ARE STATIC AND DYNAMIC PLANNING APPROACHES COMPLEMENTARY? A CASE STUDY FOR TRAVEL DEMAND MANAGEMENT MEASURES

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Abstract

In this article, we determine the relevance of the displacement management measures in an urban road network. The main contribution, limitations and the balance among the static and dynamic planning approach are evaluated. In order to compare results from these approaches, four criteria to evaluate effects induced by simple and combined travel demand measures are established: configuration of the road network, efficiency rates, additivity of effects and multicriteria analysis. These criteria are quantified in two prototype networks which allow choosing between a series of flexible measures these ones which improved current circulation conditions. The obtained conclusion contribute to the decision making process because the managing authorities of urban transportation could know the effects induced by these measures, their spatial distribution and advantages or disadvantages from each modelling approach.

Keywords: Static and dynamic approach; Planning; Travel demand management
Topic Area: C1 Integrated Planning of Transport Systems

1. Introduction

Traditionally, urban transportation systems' analysis is based on a static modelling point of view. This approach admits all journeys and infrastructure service level as constants, during a determined time interval (usually an hour or a peak period), taking into account that this hypothesis, methods, algorithms [e.g. (Beckmann et al., 1956) or (Sheffi, 1985)] and commercial software (emme 2, TransCad, Estraus, Davisum, etc.) have been developed to find a network's equilibrium state (Miller, 1997). Based on this approach, alternative solutions to the urban transport essential problem are proposed: given a limited capacity transport network (supply) and some population's mobility characteristics (demand) to find the journeys' optimum assignations where transportation costs would be the most efficient (minimum) supposing that the assignment is implicitly linked to infrastructure's performance level.

Based on urban centres' developing stage and financial resources availability, the solutions to urban congestion were oriented to increase infrastructure capacity. Simulation tools, based on static approach, were sufficient in this way for transport network's planning (network design, infrastructure's capacity etc.) mostly because travel pattern and travellers' behaviour were more or less constant. Correspondence between model's hypothesis and simulated reality were consequently coherent. Actually, this paradigm has lost robustness due to societal changes (Giuliano, 1998), congestion levels induced in mobility decisions and more flexible and unstable day after day travel patterns. The fact is that the static approach is not enough to deal with this reality (Goldman, 1999).

Nowadays, relentless growing in motorised mobility, perverse or negative effects (Myrdall circle) induced by an increment in infrastructure's capacity policy (see for example Button, 1996), the over-offering automotive industry, the limited financial resources for new infrastructures, and high urban population density, have turned the possibility to continue with the same not feasible treatment of transport problems.

An alternative treatment is viable, in which management of demand must be included: the travel demand management (TDM). In the 90 a series of transport policies based in this new paradigm emerged (Button, 2002). Nevertheless, even such planning approach's theory was founded in the 70 (Vickrey, 1969); few operational tools lived up to be feasible. The evaluation of such policies couldn't be more coherent. As a matter of fact, congestion phenomenon is characterised by its variability: firstly, traffic conditions are not the same throughout the day, neither days of the week or months of the year. This is due to infrastructure performance variation with demand's level (non-linear relation). Secondly, user's behaviour is not fixed, too. Travellers change mobility decisions (e.g. selection of start time to travel, itinerary, transportation modes, etc.). to adapt to current traffic conditions. Considering these components in the phenomenon treatment have caused an alternative approach called dynamic [e.g. (Vickrey, 1967), (Ran and Boyce, 1994)], it is theoretically appropriate to analyse the effects of TDM (Palma et. al., 1997).

Although the mentioned approaches are different (philosophy, modelling approach, algorithms, etc.), they are used to help transportation planning decision, but which one is more pertinent? And under which circumstances? Under which parameters are they reliable? These are only some of the questions that transport authorities can set. The objective of this article is to give answer elements in this way. That is the reason to analyse the implications of defining a journey's policy based on static and dynamic simulation approaches. Such analysis has been oriented into four directions: network's configuration, spatial distribution effects, additional flexible measures and alternatives' selection.

