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A new approach for the freight transportation system in Venice

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Abstract

Venice is worldwide known as one of the most intriguing places, hosting an average of 15 million tourists per year. This paper describes the causes of the economical inefficiency of the freight transportation system in Venice, and analyses the problems caused by the damages done by the waves. A properly modified form of road pricing, aiming at improving the efficiency of the traffic chains by introducing the pressure of competition between the freight operators, is thereby conceived and the possible deriving scenarios are described.

Keywords: Venice; Lagoon; Wave; Road pricing; Freight; Transportation.

1. Introduction

A "peculiar" city of Arts has "peculiar" traffic problems and requires thereby a "peculiar" approach. In Venice, the increasing amount of freight boats causes an unsustainable wave motion which jeopardizes the survival of the foundations of the old buildings by the sides of some canals.

After reviewing the past attempts to reduce the problem of the wave motion, this paper considers hereby the movement of the boats as a mere kinetic phenomenon, considering the effects of congestion and pollution ultimately not much relevant.

Taking these preliminary remarks into account, a new traffic tool is conceived and thoroughly explained. The possible scenarios deriving from the effectiveness of the tool, and their consequences on the freight delivery system are analysed, leading to the conclusion that the intervention proposed in this paper should be possible, even in a such complex, "peculiar" background.

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1.1 Short notes on the city

An incessant, slow, physical metamorphosis has characterized Venice from its foundation till the present days, due both to the erosion produced by the sea and to the deposits carried by the rivers (Caniato et al., 1999).

This evolution has led to several interventions, accomplished especially by the Venice Republic in the 18th century, meant to keep under control on the rivers of the region, to open new canals, to create the so-called "*bocche di porto*" (i.e. the openings that connect the sea and the lagoon), and other interventions to protect the seafront of the lagoon.

The city changed along its history especially with the establishment of the railway bridge which connects the islands and the mainland (1846) and with the road bridge (1932): San Marco lost then its role of city headquarters becoming a tourist hotspot; the Arsenal and Salute dismissed their respective docking and duty roles. Unlikely, Rialto always kept its ancient role, having always been the commercial centre of Venice with markets and banks. The terminal of *Piazzale Roma* and the *Tronchetto Island* were also created as the new access gates for Venice, both for freight and for passengers. This area (*Tronchetto, Piazzale Roma* and the *Rail Station*, see figure 1) receives the 100.000 people arriving daily in Venice, switching them to the public boat service.

