number of vehicles in circulation. After World War II, the use of public transport has declined as the access to private transportation increased. Since the beginning of the new millennium, the society is increasingly aware of the necessity to safeguard the environment. The Division of Waste and Hazardous Substances of Delaware found that "a bus with as few as seven passengers is more fuel-efficient than the average single occupant auto used for commuting" and that "buses emit only 20% as much carbon carbon monoxide per passenger mile as a single-occupant auto" (State of Delaware:

the Official Website of the First State, Division of Waste and Hazardous Materials[6]). Therefore, incentivise the use of public transportation can make a significant difference.

In order to drive choice of mode towards public transport, many policy makers suggested to increase the price of private vehicle travel through a congestion or pollution tax. The rationale is to charge car drivers the social marginal cost of their actions. This policy has been implemented in large metropolis such as Beijing and Singapore, but it presents some political risks. Therefore, in order to promote a significant shift from private to public transport policies should aim at enhancing travel comfort, increasing the access to the service, reducing travel time and, in general, making public transport more convenient.

Another important issue connected to transportation is tourism. Tourists need mobility and a very small portion decides to rent a private vehicle. In many European cities the increase in demand for public transport is not negligible, even though sometimes it is not considered by city planners. If the increase in demand is not followed by an increase in supply, then public transport becomes congested and residents start competing with tourists for limited resources.

Tourism today is a significant source of revenue for cities and there are several reasons why enhancing public transport may have beneficial effects.

Firstly, the level of service and access to transport network are relevant factors in the tourists' choice of destination. Secondly, an efficient transportation system maximises the revenues from tourism: if everything works smoothly, tourists will be able to visit more attractions, to go out during the evening, etc. etc.

Furthermore, there is also an important economic reason. Tourists generally occupy buses during off-peak hours and they justify the high frequency provision of the service even though there are few residents. Another way to see it is that tourists make off-peak periods more profitable and provide a cross-subsidy for on-peak periods. Lastly, tourists' average expenditure on transport is higher than that of local citizens, who benefit from annual subscriptions and other discount schemes.

So far we have mentioned market failures related to urban transport, in the next section we will see how governments have addressed these issues and how effective their interventions have been.

1.9 Regulations on Public Transport

As we have seen in previous sections, public transport is linked to several market failures, thus it is easy to imagine that transportation is heavily regulated. Designing a policy for transportation

[6] http://www.dnrec.delaware.gov/dwhs/info/Pages/OzonePublicTrans.aspx

presents many difficulties; regulators have to take into account many factors such as congestion, users' time costs, pollution, tourism, etc. etc. Our focus will be on Europe and European Union transport policies.

In many European countries the ownership structure followed a common pattern. Since the beginning of the 20th century governments started to take over the industry both at a national and at a local level. By the half of the century the State was the main provider of transport. However, this trend was reversed in the 80s, when the liberalization process began. The driving force was a financial one: due to the massive use of car led to a decreasing patronage of public transport operators. Today the ownership structure and regulations vary across countries, but also in this field the European Union aims at having integrated and harmonized rules. Transportation has been a great concern of the EU since its inception. Without a smooth transportation system, three of the four freedoms of the common market established by the Treaty of Rome (1957): the free movement of individuals, goods and services. As the European Commission explains: "Europe needs strong transport connections to drive trade and economic growth, and to create employment and prosperity. Transport networks are at the heart of the supply chain and are the foundation of any country's economy"[7]. A transport network is truly efficient as whole when it is efficient at a local level. A high speed train from Rome to Paris would be useless if the poor quality of urban transport makes it inconvenient to reach the respective stations.

The Regulation (EC) No 1370/2007 of the European Parliament and of the Council provides a set of rules on public passenger transport services by rail and by road. Article 3 par.1 states that "Where a competent authority decides to grant the operator of its an exclusive right and/or compensation, of whatever nature, in return for the discharge of public service obligations, it shall do so within the framework of a public service contract". The European Union recognises the beneficial effects of having a single operator with legal monopoly status, awarded through a public tender. Article 4 regulates the content of the public contract and stresses the risk of overcompensation. Paragraph 1 indicates that "Public service contracts and general rules shall: […] (b) establish in advance, in an objective and transparent manner, (i) the parameters on the basis of which the compensation payment, if any, is to be calculated, […] these parameters shall be determined in such a way that no compensation payment may exceed the amount required to cover net financial effect on costs incurred and revenues generated in discharging the public service obligations". The EU also addresses the need of subsidisation, but it does not set a common threshold. Indeed, the level of subsidies vary across countries: in France 46% of operating costs is covered by subsidies, whereas in

[7] "The EU explained: Transport", European Commission, Directorate- General for Communication Citizens information, 2014

the Netherlands 65-70%, depending on the region. But we have to be careful when we deal with these data because, as we have seen, the regulation does not provide a uniform way to compute the level of subsidies. In the next chapter, we will discuss specifically the Italian legislation on public transport and its compliance with European rules.

As far as pollution is concerned, the European Commission establishes with the Clean Vehicles Directive 2009/33/EU that up to 50% of the buses purchased, leased or rented in 2025 and up to 75% in 2030 have to be “clean vehicles”, i.e. electric or hybrid buses. Therefore, public transportation will be environmentally-friendly not only because it reduces the number of vehicles on the road, but also because its vehicles will emit less CO_2 and other pollutant agents. However, the Directive does not mention the costs for the industry and how investments will be done.

This is just a short overview of European regulations and directives on local public transport. The general trend is to have many coordinated operators, each with his geographical area of exclusive competence, with the aim of having an integrated accessible capillary transportation network.

1.10 Conclusion

This Chapter has dealt with the theoretical aspects of urban public transportation and it has pointed out some policy implications. Transportation is different from other commodities in that the consumption of each transportation facility is unique in time and space, implying that consumers have to supply an essential input: their own time. Time cannot be traded on a market, thus it has not a price, but this does not mean that it is not valuable. In order to perform any cost-benefit analysis a method to evaluate time in monetary terms is necessary. Hourly wage can be a good proxy of the value that individuals attach to their own time, even though several assumptions must be made.

On the production side, we investigated on the economies of scale and scope of the transport industry. Transportation clearly exhibits economies of scope, whereas some doubts arise around the existence of economies of scale. Empirical research led to to the conclusion that as far as only producers’ costs are concerned, transportation industry is subject to constant returns to scale. Given this findings, it would be straightforward to conclude that urban transport is not a natural monopoly. Despite this, even where transport is deregulated there is not much competition. A plausible explanation is that a well-integrated transport system which has a unique central planner provides a higher quality service and reduces average waiting time. This intuition can be formally explained through the Mohring effect, named after the economist Herbert Mohring. He proved that once users’ time costs are included transportation is subject to increasing returns to scale. Mohring advocates the subsidisation of urban transport in order to bridge the gap between marginal and average costs and achieve first-best pricing.