Following the traditional transport planning procedure [e.g. (Ortuzar and Willumsen, 1994)], firstly, supply and demand characteristics for two prototype networks are introduced (sections 2 and 3, respectively); then, supply and demand equilibrium criteria is described for each one of the approaches mentioned (section 4); afterwards, stages oriented towards TDM's flexible measures are described (section 5); and finally, obtained results are analysed (section 6) and final comments are presented.

2. Modelling supply

To show the representation of a generic transport system, two prototype networks of transport were modelled, they have been called reticular and circular configurations. The components of each network are as usual: centroids, arcs, nodes, and links, while centroids were located in the geometrical centre of each area, limited by streets (blocks). Nodes were located in each intersection of the network and were considered as self-regulated which means that no penalisation coefficients were used for turns. The road sections between two intersections were characterised by arcs and their physical properties such as: maximum permitted speed, number and capacity of lanes. Performance of such arcs was represented by means of BPR delay functions [e.g. (Spiess, 1990)]. Prototype networks' characteristics are detailed below.

2.1. Zone

To have comparison elements among the networks, simulation approaches and data comprehension, two spatial addition levels were set. The first is formed by each one of the 100 zones resulting from the criterion previously mentioned. The second, very much more added, sums the last 100 zones in six macro zones and its names depend on their orientation: Central Business District (CBD) A and B on the city centre, northeast, southeast, southwest and northwest (s. figure 1).

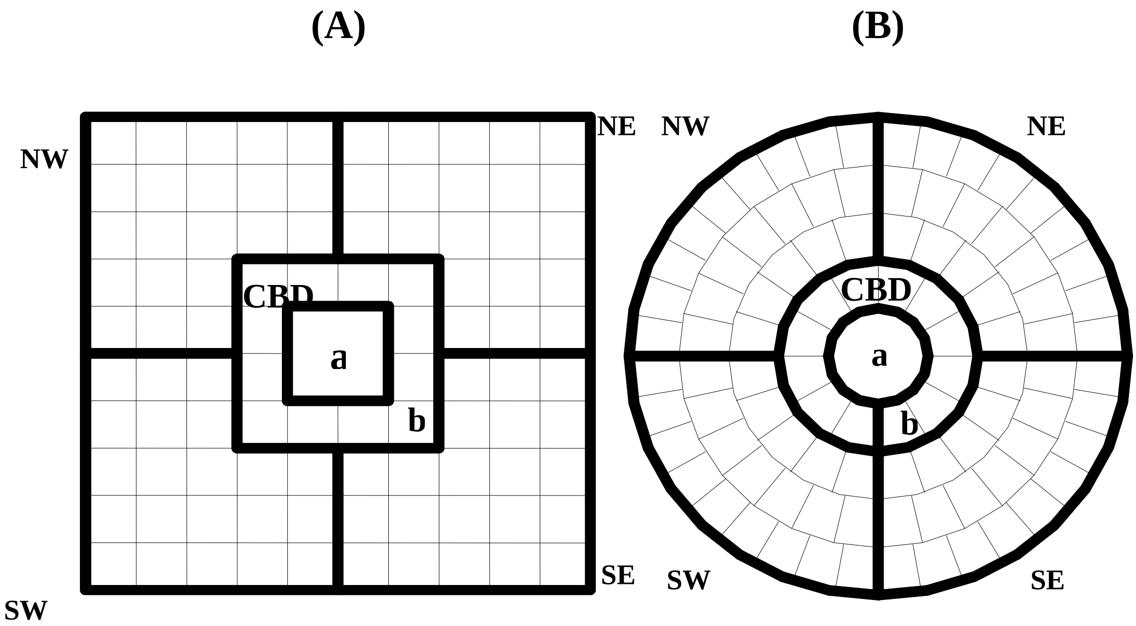

Figure 1: The macro zones and the prototype networks: (A) Circular Network, (B) Grid network.

2.2. Radial network

This configuration represents European and some Latin American cities. The network was constructed from two basic perpendicular axes North-South and East – West which drive the vehicle flow to city centre and also to three concentric peripheral rings, which drive the flow to secondary roads. The basic structure of this network is formed by concentric rings, separated by 500-metres each. These rings are linked with road segments, which do not follow a geometric pattern, for their aim is to provide a number of nodes similar to the reticular network. Thus, for a five-kilometre diameter outer ring, the radial network has: 120 nodes, 852 arcs in an over 342-kilometres length. Note that radial net is smaller in dimension than the reticular one. This situation is due to the configuration. In fact, arcs' average length compares this last thing: 0.4-km. of radial net against 0.42-km. of reticular net. This particularity will have implications comparing efficiency in journeys that we will show it in section 6.

2.3. Reticular network

This prototype network represents American cities' drawing and is illustrated in figure 1B. Analogically to radial network, it is made up by two axes that divide the city. These axes do not cross the city centre (CBD) but feed two avenues that drive around the first and second city squares. The aim of these two avenues is to distribute the vehicular flow into the secondary roads. Secondary two-way roads, every 500 meters with north-south and east-west direction, complement the former basic structure. A node represents every intersection. Under this configuration and considering a network extension of 25 km^2, 121 nodes and 824 arcs were obtained in a 354 kilometers net's length.

3. Modeling demand

Travels' spatial distribution was made considering the existence of an attractive geometrical centre (historical centre or CBD). Attraction and / or emission of travels were fading as the edge was reached. The travel's pattern previously described represents cities typically centralised, in which diversity, quality and quantity of goods and services are more concentrated in downtown area while the periphery is used as residential area.

3.1. Users

A homogeneous population was assumed with respect to its socio-economic characteristics and all the evaluations were done in travel time terms to use them as a comparative measure. Consequently, in the static model approach (see section 4.1), it was not necessary to define a value of time (VOT). Even though, due to dynamic model's considerations (see section 4.1) it was necessary to define the following parameters: VOT α = 1USD / hour; the unit cost parameter for late arrival γ = 2.5 USD / hour; the unit cost parameter for early arrival β = 0.8 USD / hour; and the flexible arrival period (not penalised arrival time) Δ = 10 minutes. All these parameters are medium values of normal distribution [see details in (Palma and Marchal, 2002)]. Additionally, a uniform distribution of desired arrivals was considered. Unitary cost parameters was described considering wages and time in absolute terms to emergent countries and in relative terms to obtain relations empirically [e.g. (Small, 1992); (de Palma and Rochat, 1998); (THEMA-TTR, 2001)]. These values were lightly modified to reach an important users' concentration in the rush hour. We only consider work-home travels due to their regularity and importance, measured by the sum of journeys.

3.2. Generation and distribution models

To obtain a centralised travel's spatial distribution, an enclosed exponential distribution model was used:

$$\begin{aligned} V_{i,j} &= A_j P_j * \exp\left(-\frac{tt_{i,j}}{\mu_k}\right) \quad if \quad tt_{i,j} > tt_p . \\ V_{i,j} &= 0 \quad\quad if \quad tt_{i,j} \le tt_p \end{aligned} \qquad (1)$$

In this equation $tt_{i,j}$, represents the travel time from *i* zone to *j* zone in minutes; tt_p shows the maximum travel time on foot expressed in minutes, that people are willing to spend by going to destination in minutes; V_{ij} are the travels made from *i* zone to *j* zone (travels / peak hour). Finally μ_k is a model's parameter in minutes. Equation 1 lets us know the travel's distribution to each zone whenever user's travel time is greater than bearable time on foot by the inhabitants of the selected zone (normally 5 minutes). To value the accessibility as well as zone attraction, services, equipment, facilities and commercial centres were considered to represent the city centralism. Finally, μ parameter was adjusted to the travel's frequency to be minimum compared to the user's total travel time, as if it was equal to the travel time from CBD to an outer point of the network. In this way two different coefficients were used to represent both behaviour of outer inhabitants and drivers from centre to suburbs. The reason for this separation is justified because central inhabitants have few reasons? To moving to get high quality services and goods , and suburbs inhabitants are used to move into downtown to get high quality services and goods.

3.3. Results

The previous model's adjustment sets the possibility of knowing the total amount of travels within a peak hour. In this way, an origin-destination matrix was obtained. The matrix consisting of 8,700 elements represents 151, 819 trips. Table 1 shows spatial distribution in the five macro zones described before. Generated travels from/to network's centre (CBD) were divided in two parts, being the closest CBDa and a ring CBDb. From

Table 1, it can be verified that more than 40% of the total amount of travels have CBD as destination, while internal travels to CBD represent about 9% of the total; and generated travels from CBD reach a 16%. Travels among macro zones, excluding CBD reach only 42% of the total.

Table 1: O/D Matrix aggregated by macro zones

Mzone	CBD-a	CBD-b	NE	SE	SW	NW	Total
CBD-a	0	2252	2812	2508	1259	2246	**11077**
CBD-b	3165	7636	3221	4966	3313	4946	**27248**
NE	3576	6433	9750	5006	102	4014	**28882**
SE	10030	9951	4996	9401	4548	439	**39366**
SW	5032	6622	102	4545	9649	4087	**30035**
NW	3827	4136	542	204	3068	3435	**15211**
Total	**25630**	**37031**	**21423**	**26630**	**21940**	**19166**	**151819**

4. Supply and demand equilibrium

The essential difference among the dynamic and static simulation approach is located in the hypothesis of users' behaviour which determines the equilibrium of the transportation system. While the individual characteristics of mobility are fixed in the period of analysis (origin-destination or o/d matrix, departure time and traffic conditions) in the static model, the user faces every moment an alternatives set in the dynamic model: make travel or not, departure time, transportation mode, itinerary, etc. In this way, the modelling demand in our static approach is define as aggregated and uses almost exclusively physical notions while the dynamic one is individual or disaggregated and it is based on micro-economical notions of the user's behaviour.

4.1. The static approach equilibrium

The equilibrium principle of this approach is based mainly on the traffic macroscopic theory [e.g. (Sheffi, 1995); (Leutzbach, 1988) or (Daganzo, 1997)] and on the fundamental relationship [e.g. (Wardrop, 1952), reformulated in (Gerlough and Huber, 1975)], in which the travel time is bounded by the speed-flow relation by means of a delay function. This function measures the performance of each road section according to their saturation level. It is the base on which the users, or a group of users, choose their itinerary (sequence in the use of links), in an interactive way and according to search criterion. The stationary state or equilibrium supply-demand is reached when "*the journey times in all used routes are equal or less than those which would be experienced by a single vehicle on any unused route*" (Wardrop's first principle or optimum individual, Wardrop, 1952), or "*when the travel times are the minimum for the all the users*" (Wardrop's second principle or optimum social). There is a series of variants for the two types of equilibrium mentioned, as well as diverse algorithms that permit to reach them. For more details see for example (Sheffi, 1985) or (Miller, 1997).

4.2. The dynamic approach equilibrium

The dynamic approach, proposed initially by (Vickrey, 1969), is based on the model of individual election of departure time: the users choose among avoiding the congestion setting off before or after its usual time or to reach its destination at the desired time but with a more extended time of journey (time of the journey elapsed in longer time of journey). In this way, for any displacement, the individuals support a generalized cost C that depends on: the departure time (td), the effective travel time (tt), the desired arrival time (t^*) and a flexible arrival period (Δ) which supposes a null cost, due to a not penalty, for the user (cf. equation 2). Under these premises, we have three cases related to the arrival time (*ta*): early arrival ($ta<t^*$), late arrival ($ta > t^*$) and arrival on time ($ta = t^*$). Generalized cost function is given by:

$$\begin{aligned} C(td) &= \alpha tt(td) + \beta\left\{\left(t^* - \frac{\Delta}{2}\right) - [td + tt(td)]\right\} && si \quad ta < t^* \\ C(td) &= \alpha tt(td) + \gamma\left\{[td + tt(td)] - \left(t^* + \frac{\Delta}{2}\right)\right\} && si \quad ta > t^* \qquad (2) \\ C(td) &= \alpha tt(td) && si \quad ta = t^* \end{aligned}$$

In the previous equations, (α) is the value of the time, (β) is the unit cost parameter for early arrival, (γ) is the unit cost parameter for late arrival. From both theoretical [see (Vickrey, 1969)] and empirical [(de Palma and Marchal, 1998) or (de Palma and Fontan, 2002)] points of view, the costs due to the early or late arrivals (schedule delay cost) can result on half of the general cost of the journey. In this way, the static focus does not permit to determine an important part of the total travel cost (see also Table 3). Underestimation of this cost is important since this variable is determining in the analysis of the modal distribution or in the calculation of the benefits induced by TDM. The model previously described represents the heart of the dynamic focus and its complement for the consideration of the adaptive aspect of the users. The last one is characterized by a learning process that leads the system into a stationary state [see (de Palma and Marchal, 2002)]. In a transportation system, conformed by *N* heterogeneous users with its preferences of election and with its VOT (journey, early and late arrival), there will be a distribution in the schedules of arrival that, combined to the duration of each one of the trips, implies that travelers use the network at the same time causing congestion and that the users will incur in an excessive transportation costs (due to incomplete information about traffic conditions). Nevertheless, as the time goes by, such costs will tend to be reduced and the user will adapt its habits of displacement (alternatives of election). Finally, the system tends to be stabilized once the users minimize its generalized costs of transportation: At the equilibrium, no driver can modify her/his departure time in order to strictly decrease the travel cost (Wardrop's first principle applied to dynamic approach). It's important to mention that the election models for departure time, way of transportation, itinerary are discrete choice model [e.g. (Ben-Akiva and Lerman, 1985)] correspond to the simulation of stochastic processes for which the stationary state of the system is achieved after an important number of interactions [see (THEMA-TTR 2001)].

5. Scenery design

According to the centralized structure of the trips' spatial distribution (see figure 1), it is expected that the greatest problems of congestion are in the central macro-zone called CBD. From the purpose to improve the circulation in this zone, TDM measures are used to describe a variety of auxiliary actions to reduce or to modify the intensity of displacement (Button, 2001). TDM concept has got success since the 70's. It's due to the mobility increment and its advantage is that the employed measures do not generally require an increase in the capacity of the infrastructure. Globally, the demand in the systems of transportation surpasses the diagnosed limits in the installments of its services and the public authorities responsible for this management, are not willing or do not have the financial requirements to improve, to adapt, or to build the required infrastructure. The policies based on TDM are an answer to the problems originated by the increase of urban congestion problems, since these intend to diminish problems generated due to congestion through the application of flexible measures that do not require large investments.

The management of demand in transportation involves different measures, among the following: internalize congestion costs, electronic toll, shared trips, access interdiction to CBD, rearrangement of circulation ways, etc. In this paper, we take into account only the two last measures mentioned above. The main objectives of these measures, in the medium term, are (VPTI, 2000):

To modify the travellers' behaviour: the most common objective is to reduce the number of trips, as well as to change the users' attitude in order to use another transportation mode or a different schedule to reduce the traffic concentration periods to get a better demand distribution throughout the day,

To diminish environmental damages: the construction and transportation services operation is always going to cause environmental impact such as air pollution at local (ozone, CO, suspended particles, etc.) and global level (weather changes, consequences caused by ozone), noise and water contamination.

To diminish the dependence of the car: the easy access to a specific place implies a commercial and housing development. Because of it, the measures of management of demand intend to reduce this damage based on urban design that diminish the dependence toward the individual use of vehicles, and besides, they help the cyclists and pedestrian circulation.

To increase the security of the trip: if the number of trips is reduced, possibly the number of accidents, collisions, damage to vehicles, fatalities, injuries and emergency calls can be reduced too.

In the next subsection, we describe the analysed measures based in TDM. It is important to mention that different TDM measures were added on the base case in order to evaluate additive effects.

5.1. The base case

It represents the "current traffic conditions" in the network corresponding to the supply and demand characteristics described before (see section 2 and 3). From the purpose to establish a comparative framework among both networks prototype and among the measures implemented, the system's performance was analyzed "without congestion" (SC) that comes to represent the minimum travel time for the origin-destination matrix described synthetically in table 1. In a way, to fixed demand, any TDM policies implemented will not be able to obtain better levels of performance with this situation (see tables 3,4 and 5).

5.2. Scenery 1

The main measure of this Scenery consists in providing a pedestrian zone in the first square/ring of the city center. This zone is close to the car circulation. As mentioned before (section 2), the structure of the networks and the travel demand induced high levels of traffic in the CBD (see section 6). To compensate the loss of capacity that implies the prohibition mentioned, we proceeded to eliminate the public parking in the streets around the mentioned first square/ ring. This measure allows to gain an additional lane to car circulation. We considered that other actions were implemented to increase circulation speed too. These actions mean an increase of 5km/h the speed.

5.3. Scenery 2

In this case, we include supplementary (additional) measures for the Scenery 1. They vary according to the kind of network. In the reticular network, the street ways for the first square of the city were changed in a one-way clockwise circulation while the public street parking in the second square was restricted to gain an additional lane. Thus, same improvements were carried out to increase the circulation speed in 5km/h. In the circular network they only improved the conditions of circulation in the second peripheral ring enlarging its capacity in a lane and the circulation speed in 5km/h. These measures come from a series of simulations using software based on the static approach EMME2 (INRO, 1998). The results showed by this software indicate that the average travel time through was lowered in comparison to the current situation (base case) in both networks.

5.4. Scenery 3

In this Scenery, our research focused towards circulation way changes that contributed to alternative itineraries to the users who travel towards the center of the city. In the reticular network and based on the modifications of Scenery 2, two unidirectional parallel group lanes were implemented. The first one runs in North-South and south-north direction and the second one runs in East-West and West-East direction. Each one of the unidirectional parallel group lanes doubled its capacity according to the number of lanes due to the fact that the parking restriction was not established. For the circular network, the first peripheral ring was considered as unidirectional. Hence, three lanes were obtained ready to circulation.

5.5. Scenery 4

Additional measures were included in this case to improve the circulation conditions of Scenery 3. In the reticular network the unidirectional parallel group lanes lengths were reduced being limited to the second square of the city. In the circular network, changes of direction in the road sections, that feed the periphery of the first square, were made. Four sections were modified to become one-way with the consequent duplicity of the circulation lanes.

6. Results

Due to the fact that the results obtained by both simulation approaches are comparable in terms of travel time only, this criterion was used for the first level of analysis. The results obtained for the benefits spatial distribution for sceneries considered are commented in a brief way [for a detailed description see (Sanchez, 2002)]. The second level of analysis is exclusive of the dynamic focus and refers to the measures of effectiveness (MOEs). These measures are used to analyze transportation system's performance.

6.1. Spatial distribution of benefits (static model)

Although the measures of management implemented contribute, in general terms, to decrease the travel time, it is necessary to determine in what zones the population obtains the circulation improvements. We introduce two levels of analysis to evaluate effects induced by measures in sceneries considered from static approach point of view. The first one concerns the spatial distribution of effects (how benefits for each zone are different). The second one is related with the magnitude of effects (how many the total travel time is reduced). A summary of comparative analysis is described in the next lines:

In the reticular network the users of the external zones obtain the greatest benefits in travel time reduction terms, while for those who arrive or leave the CBD, the travel time increases. The results are valid for all the analyzed sceneries.

There is an almost homogeneous benefits distribution in the circular network about the reduction/increase of the travel time, even for the scenery that contributes the most to the reduction of travel time (Scenery 2). The highest benefits are for the users that enter/leave the city center (CBD).

In a non-congestion situation, the travel time is, in general terms, upper in the reticular network. Only in the relations NE-SE and NE-CBD this situation is reverted.

The justification of the mentioned results and the detailed analysis of other distribution conditions is described in (Sanchez, 2002).

6.2. Measures of effectiveness.

In dynamic approach, the simulations were carried out using the METROPOLIS software (de Palma et. al. 1997) which produces aggregated MOE's from aggregation of individual data. Due to the extension of this work, all the results related to the costs (schedule delay cost and individual travel costs) will be omitted. However, the next variables will be used: the average travel time, the total average travel cost, the congestion level, the average vehicles-kilometer, and the average number of links used by motorist.

6.3. