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Evaluation of pricing tools in urban multimodal paths

D. Ambrosino & A. Sciomachen
Department of Economics and Quantitative Methods (DIEM),
University of Genoa, Italy

Abstract

Modal change nodes play a relevant role in urban passenger mobility. The main aim of this work is to analyse different pricing tools aimed at minimizing the negative components of the transition costs from the private modality to the mass transit one at the modal change nodes. In particular, we compute and compare the generalized cost of origin-destination paths in the case of both multimodal and private networks. We report on some data related to the city of Genoa, Italy, in that for its topological and geographical structure, and the wide offer of the public transportation system, it is well suitable for intermodality. We perform some scenario analysis using the spreadsheet Excel considering different origin-destination paths and different pricing policies. In particular, we investigate some possibilities that reflect two different government policies: 1) to increase the cost of the private paths by introducing road fees and increasing the cost of the car parks in the main central areas; 2) to reduce the cost of intermodal paths by reducing both the parking fee and the bus ticket. Results obtained by using these different policies depend on many factors, among others the perception of the services offered by the mass transit transport and the cost of the transaction arcs at the modal change nodes. For these reasons, in the scenario analyses we evaluate the effect of the different pricing policies when varying the weight of two main components of the generalized cost function: the cost components and the time ones.

Keywords: multimodal passenger transport, pricing tools, spreadsheet optimization, generalized cost function, shortest paths.
1 Introduction and problem definition

Origin – destination (o-d) paths in urban passenger transportation networks can be accomplished by using different travelling modes, that is cars together with buses, subways and trains. The use of more than one transportation mode results in higher monetary and time costs due to the modality change, that is the so called transition costs, associated with a greater discomfort paid by the users; on the other hand, some travelling costs can be reduced since economies of scales can be obtained when using different transportation modalities. Even if starting from the last decades the quota of users choosing more than one transportation modality for their trip is increasing, the private modality is still the most preferred one.

As a matter of fact, the final selection of the path, either an intermodal or monomodal one, is performed directly by the user on the basis of the foreseen traveling cost, that includes also some subjective elements that are not easy to be evaluated, such as social economic factor, propulsion at walking, time perception and discomfort (strongly affected by the weather conditions). Of course, it is clear that the majority part of the negative cost components perceived by drivers are paid at the modal change nodes, that consequently strongly penalizes the multimodal solutions. Moreover, passengers ask for more adequate information about traffic conditions, transportation facilities and modal choice nodes. Indeed, in the evaluation of the optimal trade-off between benefits and costs, a crucial role is paid by the modal choice nodes.

Motivated by the above considerations, we decided to compute the generalized cost of o-d shortest paths, both on monomodal and multimodal networks, with the aim of finding different pricing tools for moving the users from the private network to the public one.

In particular, in this paper we analyse different pricing tools aimed at minimizing the negative components of the transition costs from the private modality to the mass transit one. The analysis of different pricing tolls is mainly devoted to find the best local government policy in order to reduce congestion. We investigate some possibilities that reflect two different government policies: 1) to increase the cost of the private paths by introducing road fees and increasing the cost of the car parks in the main central areas; 2) to reduce the cost of intermodal paths by reducing both the parking fee and the bus ticket.

Some research efforts have been already devoted to urban passenger mobility and to pricing tools in multimodal networks. Future directions for transportation modelling are reported in a recent work of Bielli and Ottomanelli [4]. An overview of how designing urban road pricing schemas is reported in de Palma et al. [7]. In D’Acierno et al. [6] some parking pricing strategies for obtaining a more balanced modal split in urban areas are described together with an optimization model. The authors analyse society’s global cost due to the transportation system related to local administration revenues for parking, user costs, external costs (in terms of pollution, quality of life etc.) and operational net costs of transit system. They also include in the model the equilibrium condition according to the equilibrium assignment model (Cantarella [5]).
Hamdouch et al. [8] construct a user equilibrium and system optimal model for determining tolls in a multi modal transportation system.

As far as the multimodal shortest path problem is considered, we can cite the bicriterium shortest path algorithm presented in Mote et al. [12], the method based on the evaluation of a utility function given in Modesti and Sciomachen [11], the algorithm for network with dynamic arc travel times (Ziliaskopoulos and Wardell [15]) and the adaptive methods proposed in Miller-Hooks and Mahmassani [10]. In the present work, for the computation of the shortest o-d paths we use the labelling algorithm proposed in Ambrosino and Sciomachen [2] that takes into a proper account the modal change nodes. The computation of viable paths, that is paths that satisfy some constraints on the sequence of the selected travelling modes, is considered in Lozano and Storchi [9]. Finally, Bielli et al. [3] present a very interesting multimodal travel system based on an object-oriented modeling paradigm with the help of a GIS tool.

The present paper is organized as follows. In Section 2 our referring multimodal network model and its associated costs are given. In Section 3, we present the case of Genoa and we perform some scenario analysis using the spreadsheet Excel considering different o-d paths and different policies.

## 2 The multimodal transportation model

In this paper we consider the following passenger transportation modalities: private, i.e. users in the private network are car drivers; mass transit, i.e. users in the public network go from one location to another by bus, subway, etc.; pedestrian, i.e. users move into the pedestrian network by walking. In particular, we consider the pedestrian modality only a communication link between the private and the mass transit modalities.

We model an urban multimodal transportation network by a digraph $G = (V,E)$. $G = (V,E)$ is the union of three subgraphs, representing, respectively, the transportation modalities listed above: $G = G_D \cup G_M \cup G_W$, where $G_D = (V_D,E_D)$ models the private network and $G_M = (V_M,E_M)$ is the mass transit network.

Note that $G_M$ is in turn considered as a multimodal transportation network, in which different means could be used. As in Ambrosino and Sciomachen [1] we associate with each arc $t_{ij}$, $\forall (i,j) \in E_M$ a weight corresponding to the value of the shortest path from $i$ to $j$ computed on $G_M$ by allowing at most two line changes. Moreover, we consider the mass transit network as a time-expanded graph (see e.g. Schulz et al. [14]) in which the arrival time schedule of each mean at the corresponding bus stop is known; in this way we are allowed to include the (average) waiting time in the arc weight.

As far as the private network $(G_D)$ is concerned, we have to specify that weights on the arcs belonging to $E_D$ are derived by using the usual cost functions that can be found in the transportation literature (see, for instance, Sheffy [13]), provided that they are increasing function with respect to the flow on the corresponding arcs.

Finally, considering the pedestrian network, $G_W = (P,T)$, where $P$ is the set of available parking places (both on the street and on buildings), and $T$ is the set of
transition arcs that represent the possibility of commuting between the private and the mass transit modalities, we have to keep in mind that arc set $T$ plays a crucial role in the present analysis since it represents, as well as the monetary cost, the negative factor in the choice of users between the alternative of continuing the path on the same modality, that is to reach node $d$ by car, or taking the mass transit network.

Thus, $V_D$ and $V_M$ are, respectively, the nodes reachable by car and by the public transportation means; let $I = V_D \cap V_M$ be the set of the modal change nodes of $G$.

We consider any arc $t \in T$ as consisting of two commutation phases, namely the search for an available parking space and the walking path from the car park to either the destination node or a bus stop. Consequently, we associate with each transition arc $t \in T$ a weight expressing two different components: 1) the sum of the time required for looking for a car park and to go by walking, if necessary, from the car park to either the destination or the bus stop; 2) the monetary component representing the parking tariff. Many pricing tools can act on the weight of these arcs.

In order to better understand the transition cost of o-d paths in a urban multimodal network, let us consider the simple network reported in Figure 1, where nodes $p_1, p_2, p_3, p_4 \in P$, bold arcs belong to $G_{D}$, normal lines depict the arcs of $G_M$ and dotted lines represent the transition arcs of $T$ towards car parking.

![Figure 1](image)

Figure 1: A simple example of path components in multimodal passenger transportation network.

Let us assume that possible alternative paths connecting the origin node $o$ to the destination node $d$ are the following:

a. a path through the private network, in which a driver can reach either node 1 or node 2 at the barrier where has to pay the corresponding fee for entering into the road pricing zone (depicted in Figure 1 as the oval zone), and finally park the car at either $p_3$ or $p_4$.
b. an intermodal path, in which the driver before reaching the barrier can leave the car at a park, that is either node \( p_1 \) or \( p_2 \), and then continue the trip by taking a mean belonging to the mass transit transportation network.

Let us now evaluate the cost of the above choices. In the first case the driver has to travel sequentially for instance along arcs (o, 2) (2, 4) (4, 5) and (5, d), parking the car at \( p_3 \). The corresponding costs are related to the traveling time \( t_{od} \) through the arcs belonging to \( E_d \), a possible road fee \( \chi \), entering the oval zone of Figure 1, the fuel cost \( c_{ub} \), the transition cost given by the parking fee \( c_{p3} \), and the transition time \( t_{dp3} \) given by the parking time at \( p_3 \) plus the walking time \( t_{p3d} \) from \( p_3 \) to \( d \). By generalizing this simple example, let us hence assume that the generalized cost of any \( o-d \) path traveled on \( G_d \) is obtained by counting all the above components and weighting them by considering parameters \( \omega_1, \omega_2 \in [0, 1] \), that correspond to the perception of the users of the time and the monetary cost, respectively, as it will be explained later; therefore, it can be easily observed that the overall generalized cost \( C_{od}(G_d) \) of any \( o-d \) path in \( G_d \) is given by eqn (1), where \( p_j \in P \).

\[
C_{od}(G_d) = \omega_1 (t_{od} + t_{dpj} + t_{pjd}) + \omega_2 (\chi + c_{od} + c_{pj})
\]  

(1)

In the second case, i.e. following a multimodal path, the user has to travel sequentially for instance along arcs (o, 1) (1, 3) (3, 5) and (5, d), parking the car at \( p_2 \). The corresponding costs are due to the car from the origin to the modal change node, that is the traveling time \( t_{oi} \) and the fuel cost \( c_{oi} \) plus the cost associated with the transition arcs, that is the parking fee \( c_{p2} \) and the bus tickets \( \beta \); moreover, we have the transition time that includes the parking time \( t_{lp2} \) at \( p_2 \) and the walking time \( t_{p2i} \) towards the bus stop; finally, we have to consider the traveling time \( t_{id} \) on the public mean. Note that also in the present case the weight representing the traveling time on the mass transit network includes the waiting time at the bus stop (in the example at node 1).

By considering the same weights as before, the overall generalized cost \( C_{od}(G) \) of a path on \( G \) is then given by eqn (2), where \( i \in I \) is a modal change node and \( p_k \in P \).

\[
C_{od}(G) = \omega_1 (t_{oi} + t_{ipk} + t_{pki} + t_{id}) + \omega_2 (c_{oi} + c_{pk} + \beta)
\]  

(2)

Of course, the alternative paths are considered identically preferable by the users if they have the same cost. Unfortunately, as we will see in Section 3, for the most congested paths in urban areas the generalized cost given by (2) is almost always greater than that in (1).

3 Driving paths versus inter modal ones by using pricing tools

We report our studies on the impact of pricing tools in the urban networks referring to the city centre of Genoa, Italy. Let us consider the map of the central area of the city of Genoa reported in Figure 2, where the main paths from east to west side, and vice-versa, are outlined together with nodes 1-11 that represent
the centroids of the most relevant zones in terms of urban passenger mobility. The oval zone corresponds to the road pricing area.

Having in mind Figure 2, let us now focus our attention on nodes 1, 10 and 11 that are located at the frontier of the central area for drivers coming both from the east and the west side of the city. By computing the generalized cost components of eqns (1) and (2) of the most congested paths having those nodes either as origin or destination, we obtained the values reported in Table 1, where columns headings are as follows: the traveling time $t_{od}$ and $t_{di}$ from origin $o$ to destination $d$ and to modal change node $i$ respectively, the transition time components $t(G_D)$ and $t(G)$ of the generalized cost function in the case of only driving and multimodal choice, respectively, and the values $C_{od}(G_D)$ and $C_{od}(G)$ of eqns (1) and (2).

Note that in order to be able to compute the shortest paths between the above nodes we have considered the average distance from any reachable modal change node, to parking places in terms of driving time on $G_D$ and the successive connection to $G_P$. We then derived the corresponding generalized cost by assuming the time conversion factor of 15 Euro / hour. Moreover, we consider a bus ticket of 1.2 Euro and parking fees as 2 and 1 euro for car parks in central zones and in modal change nodes, respectively.

In the computation of the values reported in Table 1, we first used a Dijkstra-like algorithm for determining the shortest paths in both the private and mass transit network ($G_D$ and $G_M$) for each one of the $o$-$d$ selected paths and successively computed the corresponding multimodal shortest path by using the algorithm presented in Ambrosino and Sciomachen [2].
Table 1: Generalized cost components of the main selected o-d paths.

<table>
<thead>
<tr>
<th>1-4</th>
<th>1-5</th>
<th>1-9</th>
<th>1-8</th>
<th>1-6</th>
<th>1-7</th>
<th>1-3</th>
<th>11-4</th>
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<th>11-3</th>
<th>10-5</th>
<th>10-6</th>
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<tr>
<td>t_{od}</td>
<td>t_{ij}</td>
<td>t(GP)</td>
<td>t(G)</td>
<td>C_{od}(GP)</td>
<td>C_{od}(G)</td>
<td>t_{od}</td>
<td>t_{ij}</td>
<td>t(GP)</td>
<td>t(G)</td>
<td>C_{od}(GP)</td>
<td>C_{od}(G)</td>
<td>t_{od}</td>
<td>t_{ij}</td>
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<td>t(G)</td>
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<td>10.45</td>
<td>6.27</td>
<td>10.23</td>
<td>17.973</td>
<td>5.84</td>
<td>6.66</td>
<td>7.72</td>
<td>6.27</td>
<td>11.50</td>
<td>20.433</td>
<td>5.58</td>
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<td>8.74</td>
<td>3.11</td>
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<td>7.86</td>
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<td>8.77</td>
<td>11.66</td>
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<td>5.61</td>
<td>3.91</td>
<td>0.00</td>
<td>10.58</td>
<td>13.183</td>
<td>4.63</td>
<td>5.03</td>
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<td>0.00</td>
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<tr>
<td>3.63</td>
<td>0.97</td>
<td>14.40</td>
<td>22.883</td>
<td>5.21</td>
<td>7.18</td>
<td>3.58</td>
<td>0.97</td>
<td>13.45</td>
<td>7.54</td>
<td>5.04</td>
<td>5.76</td>
<td>3.59</td>
<td>0.97</td>
<td>8.57</td>
<td>9.34</td>
</tr>
<tr>
<td>2.81</td>
<td>0.00</td>
<td>11.45</td>
<td>14.53</td>
<td>4.54</td>
<td>6.46</td>
<td>3.54</td>
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<td>16.05</td>
<td>5.00</td>
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<td>5.58</td>
<td>7.07</td>
<td>6.12</td>
<td>6.03</td>
</tr>
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</table>

By looking at Table 1 the reader can see that only in one case, that is path 1-7, the multimodal choice results to be more convenient than the private one; in this case the suggested modal change node is node 2 that is a well performing node, according to the attractiveness value given in Ambrosino and Sciomachen [1]. In all the remaining rows the value of column $C_{od}(GP)$ is less than the corresponding value in column $C_{od}(G)$; however, note that the traveling time on the mass transit network, including the waiting time, is very competitive with respect to the driving time in the urban transportation network of Genoa; the factors that mainly penalize the multimodal paths are the transition time and cost.

There is hence the need of evaluating some pricing tools that could have a different impact on the generalized cost function thus making the intermodal network more favorable than the private one. Let us hence think about some pricing actions that could improve the intermodal paths, provided that modal change nodes are well served as they need.

### 3.1 Scenario analysis

The possible pricing tools that we can consider in order to increase the preferences for the multimodality are the parking fees $c_{pk}$ and $c_{pj}$, the road pricing $\chi$ and the bus ticket $\beta$, where $j$ and $k$ are, as in (1) and (2), nodes belonging to set $P$ in a nearby of the destination and the modal change node, respectively.

We performed some scenario analysis using the spreadsheet Excel for investigating, as already said, some possibilities that reflect two different government policies: P1) to increase the cost of the private paths by introducing road fees and increasing the cost of the car parks in the main central areas;
P2) to reduce the cost of intermodal paths by reducing both the parking fees and the bus ticket.

Table 2 represents our spreadsheet for computing the number of preferred intermodal paths when different policies are used. In particular, the case reported in Table 2 is an example of policy P1; we evaluate how the users’ preferences change when they have to pay a road fee of 1 Euro for entering in the oval area of Figure 2. In this example, by adding the road fee the number of preferred intermodal paths passes from one to nine.

Table 2: Effect of the road pricing.

Table 3 shows the number of intermodal paths preferred to the private ones when different policies (P1 and P2) are used. In particular, we simulate different applications of policies P1 and P2, by modifying both the parking fee ($C_{p1}$) for car parks in the central area and the road pricing for policy P1 and by modifying both the parking fee ($C_{p2}$) for car parks in modal change nodes and the bus ticket for policy P2.

During our experiments on different scenarios, we observed that the results obtained by using these different policies depend on many factors, among others the perception of the services offered by the mass transit transport and the cost of the transaction arcs $T$ at the modal change nodes.

For these reasons, we evaluate the effect of the different pricing policies when varying $\bar{w}_1$ and $\bar{w}_2$ in eqns (1) and (2), such that $\bar{w}_1 + \bar{w}_2 = 1$. We remind that by
choosing $\omega_1$ closest to 1 we consider very important the time components of the generalized cost of each path; otherwise, by choosing $\omega_1$ closest to zero the cost component is considered more relevant than the cost one.

Results reported in Table 3 are related to three different experiments. In the first case ($\omega_1 = 0.5, \omega_2 = 0.5$) we assume that for users the cost component is as important as the time component of the generalized cost function. In the second case ($\omega_1 = 0.2, \omega_2 = 0.8$), we assume that users consider more important the cost component whilst in the last one the time component is more relevant for users. The last case ($\omega_1 = 0.8, \omega_2 = 0.2$) reflects the expectations of richer users: for this kind of people is difficult to leave their car far from destination even if a strong policy P1 is adopted by the government that is a road fee (2 Euros) and an high parking fee (3 Euros); only seven intermodal paths are preferred.

The second case reflects the preferences of users belonging to lower social class. These users are not able to pay so much for reaching their destination by cars and so they prefer mass transit modality. In this case, all the sixteen intermodal paths are preferred to the private ones.

### Table 3: Effect of different pricing policies.

<table>
<thead>
<tr>
<th>P1 Parking fee near destination nodes</th>
<th>Road pricing</th>
<th>(\omega_1 = 0.5, \omega_2 = 0.5)</th>
<th>(\omega_1 = 0.2, \omega_2 = 0.8)</th>
<th>(\omega_1 = 0.8, \omega_2 = 0.2)</th>
</tr>
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<tbody>
<tr>
<td>2</td>
<td>0</td>
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<td>0</td>
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<td>2</td>
<td>1</td>
<td>9</td>
<td>16</td>
<td>1</td>
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<td>2</td>
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<td>16</td>
<td>16</td>
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</table>

<table>
<thead>
<tr>
<th>P2 Parking fee in modal change nodes</th>
<th>Bus ticket</th>
<th>(\omega_1 = 0.5, \omega_2 = 0.5)</th>
<th>(\omega_1 = 0.2, \omega_2 = 0.8)</th>
<th>(\omega_1 = 0.8, \omega_2 = 0.2)</th>
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<tbody>
<tr>
<td>1</td>
<td>1.2</td>
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Also policies P2 are not able to influence the preferences of richer users. For increasing the number of users choosing the intermodal paths, the government would act also on the mass transit offer, i.e. by improving services. Also in an unrealistic scenario in which it is possible both to travel on $G_M$ without paying a ticket and to park a car in modal change nodes without paying a parking fee, the number of preferred intermodal paths is seven.
Policies P2 are very effective on users belonging to middle and low classes; in fact, the number of preferred intermodal paths is really affected also by small reductions in the cost component of the generalized cost function.

In all cases when the parking cost in a neighbourhood of the destination is higher than that of any modal change node the number of users that choose intermodal paths increases, even if the waiting time for an available place in the car park results lower.

When considering higher traveling time in the mass transport modality the number of intermodal paths preferred decreases.

As a last consideration we have to say that by computing the shortest path for all o-d pairs given in Table 2, when the intermodality results to be the best choice for users, the chosen intermodal nodes are 2 and 3, that are our most favourite intermodal nodes from a attractivity point of view, that is following the proposed approach for evaluating the intermodal nodes (Ambrosino and Sciomachen [1]).

4 Conclusions

Some analysis performed by using the spreadsheet Excel was carried out to assess the impact of different pricing tools in the choice of multimodal paths in urban networks. The results reported in this paper confirm us that the social class of users influences their expectations and preferences, in particular, a road fee is acceptable by most drivers belonging to medium – upper class, that attach a high monetary value at the travelling time. Moreover, the perception of both the services offered by the mass transit transport and the transaction costs for changing modality really impact on the effectiveness of pricing policies.

References