Public transport is unavoidably connected to private transport, since these two modes usually make use of the same facility: the road. Road can be seen as a partial public good; when the number of vehicles exceed road's capacity, the road becomes congested and its use becomes rival but non-excludable. Solving the problem of congestion is the key to make a dramatic improvement in mobility in metropolitan areas. Moreover, large cities have to cope with pollution. Public transport emits less pollutant per passenger with respect to private transport. Shifting the demand from private transport towards public transport may be the best way to solve both problems at the same time. One way to achieve this result could be tolling private vehicles. However, this policy is difficult to implement in branching road systems and it presents some obstacles in its political acceptability. Therefore, policies should be aimed at making more convenient and accessible instead of making private transport more expensive. Also in this case, subsidisation of public transport seems to have solid economic justifications.

Government intervention can take many forms, from the takeover of the industry to regulation on maximum fares. Many long run decisions, such as the choice of technology, play an important role, but they are subject to the specific structural constraints of the cities. We focused on short run variables, fares and frequency, so that the conclusions could be as general as possible. Through the development of a simple model, it has been showed that if the market was left to a profit-maximiser monopolist, he would provide lower frequency and higher fares with respect to the social optimum. Therefore, public authorities should regulate and subsidise public transport in order to maximise welfare. The model suggests that the subsidy should cover all production costs, however, this may not be optimal if we add layers of complexity and we take into account government's budget constraints. Thus, the optimal size of the subsidy depends both on micro and macro-economic variables. All in all, there is a general consensus on the subsidisation of urban public transport, indeed all laws and regulations issued in last decades move in that direction. For instance, the Regulation (EC) No 1370/2007 of the European Parliament and of the Council establishes that a compensation should be given to public transport operator in return for the discharge of public service obligations, but it does not provide a general rule for the size of the subsidy.

Mobility is at the centre of many economic debates. The expansion of cities requires an adequate transport planning; more and more people will need to travel long distances and not all of them will be able to afford a private vehicle, but even if everybody could afford a car, congestion and pollution would become unsustainable. Public transport may be the key to fight inequality, improve accessibility and face climate change.

Chapter 2: The analysis of ATAC: the public transport operator in Rome

2.1 Introduction

In this chapter we are going to make a positive analysis of public transport, specifically we have decided to examine the public transport operator of Rome: ATAC (Agenzia per i Transporti Autoferrotranviari del Comune di Roma). The chapter is structured as following: the first section is dedicated to the supply side of the market, the second section to the demand side, while the last sections will concern topical debates, namely the debt, the arrangement with creditors and the referendum.

The analysis of the supply includes firstly a brief description of the history of the company and its current ownership structure. Secondly, we report the finding on economies of scale for large Italian transportation companies and the actual expenses of ATAC from its latest Income Statement (2016). Thirdly we go through a descriptive analysis of the service offered and of the fare scheme.

The analysis of demand starts from the description of the historical analysis of sales volumes. In particular, we focused on BIT (Biglietto Integrato a Tempo), BTI (Biglietto Turistico Integrato) and annual subscriptions because we can generally associate these fares to different riders' categories, which are occasional riders, tourists and regular commuters. The descriptive statistics is followed by considerations on factors that could have affected sales volumes and their differential impact for each category of ticket. Furthermore, the increase in tickets price in 2012 allows us to make a rough estimation of the elasticity of the demand for each category of ticket.

Lastly, we analyse all the steps that have led ATAC to accumulate such a colossal debt from the 90s to present days and we discuss what are the possible scenarios for the future of public transportation in Rome.

2.2 Analysis of the supply

2.2.1 Ownership structure

In this section we will briefly report the history of ATAC and we will analyse in detail the current ownership and governance structure.

The first municipal public transport operator, the AATM ("Azienda Autonoma Tramvie Municipali"), was founded in 1909 on the initiative of the mayor Ernesto Nathan. Two years after the service started with three routes. The company was founded at the eve of the Great War, a tough period which will be followed by equally complicated phases. The Great Depression hit also the service sector, which had to deal with a significant increase in the cost of inputs. At the end of the 20s the ATAG, as the company was renamed in 1925, ran a substantial deficit and the Second Word

War worsened the situation. Most of the employees were at the front, infrastructures and vehicles were completely destroyed by the bombings. On the Liberation Day the company was on the edge of the collapse. The restoration of the company, which got renamed as ATAC, took three years, just in time to support the mobility of the city during the economic boom. By the end of the boom, troubles began: Rome at the end of the 60s has only one underground line long less than 10 km, a crumbling tramway network continuously downsized by the political class. The elevated costs to guarantee the service and and high salaries complete the scenario. In the fist years of the new millennium, ATAC turned into a planning agency. The management of surface transport was assigned to the company Trambus, while the management of trains and undergrounds was assigned to the company MetRo. The Figure 2.1 shows the ownership structure at the beginning of the years 2000. The City Council of Rome owned 100% of ATAC and Trambus and 95.46% of MetRo.

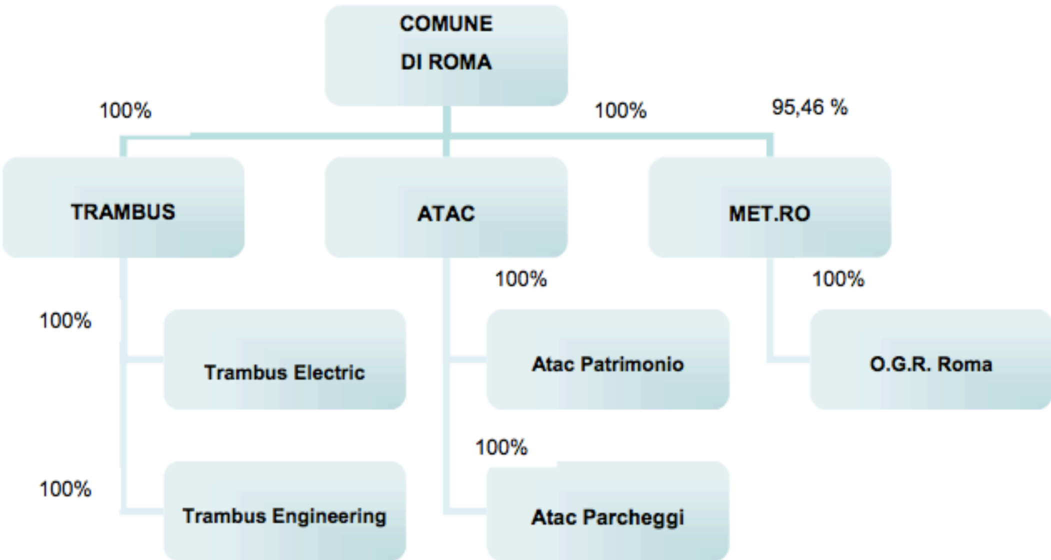


Figure 2.1 *The Ownership Structure in years 2000s* ***Source****: Agenzia per il controllo e la qualità dei servizi pubblici locali del Comune di Roma, Trasporto pubblico locale a Roma: affidamento dei servizi e analisi del mercato, 2012*

In 2010 ATAC incorporated Trambus and Met.Ro, going back to the direct management of public transport, while “Agenzia Roma servizi per la mobilità” separated from ATAC. The Figure 2.2 shows the new ownership structure.

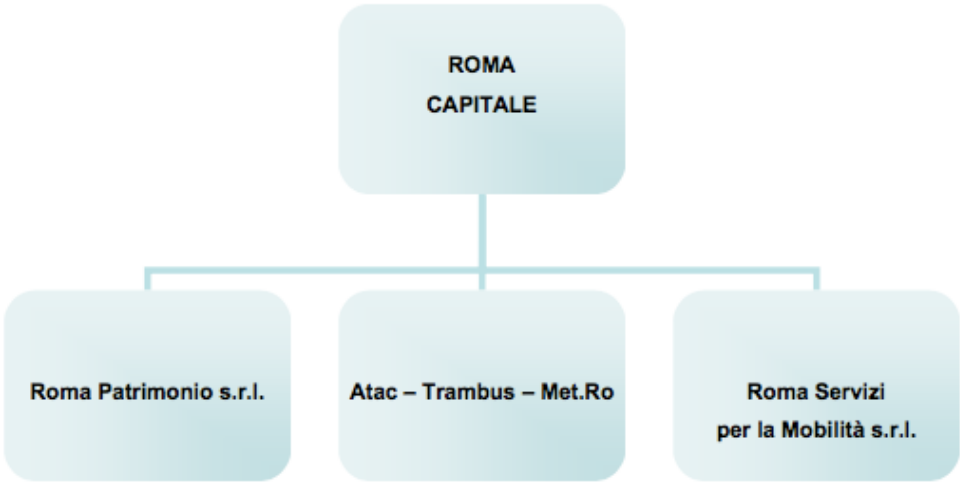


Figure 2.2 *The Ownership Structure in 2010* ***Source****: Agenzia per il controllo e la qualità dei servizi pubblici locali del Comune di Roma, Trasporto pubblico locale a Roma: affidamento dei servizi e analisi del mercato, 2012*

On the 1st June 2011 the private consortium Roma TPL signed a contract with Roma Capitale and ATAC with the aim of running some routes in the suburbs, including some night routes.

All these corporate rearrangements postponed an unavoidable crisis which came in 2017. The company accumulated 1.3 billion euros of debt and the bankruptcy court welcomed the arrangement with creditors. ATAC will have to provide an industrial plan in order to prevent a disastrous bankruptcy which will leave the city without a public transport operator. On 31st January 2018 the mayor Virginia Raggi announced a consultative referendum, which will be held in June. The referendum will concern the invitation to tender of the service.

This is a brief summary of the history of ATAC, in later sections we will focus on the latest events, which will affect deeply the future of public transportation in Rome.

2.2.2 Production Costs

In this section we will revise the literature on the cost function of Italian public transport enterprise and next we will do a descriptive analysis of the costs of ATAC reported on the latest financial statement.

Studies on Italian public transport have been developed in recent years due to the continuous crises that have characterised this sector in the last decades.

Fazioli et al. (1993) analysed suburban transport enterprises in Emilia Romagna and they found out relevant economies of scale, both in the short (1.66) and in the long-run (1.71) and economies of density, whose importance decreases as the companies' size increases. Levaggi (1994) used a sample of 55 Italian enterprises and he found slightly different results. According to his study, there are high economies of density in the short run (1.38) economies of scale are relevant in the short-run (1.43), while in the long run there are slight diseconomies of scale (0.92).

A more recent studies were carried out by Fraquelli et al. (2001; 2004), who have analysed variable costs of a sample of 45 public enterprises between the years 1996-1998. Their estimates highlight relevant economies of scale not only in the short run, but also in the long run. Their analysis focuses also on the role of some environmental variables that have a relevant impact on the magnitude of costs; in particular, traffic congestion entails a loss in the productivity of drivers and an increase of operational costs, without mentioning the ecological impact.

In sum, all theses analyses point out that there may be a limit to the exploitation of economies of scale, suggesting that small sized companies should extend their catchment area, while large companies should split and reallocate the service among different operators.

Given this theoretical background now we turn to the analysis of ATAC's Income Statement for 2016, with a focus on costs. In Table 2.1 we reported items of interest.

Items	**ATAC 2016**	**ATAC 2015**
External Operational Costs	310,557,936	342,857,282
Personnel Costs	538,820,709	536,848,369
EBITDA	**82,649,559**	**61,302,702**
D&A	284,511,751	126,829,751
EBIT	**(201,862,193)**	**(65,527,050)**
Financial costs	15,834,972	11,802,439
Taxes	(4,986,956)	1,864,895
NOPAT	**(212,710,208)**	**(79,194,384)**

Table 2.1 *ATAC Income Statement* ***Source:*** *ATAC Financial Statement 2016*

The value of production is basically revenues from sales (88.8%), which include public service contracts (474.5 million euro from Roma Capitale and 68.2 million euro from Regione Lazio), fares and parking (284.7 million euro). On the other hand, the costs of production are made for the 64% of personnel costs and 37% of costs for the provision of the service, replacement and consumption goods.

The gross operating margin improved by 21 million euro with respect to 2015. The improvement is almost entirely given by the decreasing external operational costs, whose reduction is due to the lower volume of production, which in turn caused a reduction in the expenditure on gasoline and replacement parts. The increase of personnel costs can be attributed to the wage increases due to the implementation of the new allowance for productivity and new Threshold.

The value of the gross operating margin is entirely absorbed by amortisation and devaluation, resulting in a negative EBIT.

In this section we have analysed the costs of the supply side of the market. In the next paragraph we will make a qualitative description of the service offered and the fare system.

2.2.3 The service offered and the fare system

In this section we will analyse the service offered by ATAC, the most used routes and the fare system. As to surface transport, ATAC and TPL provide the service for 309 routes, of which 302 are bus routes, 6 tram and one filobus route. As to underground transport, ATAC manages three lines, even though Metro C is still incomplete, with a total length of 53.2 km. Roman citizens can also benefit of the three railways (Roma-Lido, Roma Giardinetti and Roma-Viterbo) which have 47 stops inside the urban area.

As we can see from the data reported in the last financial statement the majority of the service provided is surface transport.

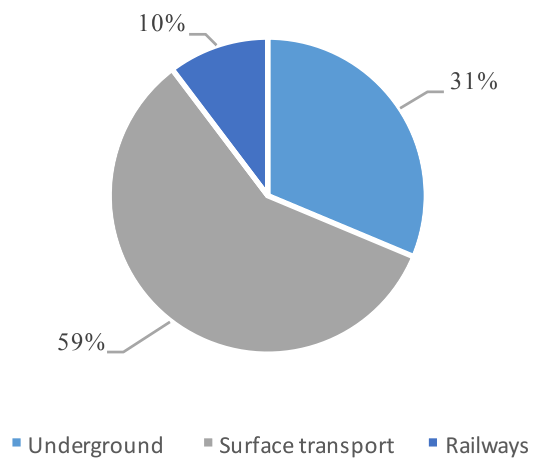


Figure 2.3 *Service provided in 2016* ***Source:*** *on elaboration on ATAC Financial Statement 2016*

Surface transport resembles almost 60% of the total service provided, with 87,221,141 km per vehicle. This may be a problem since Rome suffers from high level of traffic congestion and the total length of bus lanes in the whole territory of Rome is 112km. Congestion may prevent the regular provision of the service. The average journey length of commuters in the area of Rome and Lazio is 79 minutes[1] and over the 80% spend more than 2 hours per day on means of public transport, while the average waiting time is 20 minutes. The natural solution to congestion would be improve the underground lines, moving people off the road. However, it appears clear from the 11-year works for the Metro C that this solution is not feasible, at least in the short/medium run.

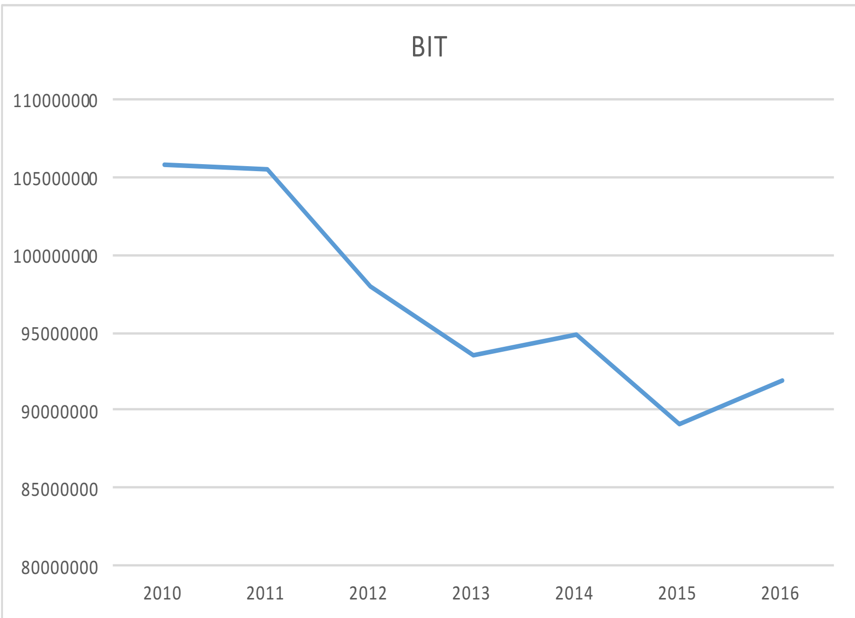
[1] All subsequent data are provided by Moovit (https://moovitapp.com/insights/it/Analisi_Moovit_sull_indice_per_la_mobilit%C3%A0_pubblica-61)

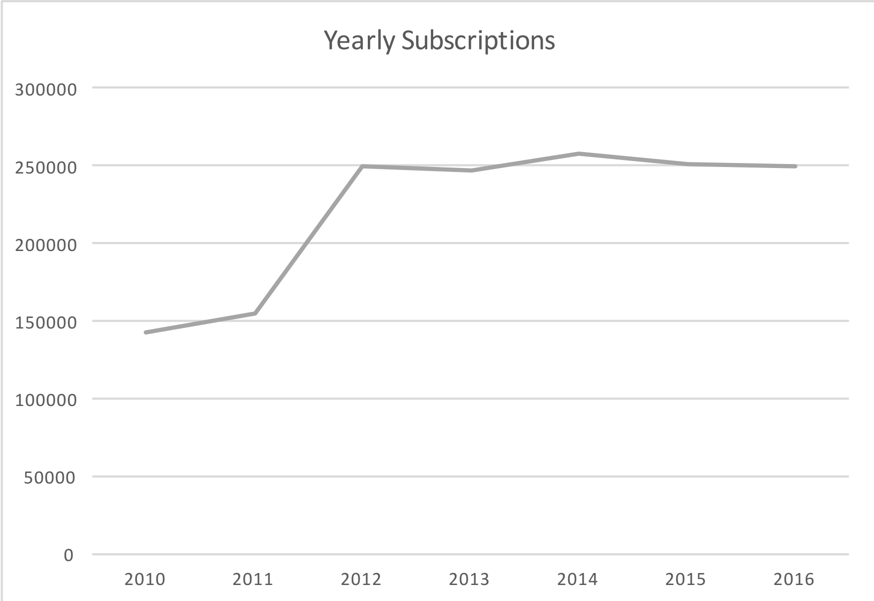
As far as the fare scheme is concerned, all fares and subscriptions are time based. The simplest fare, the BIT, has a validity of 100 minutes and for one underground ride for a price of 1.50 euro. It gives access to all surface means of transport, both ATAC and TPL, undergrounds and railways. Regular commuters have the opportunity to make weekly (€24.00), monthly (€35.00) or annual (€250.00) subscriptions. While special schemes are thought for tourists: ROMA24H (€7.00), ROMA48H (€12.50) and ROMA72H (€18.00).

2.3 The Analysis of the Demand

2.3.1 Factors affecting the demand

We start our analysis of the demand side of the market by examining the volumes of sales and the changes in the factors that affect consumers' choice: price, price of substitutes and income. The following figures (2.4 and 2.5) show the trend of sales from 2010 to 2016 for BIT, yearly subscriptions and BTI ("Biglietto Turistico Integrato", the current ROMA 72H)





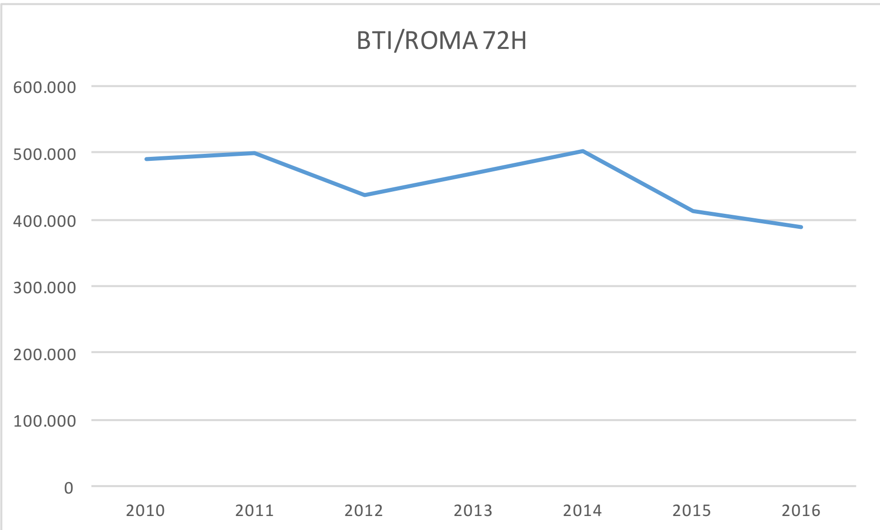


Figure 2.4, 2.5 and 2.6 *Sales volume* ***Source:*** *own elaboration on ATAC Financial Statements (2010-2016)*

BIT sales experienced a sharp decline in 2012, in the subsequent years there were signs of recovery but in 2015 they fell again. On the other hand, yearly subscriptions increased in 2012 and than they remained stable around 250,000 subscriptions sold per year. In addition, BTI (ROMA 72H as it was renamed in 2015) followed a stable pattern with only two declines in correspondence of the two rise in price: in 2012 from €11 to €14.50 and in 2015 from €14.50 to €16. BITs, yearly subscriptions and BTIs followed a very different pattern because they are very different goods. Those who buy BITs are occasional riders who do not move by public means of transport often; whereas those who buy annual subscriptions heavily rely on public means of transport and most likely they do not have a private means of transport; and finally BTIs are thought for tourists, who do not have many alternatives to public transportation. Now we will see how these trends can be related to changes in factors affecting the demand.

Firstly, we discuss the price changes. In 2012 ATAC has implemented a change of the fare scheme. In particular, the BIT price rose by 50%, from €1.00 to €1.50, while annual subscriptions price increased from €230.00 to €250.00, less than 10%. The increase in price can explain the drop in the sales of BITs, the same happens for BITs, whereas it seems counterintuitive in the case of annual subscriptions. Thus we must look for other causes.

Secondly, another factor that influence the demand is income. It is reasonable to think that annual subscriptions are inferior goods: as people become richer they can afford a private vehicle, switching their mode of transport. The year 2012 signed the beginning of the Sovereign Debt Crisis which hit the real economy. In the period 2011-2015 average annual income of households living in Lazio declined on average by 1.5% per year[2]. Therefore, if we assume that annual subscriptions have negative income elasticity, the decline in income can explain the rise in the volume of sales, despite the price increase.

Thirdly, we must consider one last factor affecting the demand: price of substitutes. As the price of substitutes increases we expect demand to increase (positive cross-price elasticity). The closest substitute is private car, even thought the costs related to private vehicles are many, we have chosen to analyse the price of oil since it is the most relevant and volatile. As we can see in the Figure 2.7, oil price has reached its peak in 2012: in August it exceeded the threshold of 2.00€ per litre.

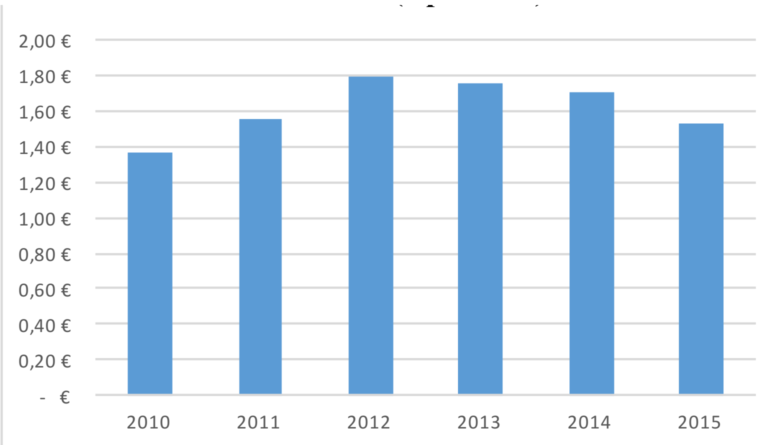


***Figure 2.7** Price of oil (€ per litre) **Source:** own elaboration on data from Ministero dello Sviluppo Economico*

Therefore, the increase in the demand for annual subscription can be explained also by the huge increase in the price of oil. Moreover, we can consider as substitute also the monthly subscription. In 2012 the change of tariffs has not been uniform, monthly subscriptions raised by 16.6%[3] while yearly subscriptions raised by less than 10%, thus making the annual subscription relatively more convenient. Therefore, we can imagine that part of the demand for monthly subscriptions shifted to

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[2] Istat

[3] The personal subscription fare.

the yearly subscriptions. Indeed, from the financial statements of 2011 and 2013 we can see that the volume of sales of monthly subscriptions dropped from 3.6 million to 2.4 million.

Lastly, we must make a consideration on the collection of data. The number of people that use the service does not necessarily match the volume of tickets sold because of fare evasion. According to Codacons 40% of passengers does not pay for the ticket, the evasion is estimated to amount to 80 millions of euro each year[4]. We can reckon that this bias mainly concerns BITs, since occasional riders have a lower probability of encountering tickets controllers with respect to those who use public transport every day.

In sum, we can imagine that the sharp decrease in the sales volume of BITs and BTIs was mainly due to price increase; annual subscriptions experienced a smaller raise in price, whereas income and price of substitutes played a major role.

2.3.2 Elasticity: the change in the fare system in 2012

In this section we will try to estimate the price-own elasticity of the BIT. Later on we will compare it with the elasticity of the BTI ("Biglietto Turistico Integrato"), which is a fare thought for tourists and has a validity of 72 hours, and that of yearly subcriptions.

Thanks to the manoeuvre in the tariff scheme on 25th May 2012 we can compute short-term elasticity. The BIT price increased by 50%, from €1.00 to €1.50. Comparing the sales volume one year before and one year after (so that we can seize all the short term effects), it has been registered a decline of 12 millions of tickets sold. It is therefore possible, to compute arc elasticity[5].

Year	Quantity sold	Price
2011	105,478,478	€ 1.00
2013	93,469,075	€ 1.50

Table 2.2 *Volumes of Sales of BIT* ***Source:*** *own elaboration on ATAC Financial Statements (2011 and 2013)*

With these data we can apply the formula of arc price elasticity, under the hypothesis of a linear demand curve:

$$\varepsilon = \frac{Q_{2013} - Q_{2011} / \bar{Q}}{P_{2013} - P_{2011} / \bar{P}}$$

[4] CODACONS: https://codacons.it/roma-atac-metro-doppi-tornelli-anti-portoghesi/

[5] Since it is a great variation of price (50%) it is necessary to compute elasticity through the technique of the median point

where $\overline{X}$ is the median point of the variable X, and we obtain ε = -0.30, which means that it is quite inelastic. Indeed, revenues from BIT raised by 34 million euros between 2011 and 2013. This may suggest that occasional riders decide to take the bus only when it is necessary.

Marabucci (2016) estimated with the same technique price demand elasticity after the change in the tariff scheme in 2003, when the BIT changed its price from 0.77€ to 1.00€. He found out that the demand was even more inelastic, in particular elasticity was equal to -0.17. This difference may be due to the amount of the increase and the different level of prices before the rise. Another possible explanation may be that the demand curve has become more sensitive to price changes, i.e. has become flatter.

Now we proceed to the analysis of annual subscriptions.

Year	**Quantity Sold**	**Price**
2011	154677	€ 230.00
2013	246837	€ 250.00

Table 2.**3 Volumes of Sales of yearly subscriptions* ***Source: *own elaboration on ATAC Financial Statement (2011 and 2013)*

By applying the same formula we obtain ε = 5.51. Not only it results to be positive but it is also big in absolute value. However, we cannot conclude that the yearly subscription is a Giffen good. If we had more data, we could do an econometric analysis controlling for income, price of substitutes, the interaction with the monthly subscriptions demand and other variables.

Now we proceed to the analysis of the BTI, renamed in 2015 as ROMA 72H.

Year	**Quantity Sold**	**Price**
2011	500656	€ 11.00
2013	470290	€ 16.50

Table 2.**4 Volumes of Sales of BTI (current ROMA 72H)* ***Source: *own elaboration on ATAC Financial Statement (2011 and 2013)*

Applying the same formula, we obtain a price-own elasticity equal to -0.16. As expected tourists' demand is more inelastic. This result was quite predictable since tourists do not have close substitutes: not all attractions are at a walking distance and renting a car is inconvenient.

2.4 Historical analysis of the debt

In this paragraph we are going to summarise the steps which have led ATAC to have such a colossal debt. We start our analysis from the 90s when the State financial crisis came in. The State was no longer able to cover the deficit of many public enterprises, among which ATAC. A new system of financing local public services was needed. The reform provided for local financing based on principles of fiscal and financial autonomy and responsibility.

The municipality of Rome was the only owner of ATAC and owned 85% of CoTraL (Compagnia Trasporti Lazio, the regional transport provider). In 1994 the two enterprises produced an annual deficit of 925 billions of liras, the debt in the financial statement of the municipality, which covered the deficit, amounted to 3500 billions of liras (the 70% of total debt). The situation was paradoxical in some sense; roman administrators did not worry because of a strongly centralised financing system: the debt of local service providers was entirely transferred to the financial statement of the State.

When the new decentralised system came into force, the whole sector of public transport had to be reorganised. Between 1994 and 1999 actions for the reconstruction of public transportation were carried out: reduction of employees, interventions on the costs and the organization of labour, renewal of the management, new service contracts and a corporate reconstructing. Moreover, a new strategy aimed at improving mobility was implemented: investments on undergrounds, tramways, and parking areas. However, the results were below the expectations, fare revenues covered just 24.5% of the costs, very far away from the 35% target.

The situation gets worse in 2002 when the Title V of the Constitution was modified: it was no longer possible to cover through debt the obligations relative to service contracts. As a result, the funds that the municipality devoted to public transportation were cut by 25%. In 2003 ATAC had a net loss of 115 millions of euros.

However, in 1999 a process of liberalization started: 30 million kilometres had been assigned through a tender. The winners had a cost per kilometre which was 55% lower than the one of ATAC. Liberalisation seemed the only instrument to realise an effective reduction of costs, increase the level of service and boost the growth of the sector. But local authorities decided to keep in house production even if the situation was dramatic: in the past 10 years public contributions reduced by 12% in real terms, the fares had not been adjusted to the augmenting price level, and costs have risen faster than inflation (+124% insurance, +15% gasoline).

This system was unsustainable, in 2012 ATAC had no choice but to raise fares, obtaining poor results. On the 31st December 2016 the debt amounted at 1.3 billions of euros and a deep crisis begun. In the next paragraph we will analysis this crisis and the possible scenarios that could occur in the next years.

2.5 The arrangement with creditors and the referendum: the future of public transportation in Rome

The debate about the future of ATAC is very topical today. In this paragraph we are going to discuss the possible implication of the arrangement with creditors and of the consultative referendum announced for the 3rd June 2018.

In 2016 ATAC had a debt of 1.3 billion euros and was de facto insolvent. ATAC has to present each year a bank guarantee of 12 millions of euros in order to be recorded in the register of enterprises, but no bank was willing to guarantee for ATAC. The public enterprise therefore decided to start the procedures for the arrangement with creditors. The arrangement with creditors is procedure aimed at avoiding bankruptcy, and in general terms it is a renegotiation of the debt. ATAC will have to present an industrial plan in order to consolidate the structure of the balance sheet. If the industrial plan is not approved by the Bankruptcy Court, the city of Rome will run the risk of ending up without a public transport provider in a matter of few months. This is of course the worst possible scenario. It is in the interest of all parties to avoid the total block of public transportation.

In the meanwhile, the radical party "Radicali Italiani" and the committee "Mobilitiamo Roma" promoted a referendum, which was later approved by the Mayor Virginia Raggi. Roman citizens are called to answer the following questions:

"Do you want that Roma Capitale entrusts all the services related to local public transport, which includes surface transport and underground, to a plurality of enterprises, guaranteeing comparative competition […]?"

and

"Do you want that Roma Capitale, beside the the sevices related to local public transport on surface and underground, favours and promotes the exercise of other forms of collective transport by competitors?"[6]

Both proposals are aimed at improving competition in the transport market. The first question is about competition within public transportation, while the second concerns other forms of collective transport that will improve mobility. According to the supporters of the referendum innovations and lower costs will come with more competition. However, we believe that a central planning authority

[6] Loose translation from the Official website: "Mobilitiamo Roma" http://mobilitiamoroma.it/ . For completeness we report the full question in Italian : "Volete voi che Roma Capitale affidi tutti i servizi relativi al trasporto pubblico locale di superficie e sotterraneo ovvero su gomma e su rotaia mediante gare pubbliche, anche a una pluralità di gestori e garantendo forme di concorrenza comparativa, nel rispetto della disciplina vigente a tutela della salvaguardia e la ricollocazione dei lavoratori nella fase di ristrutturazione del servizio?" and "Volete voi che Roma Capitale, fermi restando i servizi relativi al trasporto pubblico locale di superficie e sotterraneo ovvero su gomma e rotaia comunque affidati, favorisca e promuova altresì l'esercizio di trasporti collettivi non di linea in ambito locale a imprese operanti in concorrenza?"

is needed in order to provide integrated timetables and save users' time costs at least within the public transportation sector.

The future of public transport in Rome is very uncertain and many scenarios are possible. ATAC is on the edge of bankruptcy: if the arrangement with creditors will not be approved the municipality of Rome will have to find other providers. On the one hand, new providers may be more efficient; on the other hand, the bankruptcy of ATAC will entail high costs: its knowledge of the territory and its know-how will be dispersed. A gradual liberalisation of ATAC could be the the best solution to lower costs and at the same time do not waste the expertise that ATAC has built in the last century.

2.6 Conclusion

In this chapter we have analysed public transportation with a positive approach, in particular we have taken into examination the public transport operator in Rome: ATAC.

Starting from the supply side, ATAC is a public enterprise controlled by the municipality of "Roma Capitale". It is a large public transport enterprise, and as such it is included in the group of Italian public transport enterprises which exhibit economies of scale and density. On the cost side, the major expenses include personnel, gasoline and replacement parts. The service provided by ATAC includes surface transport (59% of the total km/vehicle offered), underground (31%) and railways (10%). As to the fare scheme, it is substantially time based.

In particular, we have analysed in detail the BIT ("Biglietto Integrato a Tempo") which is valid for 100 minutes and for one underground ride; the BTI ("Biglietto Turistico Integrato"), now ROMA 72H, which is valid for three days; and annual subscription. The approach chosen was that of analysing the behaviour of three different categories of users: occasional riders, tourists and regular commuters.

In the analysis of the sales volume, we have found out that all tickets sales but the annual subscription have fallen after the increase of the price in 2012. The increase of sales volume of annual subscriptions seemed counterintuitive, but we have found different explanations for this phenomenon. Factors affecting demand had a differential impact on the different categories of tickets. Firstly, if we think of annual subscription as an inferior good, incomes have started declining in 2012 due to the EZ crisis. Secondly, the price of substitute, gasoline, has reached its peak in August 2012. Thirdly, the relative price with monthly subscriptions has actually declined, thus annual subscriptions are relatively more convenient.

The change of fares in 2012 allowed us to make a rough estimation of own-price elasticity. As expected, tourists' demand is the more inelastic than the one of occasional riders; while the elasticity of regular commuters results positive because we do not have enough data to disentangle the effect of income and oil price.

We have dedicated the last two paragraph to the issues that ATAC is facing today: an unsustainable debt, the arrangement with creditors and the consultative referendum. In 2016, the debt amounted to 1.3 billion euros and was the facto insolvent. In absence of the bank guarantee needed to be in the Register of Enterprises, ATAC started the procedure for the arrangement with creditors. In the next months ATAC will have to present an industrial plan which must be approved by the Bankruptcy Tribunal. In case of denial, the city of Rome risks to find itself without a public transport provider. In the meanwhile, the party “Radicali Italiani” and the committee “Mobilitiamo Roma” promoted a referendum aimed at improving competition in the sector of transport. The referendum will be held on the 3rd June 2018, however it is just a consultative referendum which imposes no obligation on public authorities.

In conclusion, ATAC even though troubled, has been the public transport operator of Rome for more than a hundred years and thus has an invaluable expertise and knowledge of the territory, we believe that the bankruptcy would entail high economic costs. The best solution may be a gradual liberalisation, which would allow to lower costs and do not disperse ATAC know-how.

Conclusion

Public transport is a vital component of efficient mobility systems in medium and large cities. This is why an important branch of economics is devoted to transportation.

We investigated whether public transport is a natural multiproduct monopoly. We found out that even though data support the hypothesis of economies of scope, there are not enough evidences for establishing the existence of economies of scale. However, transportation differs from other commodities in the fact that consumers must supply a necessary input: their own time. If we include users' time costs, public transport exhibits economies of scale. This is the so called Morhing effect (Mohring, 1972), and the intuition is the following: for passengers it may be more convenient to have a single operator who can provide integrated schedules and faster connections, which reduce the average journey time, and consequently time cost. In his milestone paper, Mohring advocates the subsidisation of public transport in order to achieve the welfare-maximising price.

In line with the idea of Mohring, we reported a model proposed by L. J. Basso and S. R. Jara-Dìaz (2010) which proves that a profit-maximising monopolist would charge a higher price and provide a lower frequency with respect to a welfare-maximising operator, who accounts for time costs. The model suggests that the subsidy should cover all production costs, however, this may not be optimal if we add layers of complexity and we take into account government's budget constraints.

Further arguments support the subsidisation of public transport. The use of public transport can solve two important negative externalities: congestion and pollution. Buses occupy less space and emit less CO_2 with respect to passenger-equivalent private vehicles.

In conclusion, there is general consensus for the subsidisation of public transport, but there is no clear indication on the optimal size of the subsidy.

The theoretical conclusions are matched in the reality: the European Union recognises the right of public transport operators to receive a compensation in return for the discharge of public obligations[1]. However, Rome is a shining example of how over-subsidisation can make a serious damage. In 1994 ATAC, the urban transport provider, and CoTraL, the regional transport provider produced the 70% of the total debt of the municipality of Rome[2]. The situation got worse in 2002, when the Title V of the Constitution was modified: it was no longer possible to cover through debt the obligations relative to service contracts. As a result, the funds that the municipality devoted to

[1] (EC) No 1370/2007

[2] Lanzillotta, L. (2004). Controliberalizzazioni: il caso del trasporto locale a Roma. *Mercato Concorrenza Regole*, *6*(3), 549-558.

public transportation were cut. The debt was unsustainable, and in 2012 ATAC had no choice but to raise its fares. This event gave us the opportunity to estimate the short-term elasticity of demand.

We have identified three kinds of users: occasional users, tourists, and commuters; and we have associated each user with a fare, respectively, the BIT (valid for 100 minutes), the BTI / ROMA72H (valid for three days) and the annual subscription. We found out that occasional users have a quite inelastic demand (-0.33), meaning that public transport is more a necessity rather than a choice. As expected, tourists are the most inelastic (-0.16); using public transport is by far more convenient than renting a car.

As far as annual subscriptions are concerned, we noticed that sales increased when the price raised. This is clearly not enough to establish that annual subscriptions are a Giffen good, the increase in the volume of sales can be due to at least three reasons. Firstly, the price of monthly subscriptions raised more in percentage terms, making annual subscription relatively more convenient. Secondly, the rise in unemployment and the decline in wages augmented the demand for annual subscriptions, if we reasonably assume that it is an inferior good. Thirdly, the price of a substitute, gasoline, has reached its peak in August 2012.

The knowledge of own-price elasticity will enable policy-makers to design future fare schemes. The current financial scenario, the arrangement with creditors and the possible bankruptcy, suggests that a structural reform of public transport in Rome might be necessary in the short term.

The future of public transportation of Rome is very uncertain. On the one hand, the possible bankruptcy of ATAC can be seen as an opportunity to restart from zero and make the provision of public transport more efficient. On the other hand, this would entail a high cost: ATAC has been the public transport provider of Rome for a hundred years, its knowledge of the territory and its know-how would go wasted. The best solution may be a structural reform within ATAC, or alternatively a gradual liberalisation.

References

Agenzia per il controllo e la qualità dei servizi pubblici locali del Comune di Roma, (2012). Transporto Pubblico Locale a Roma: Affidamento dei servizi e analisi di mercato.

Albalate, D., & Bel, G. (2010). Tourism and urban public transport: Holding demand pressure under supply constraints. *Tourism Management*, 31(3), 425-433.

Basso, L. J., & Jara-Díaz, S. R. (2010). The case for subsidisation of urban public transport and the Mohring effect. *Journal of Transport Economics and Policy (JTEP*), 44(3), 365-372.

Cambini, C., Paniccia, I., Piacenza, M., & Vannoni, D. (2007). Struttura di costo e rendimenti di scala nelle imprese di trasporto pubblico locale di grandi dimensioni. *Rivista italiana degli economisti*, *12*(1), 43-78.

European Commission, Directorate- General for Communication Citizens information, (2014). The EU explained: Transport.

Evans, A. W. (1991). Are urban bus services natural monopolies?. Kluwer Academic Publishers, *Transportation*, 18(2), 131-150.

Farsi, M., Fetz, A., & Filippini, M. (2007). Economies of scale and scope in local public transportation*. Journal of Transport Economics and Policy (JTEP*), 41(3), 345-361.

Fazioli, R., Filippini, M., & Prioni, P. (1993). Cost-structure and efficiency of local public transport: the case of Emilia Romagna bus companies. *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti*, 305-324.

Fetting, D. (1996). Primer on congestion pricing. *FedGazette*, Federal Reserve of Minneapolis, April issue.

Fraquelli, G., Piacenza, M., & Abrate, G. (2001). Il trasporto pubblico locale in Italia: variabili esplicative dei divari di costo tra le imprese. *Economia e Politica Industriale*, 51-82.

Fraquelli, G., Piacenza, M., & Abrate, G. (2004). Regulating Public Transit Networks: How do Urban-Intercity Diversification and Speed-up Measures Affect Firms' Cost Performance?. *Annals of public and Cooperative Economics,* 75(2), 193-225.

Glaister, S. (1974). Generalised consumer surplus and public transport pricing. *The Economic Journal*, 84(336), 849-867.

Gwilliam, K. (2017). Transport Pricing and Accessibility. *Moving to Access*, Brookings.

Joskow, P. L. (2007). Regulation of natural monopoly. Handbook of law and economics, 2, 1227-1348.

Lanzillotta, L. (2004). Controliberalizzazioni: il caso del trasporto locale a Roma. *Mercato Concorrenza Regole*, *6*(3), 549-558.

Levaggi, R. (1994). Parametric and non parametric approach to efficiency: the case of urban transport in Italy. *Studi Economici*, n.53, 67-88

Marabucci, A. (2016) La domanda e l'offerta di trasporto pubblico locale a Roma: analisi del titolo di viaggio BIT (Biglietto Integrato a Tempo). *Rivista di Economia e Politica dei Trasporti,* issue 3, ISSN 2282-6599

Mohring, H. (1972). Optimization and scale economies in urban bus transportation. *The American Economic Review,* 62(4), 591-604.

Moses, L. N., & Williamson Jr, H. F. (1963). Value of time, choice of mode, and the subsidy issue in urban transportation. *Journal of Political Economy*, 71(3), 247-264.

OECD (2017) "ITF Transport Outlook 2017"

Oram, R. L. (1979). Peak-period supplements: The contemporary economics of urban bus transport in the UK and USA. *Progress in Planning*, 12, 81-154.

Proost, S., & Van Dender, K. (2008). Optimal urban transport pricing in the presence of congestion, economies of density and costly public funds. *Transportation Research Part A: Policy and Practice*, 42(9), 1220-1230.

Quarmby, D. A. (1967). Choice of travel mode for the journey to work: some findings. *Journal of transport Economics and Polic*y, 273-314.

Savage, I., & Small, K. A. (2010). A comment on'subsidisation of urban public transport and the mohring effect'. *Journal of Transport Economics and Policy (JTEP)*, 44(3), 373-380.

Tirachini, A., Hensher, D. A., & Rose, J. M. (2014). Multimodal pricing and optimal design of urban public transport: The interplay between traffic congestion and bus crowding. *Transportation Research Part B: Methodological,* 61, 33-54.

Van Reeven, P. (2008). Subsidisation of urban public transport and the Mohring effect. *Journal of Transport Economics and Policy* (JTEP), 42(2), 349-359.

Walter, M. (2009). Economies of scale and scope in urban public transport.

Sitography

ANSA, (2017). Italia Paese Ue a più alta densità auto, Roma al top. url: http://www.ansa.it/motori/notizie/rubriche/industriamercato/2014/10/28/italia-paese-ue-a-piu-alta-densita-auto-roma-al-top_8b10de6b-b4ba-4b17-8945-8903eeb7a64d.html

CODACONS, (2017). Roma, ATAC, su metro doppi tornelli anti portoghesi. url: https://codacons.it/roma-atac-metro-doppi-tornelli-anti-portoghesi/

Moovit, (*consulted in April 2018).* Informazioni e statistiche sui mezzi pubblici nell'area di Roma, Italia. url: https://moovitapp.com/insights/it/Analisi_Moovit_sull_indice_per_la_mobilità_pubblica-61

State of Delaware: the Official Website of the First State, Division of Waste and Hazardous Materials (*consulted in February 2018)* The Environmental Benefits of Riding Public Transit. url: http://www.dnrec.delaware.gov/dwhs/info/Pages/OzonePublicTrans.aspx

UITP (2015), Monthly Focus: The Economic Impact of Public Transport. url: http://www.uitp.org/news/monthly-focus-economic-impact-public-transport