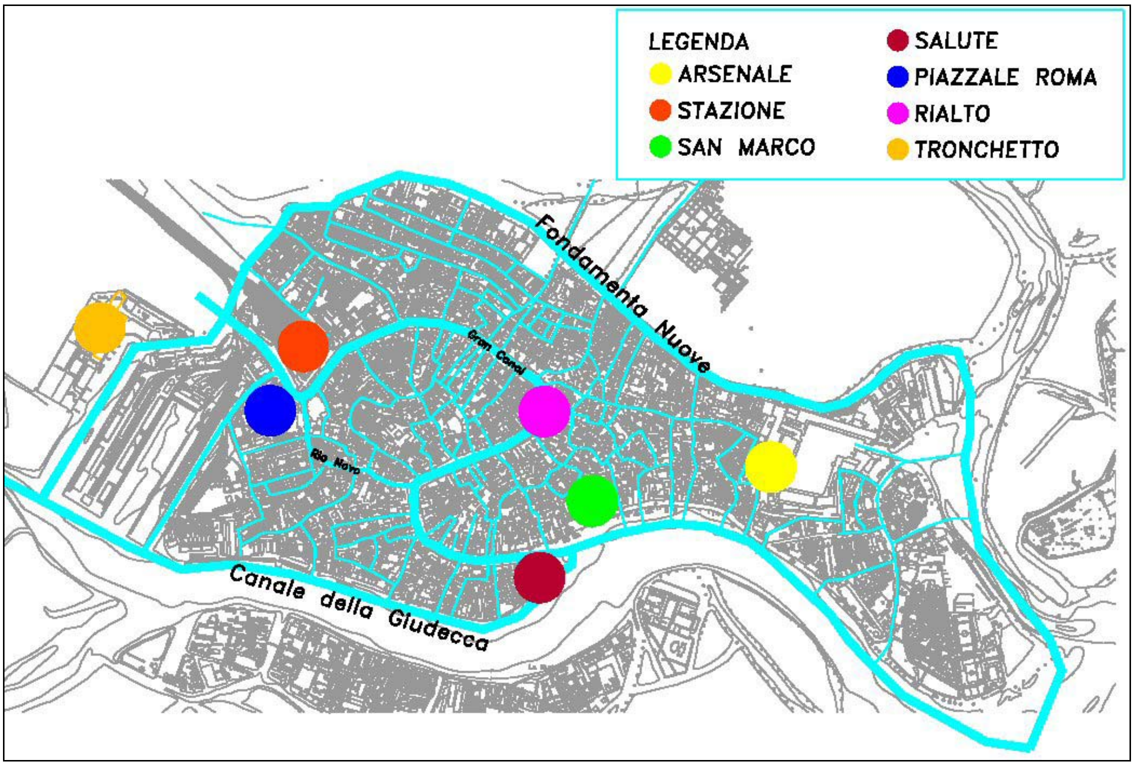

Figure 1: Plan of the city of Venice.

The transport network of the city is made from a central axis (*Gran Canal*) starting in *Piazzale Roma* and crossing the whole city up to *San Marco*, and a set of smaller canals which connect the *Gran Canal* with an external ring of greater canals surrounding the whole city (*Giudecca* and *Fondamenta Nove*, figure 1). This network has never changed, despite the creation of *Rio Novo* (1933, in order to link more directly *San Marco* and *Piazzale Roma*) and the burial of some canals during the Austrian and French occupancy along the 19th century.

1.2 Transportation issues in Venice

The appearance of different kinds of motor boats in the lagoon is quite recent: the first motor boat for public transport appeared in 1881 and remained for a long period the only motorized typology allowed. The first private motor boats appeared later (1960s). They were mainly used for freight transport, and suddenly took control over the canals. Nowadays, several typologies (both for passengers and freight) are sharing the available water space. The boats for passengers are:

- Public transport service, provided by the firm ACTV (Venice Transport Public Company), serving the stops spread in the city, whose allowed speed along the main canals (*Gran Canal, Giudecca canal, Fondamenta Nove*) is 11 km per hour.
- Taxis, which are allowed to run at 20 km per hour on the external canals and 5-7 km per hour in the inner ones. These boats are smaller than the ACTV ones and are able to run along the smaller canals of the city.
- Gondolas, divided in two categories: *traghetti*, used especially by Venetians, which link continuously the two banks of the *Gran Canal*, and the gondolas providing tourist sightseeing trips. There are no official estimations about the number of gondolas in use but they can roughly be considered around 500 units.
- Private boats, used by hotels and cruise organizers collecting people at *Tronchetto*.

The mobility network of Venice (both for passengers and freight) can not be compared with those of other cities (considering canals as roads), given the poor employment of boats for individual mobility and the very high ratio of foot-traffic.

Besides, pollution and congestion are not to be seen as the main issues in the Lagoon of Venice: the boat traffic is not the main pollutant factor for Venice, as the pollution produced both from the chemical industries of *Marghera* and the vehicular traffic of *Mestre* (both on the mainland of Venice) is carried by the wind. On the other hand, congestion affects just the main canals in the rush hours.

Unlike other cities, vehicles are then to be considered not as a pollutant, but as a kinetic concern. The boat traffic causes damages through the formation of waves, whose height depends on the speed and the tonnage of the boat, and on the section and the depth of the canals. The flow of boats produces mainly two forces on the banks: the first is caused by the waves directly generated by a boat itself (this is typical of smaller ships) and the second by the whirlpool of the seabed water (dominant for bigger boats). The waves cause a faster process of erosion, augmenting the porosity of the stones and the bricks that constitute the banks.

The small amount of boats for passenger mobility and the review of some previous analyses (see also section 2.2) suggest to focus on the freight.

The delivery of freight within the city is carried out by an oligarchy of carriers: a small percentage of this oligarchy uses private boats for transporting their own freights, while the greatest amount of the deliveries are carried out by transporters operating for third party clients. Presently, there are about 400 licensed boats, but a large amount of unlicensed carriers is present in the city (almost 200 boats)

This fleet is composed of boats different in terms of size and materials. These characteristics define the load capacity of the boats (defined for each ship at the registration). The most common boat for freight transport is the so-called "*mototopo*" (6-14 meters long, with a minimum 3.5 tonnage).

Half of the fleet is equipped with peculiar features like freezers, safe-deposit boxes etc., while the other ships are often used for general freight transport and pony express deliveries (figure 2).

Figure 2: A typical Venetian boat used for freight transport.

The logistic chain of Venice has its centre in *San Giuliano*, on the mainland, in the *Tronchetto* Island (the switching point with the road network) and in the *Fondamenta Nove* (figure 1).

The shipments are mainly concentrated early in the morning and, leaving from the collecting points described above, concern the city centre, through the *Gran Canal* and the smaller canals. Different paths are followed according to the final destination: ships directed in the city centre from the railway station follow the *Gran Canal* up to *Rialto*. The ones directed in the areas between *Rialto* and *San Marco* follow the *Rio Novo*. The *Rio Novo* is one of the busiest canals, counting up to 1800 passages per day of freight boats (60% of the overall boats passing through the *Rio Novo* - Coses, 2003).

Nearby *Piazzale Roma*, the railway bridge represents a hot spot for the ring navigation. This is due to its height, which does not allow the transit of big boats, and force them to transit in the *Gran Canal* in front of the rail station (2100 passages per day, Coses, 2003), extending significantly the length of each trip (Coses 2002a, 2002b, and 2003). The latest surveys showed an increase of 40% of the boat passages between 2001 and 2002 (Coses 2002a, 2002b, and 2003).

A very weak competition among the shipment companies, which apply flat rates reflecting a standard fare for all the operators, comes out from this picture. An external tax, evaluated according to the principles described further in the paper (with the free-of-charge tolls given to the shippers and the possibility of selling them back to the public administration) would cause a change in the actual non-competitive stuck situation.

1.3 Previous attempts to solve the problem of the wave motion

The economical and traffic systems of the city of Venice have already been object of numerous studies: a staff of Worcester Polytechnic Institute led by Dr Fabio Carrera promoted a study within the UNESCO project "Venice inner canals" to evaluate how to reduce the damages for the shopkeepers caused by the closing of the canals for their extraordinary maintenance.

The proposal of Carrera, developed in three different publications (Carrera, 1999a, 1999b & 2005), assigned to a public corporation (which was later identified with the municipality of Venice) the coordination of the contracts for the deliveries, which were to be granted to the lowest bidder. This would have caused a zone-oriented (instead of the present product-oriented) distribution, reducing the amount of circulating boats and thereby the wave motion.

The increase in the number of landing places in the islands and a different management of the warehouses would have allowed to reschedule the deliveries with less on-board and more ashore workers.

The researches of Coses (2002a, 2002b, and 2003), and Insula (2002) offered the numerical surveying, upon them several strategies for solving the problems related to the mobility (such as speed limits, traffic restricted areas, specific hours of accessibility, one-way canals and so on). Most of them failed because they were not negotiated with the subjects involved.

The authorities dealing with boat traffic have been recently unified in the so called "Governor's supervisor for Wave Motion", aimed at "facing the emergency occurred in the City of Venice, in its lagoon and in the sea canals".

The Governor's supervisor identified the new proposals for interventions defined by the Traffic Restricted Zones regulation (17 June 2005): according to the greater or smaller section of the canals and the weakness of the environments, the supervisor for the traffic within the Venetian Lagoon has defined the new speed limit along the canals (figure 3).

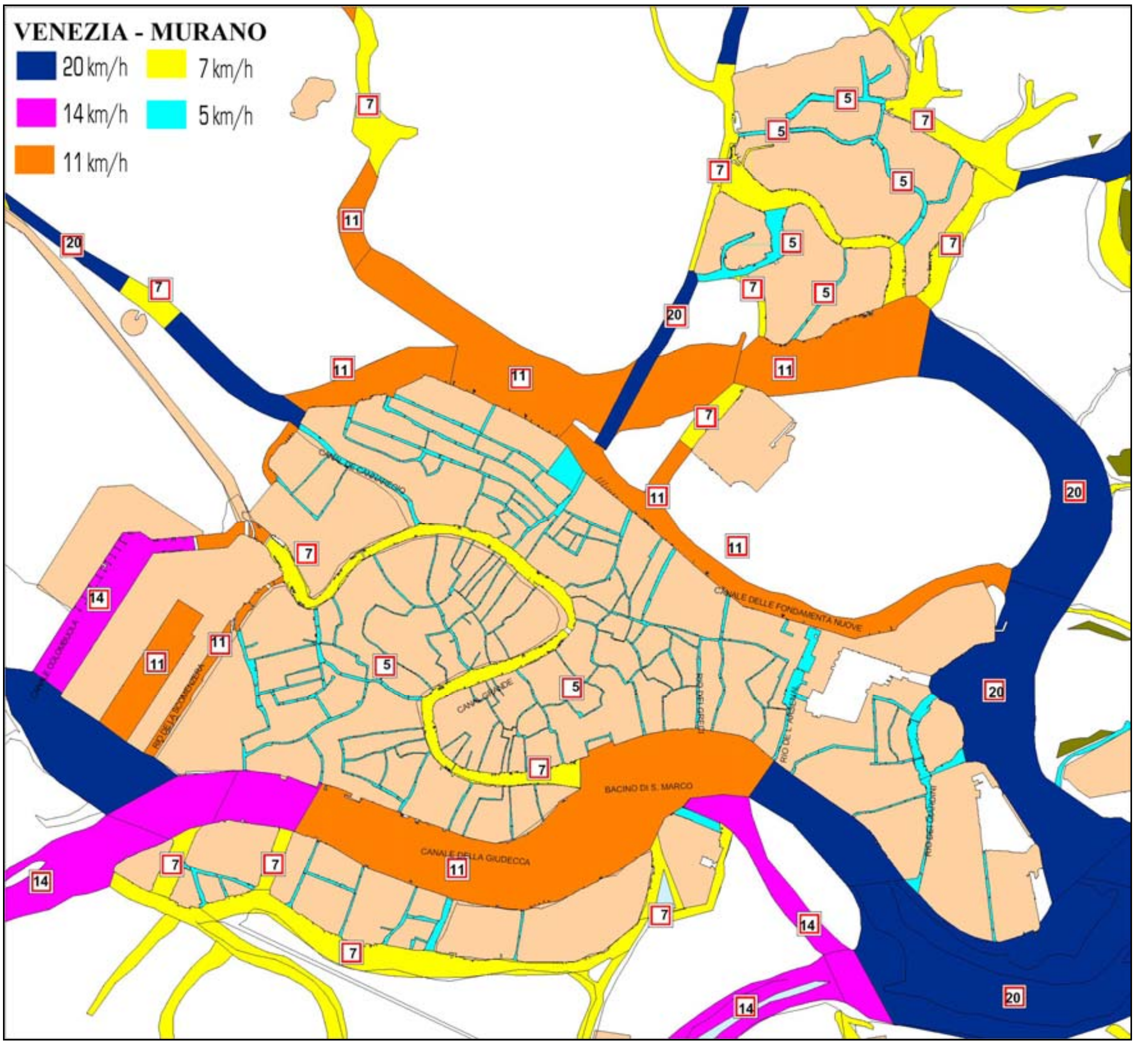

Figure 3: Speed limits in the Lagoon after the decision of the Government's supervisor for the traffic.

In spite of this rule, the problem of the wave motion does not seem to be solved: only the smaller canals gained advantage from the limitation to the passage of motorboats. The new rule has not changed much the traffic in the other canals, mostly due to the deficiency of a concrete policy in the freight movements.

2. Description of the pricing tool and its effects on the lagoon

2.1 Introduction

The pricing tool considered in this section is part of a wider plan, containing several proposals meant to solve the problematic transportation system within the Lagoon of Venice, and meant to reduce the impact of the waves.

In order to keep control on the mileage covered by boats, a direct equivalence between mileage and money is proposed. A credit is defined as the right to cover a length unit, identified as a canal between two check points.

2.2 Choice of the freight boat as target

The 35-40% of the total distances daily covered within the canals is run by freight ships (Coses 2002a, 2002b, and 2003). As a consequence, the attention has to be focused on the freight boats: their number and their size makes them chiefly responsible for the formation of waves.

Previous studies (Carrera 1999a, 1999b, and 2005) and the analysis of the current state have underlined a wide margin of optimization for both the delivery paths and the load ratios of the ships, since the actual ratio is lower than the 60% of the maximal tonnage.

The total mileage of the paths followed by freight boats could be cut down at the 20% of the distances currently covered (Carrera, 2005). This inefficiency is due to several reasons:

- a “product-oriented” delivery principle: each kind of good required by a store is delivered by a different shipper (e.g.: a brand of beer is distributed by one boat at several bars in Venice, while a second boat ships other kinds of beverages at the same bars, a third one ships food, and so on);
- A large amount of empty trips: the incomes of shippers are much higher than the fuel price and thereby they are not encouraged to improve the paths of their deliveries;
- A society based on close personal relations: shippers use every day the same bar and the same restaurant for their lunch, no matter in which part of the city they are at lunch time.

A “natural” suggestion for the pricing tool would then drive towards an increase of load ratios and a different choice of the paths of the freight boats.

2.3 Proposal for an innovative road pricing tool

This particular road pricing system implies the application of road pricing on the network of canals that constitute the road system of Venice (figure 4).

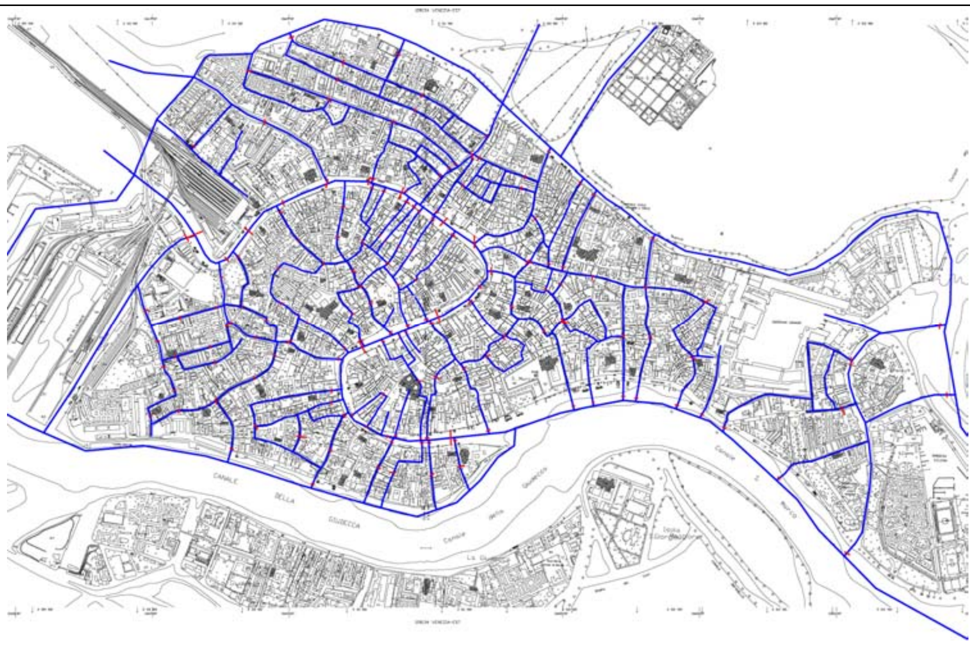

Figure 4: Canal network in Venice and location of the check points (in red).

Differently from other cases, in which the check points are located along the perimeter of the city, in this pricing system the check-points are extended along the whole net of canals with a hot spot distribution having increased density along the most sensitive banks (meant to preserve them from the destroying effects of the waves).

The solution proposed is meant to keep control over the rates applied to each shipment; this is a particular deal within Venice as far as the high costs of transport are declared to be the reason of the high prices applied in the city compared with the same products sold in the mainland.

With the aim of avoiding an immediate rise of the fares, the procedure gives any shipper an amount of free-of-charge tolls, the amount of which is calculated with the procedure described in section 2.5. This amount can be increased by buying permits from the government/system administrator, whenever needed.

The innovative aspect of this proposal is the possibility of either selling back each year the unused tolls to the administration, or keeping them for a future use. The income gained aims at promoting an optimization of the paths travelled, in order to save as many credits as possible.

Better delivery trips, a higher load ratio, and, above all, an effort for a different delivery procedure, would change the present product-oriented ("one good – one shipper") shipment in a destination-based one (see section 2.2).

The only subject allowed to buy back someone's unused credits is the public administration: this avoids speculations (e.g. people forced by someone to sell them their unused credit at an excessively low price), which would make the pricing tool ineffective.

The free tolls must be distributed by the public administration, considering an existing division within the carriers: the pricing tool will affect only the ones who convey freight mainly within the City Centre, avoiding those running through external canals.

A period of 20 years is considered suitable for reaching the goals proposed from this tool. Considering the difficulty of improving the supply chain within a shipping enterprise, a function is required to establish an appropriate schedule in the distribution of the free tolls (see following section 2.4). This function is represented by a concave curve. Since the first years have a higher improvement margin, the optimization rate is set at 15% for the first two years and then is decreased progressively every 5 years. The limit of this curve is set at the value corresponding to the 20% of the distances covered nowadays. This value is increased by 2,5% each year according to the increasing tax of freight transportation in Italy (Cappelli et al., 2005).

2.4 Description of the procedure adopted to assign the free of charge tolls

In this section the schedule of application of the pricing tool will be described, focussing onto the method used to calculate the free tolls distributed each year.

The first year of application (year 0) will be used for placing the check-point gates and for providing the shippers with the equipment to be installed on the boats. Other important tasks carried out in year 0 are awakening the shippers and collecting the data required for calculating the amount of free tolls to distribute the following year. The distances covered during year 0 are computed by analyzing the receipts compiled by the shippers for each delivery, which will contain the exact list of the canals used. The mileage covered corresponds to the amount of credits that the shipper would have used if the pricing tool had already been applied.

According to this basic value, on year 1, which is the first year of real application of the pricing tool, the function adopted provides a total amount of credits that corresponds to the 110% of the distances covered on year 0.

The increase provided is meant to avoid a limit in the companies' commercial growth by the tax eventually caused. The efficiency of the pricing tool for year 1 is measured through the effort of the shippers in saving the greater amount of free tolls, which, if sold back to the public administration, would produce an additional income in the company's financial balance.

The next year (year 2) the amount of free tolls distributed to each operator is lowered of 15% (93,5% of the distances covered during year 0). The constructive part of the pricing tool begins here: the shippers, aiming at keeping their commercial share, are forced to improve their logistic efficiency, in order to avoid the payment of the additional mileage covered. The improvement, which implies the reduction of 6,5% of the distances run compared with year 0, could be achieved just avoiding the unpaid trips (the ones covered for leisure or for a private use). The unused tolls are sold back as well.

2.5 Possible scenarios: success, failure and expected results

The total expense for the public administration (besides the costs for the equipment and its maintenance) is given by the success or failure of the pricing experience.

The following formula explains the economical sustainability of the tool proposed here by expressing the income (or the costs) for the public administration:

$$F = \left[\left(\sum_{i=1}^{N} (t_i - tg_i) \cdot p_i - K \right) \cdot (1+r)^i \right] \tag{1}$$

where:

F: income or costs for the public administration;
N: amount of years taken into account;
t_i: amount of tolls used in year i;
tg_i: amount of free tolls distributed in year i;
p_i: price of a free toll in year i;
K: fixed payments (equipment, maintenance etc.)
r: current interest rate

The case of a total inefficiency of the procedure (the shippers keep on travelling the canals without any logistic improvement, making the final customers pay for the additional tolls bought) is considered in figure 5: in this case, the income for the public administration would be given by formula (1), considering a rising in the mileage covered according to the general increasing in freight transport.

This result can also be drawn from figure 5, considering the quantity (t_i – tg_i) as the difference between a black and a white column at a given year *i*.

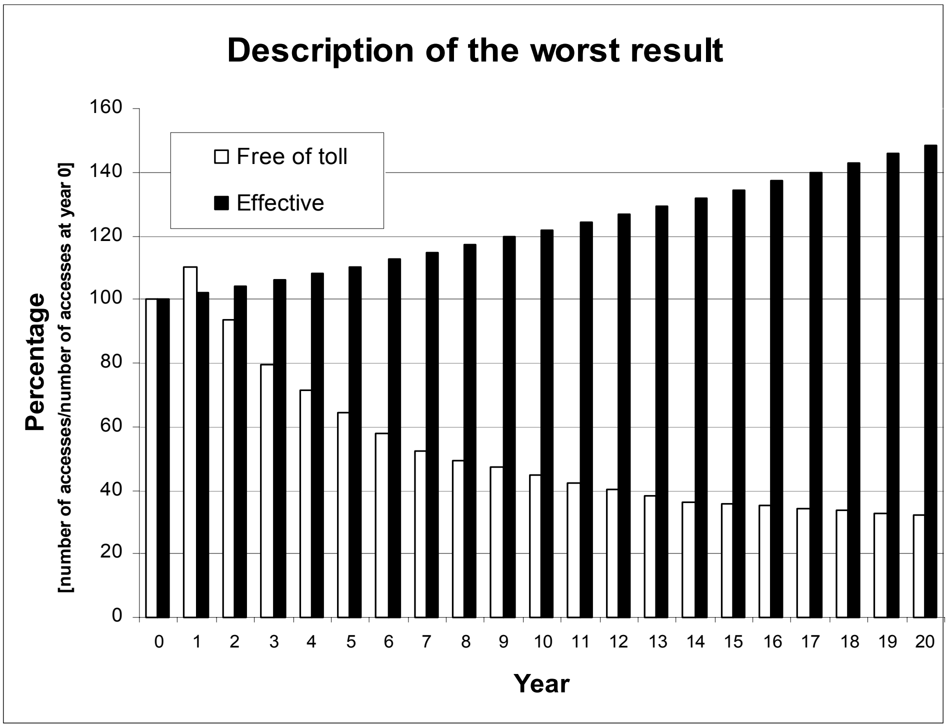

Figure 5: Description of the worst result of the tool.

Formula (1) can describe the opposite outcome as well. A perfect response of the operators (figure 6) would mean that the actually covered mileage reaches immediately the minimum possible value, which, according to previous studies (Carrera, 2005), can be estimated as the 20% of the current one. The public administration will face in this case a total cost given by the purchase of the free tolls distributed and not used, being tg_i (white columns) lower than t_i (black columns).

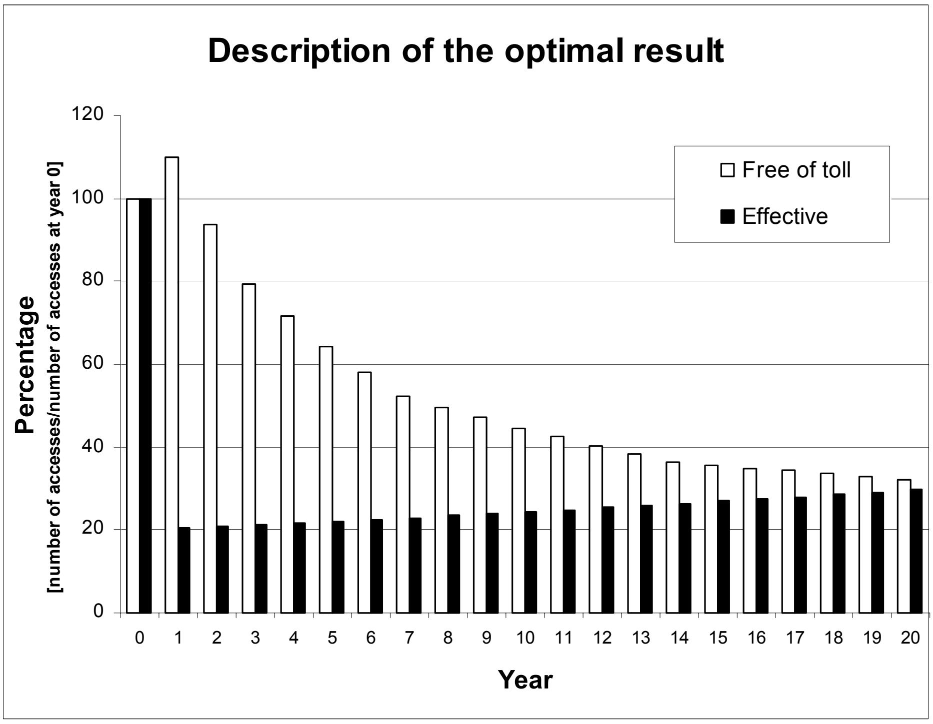

Figure 6: Description of the optimal result of the tool in the best desired scenario.

Figures 5 and 6 represent two polar, opposite situations, but at the same time show clearly that the main issues of the pricing tool proposed here are the price paid by the shippers for an extra toll and the one paid by the administration for buying the unused tolls back.

In case of an excessively low price for the extra tolls, compared with the delivery fares adopted, the tendency would probably be similar to the first described scenario. It would mean no improvement in the supply chain: the shippers would keep on with the present delivering procedures.

On the contrary, an excessive price would cause the paradox of a complete stop of all the delivery operations, due to the fact that the shippers would consider more remunerative to stop their boats and sell all the credits back to the public administration (with the obvious consequences for the city).

A moderate toll price would produce the desired intermediate scenario: a substantial and progressive increasing of the logistic chain, in which the most of the operators would be located around the toll-refund line. Some of them would optimize their deliveries optimizing the load ratio of the ships and taking advantage by the final return of the unused tolls. Other transporters would instead be forced to buy a few more tolls, being unable to optimize their supply chain (figure 7).

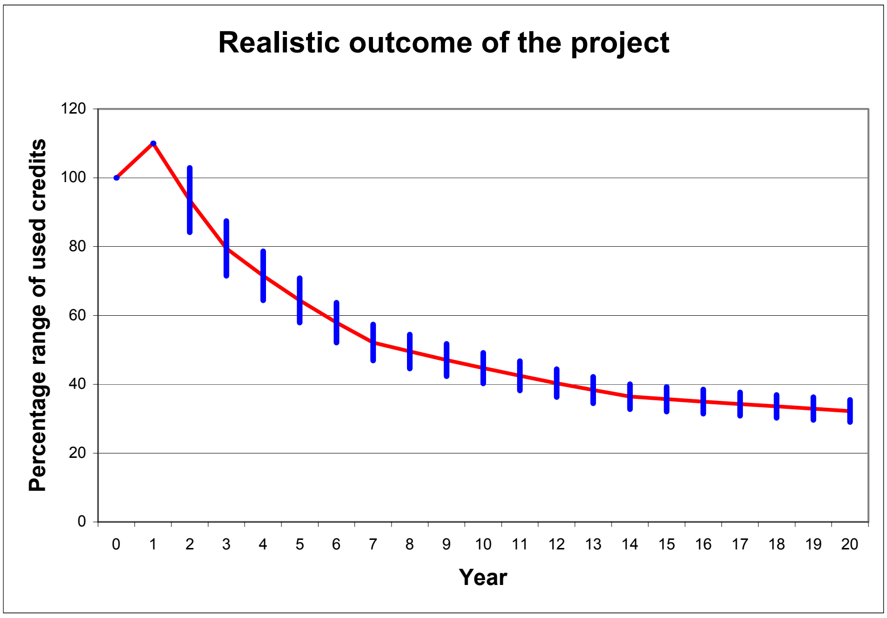

Figure 7: Representation of the realistic outcome of the tool.

The red line in figure 7 represents the same function of distribution of free credits, as the one expressed from the white column in the figures 5 and 6. The blue lines try to predict the behaviour of the shippers, who are expected to be closer and closer to the red tendency, as the pricing tool becomes established.

This gap in the final income (effective income plus refunding of the unused tolls or effective income minus price paid for buying additional tolls) will improve the competition within the sector, which is almost nonexistent nowadays. The ones who spare miles will be able to lower their rates in order to attract new users, as far as they can have benefits by selling their unused tolls back. The others, unable to save tolls, will on the contrary face additional costs given by the extra credits bought; as a consequence, they will increase their fares running out of market, which will force them to improve their logistics for the next year.

The analysis of figures 5 and 6 has not to be considered in mere economical terms: also environmental aspects play a role in the overall consideration of the effects. Venice would gain from the tool in any case: in the polar, worst case (figure 5) the inefficiency of the tool would be rewarded by some extra money, which the municipality could invest in a more frequent maintenance of the banks. In the opposite, best case (figure 6), the tool would effectively reduce the mileage covered by the boats and then directly the erosion of the banks. In the more realistic, intermediate scenarios described in figure 7, the total expenses for the public administration would be the maintenance of the equipment, as the tolls refunded would be almost equal to the additional tolls sold.

The optimal distribution of the check points must be evaluated carefully, in order not to worsen the accessibility of some inner areas of the city, but for avoiding the crossing of those areas for the delivery of small amounts of goods.

For this reason, a maintenance of the free access in the external canals (*Giudecca Island* and *Fondamenta Nove* – see figure 1) is proposed, aiming at moving the trips connecting the opposites parts of Venice to the less vulnerable areas. This is to be achieved through:

- The creation of a logistic centre located on Tronchetto Island;
- A stronger policy of controls and penalties;
- An educational program for improving both the load ratio of boats and the logistics.

The cause of the present disorganization is not to be found only within the transporters, although they are responsible for a general lack in the observation of rules and technical progress. The public administration is guilty as well, since it was not able to find an alternative, suitable location for the logistic centre of *Tronchetto* (the first projects were developed in 1980 – TransCare, 2003) and has not arranged financial aids for the renewal of the fleets (the most of the boats are from the seventies and many of the others even from the sixties).

Also some shop holders share a portion of responsibility, as they swapped large social external costs for small private incomes.

3. Conclusions

This paper sums up different measures of intervention on the urban mobility system, belonging in the literature to the two main topics of "Road Pricing" and "City Logistics".

Particular originality and complexity are imposed by the area of application, i.e. the city of Venice, in which the mobility through water canals determines externality and needs therefore more complex control systems.

The pricing tool described here has the objective of modifying the status quo of the organization of the freight movement in the lagoon, with the aim of introducing the pressure of competition between the operators, who nowadays operate in a sheltered market system with low efficiency.

Because of the weakness of the ecological system and the strong rootedness of oligopolistic customs, the developed system needs to be tested (in its first year of application, always referred to as "year zero" in the previous sections), in order to calibrate the elasticity of demand, the yearly percentage of optimization of the mobility (i.e. the obtained reduction of the traffic flows) and the final objective of its total reduction (i.e. the level of reachable efficiency).

The conditions of feasibility of the intervention are in any case comparable with those of similar initiatives, with the only complication of dealing with a segment of market rather closed to external measures of rationalization, and which has been accustomed in the years "to take advantage" of the particular economical and urban conditions of the lagoon of Venice.

The analysis of the possible scenarios, however, leads to the conclusion that the margin of action of this pricing tool has to be estimated as significant, and by all means greater than the ones present in comparable situations in the traditional city areas, being the current state of freight transport demand far away from efficiency. This consideration leads to the conclusion that this intervention should be feasible even in a complex background such as Venice.

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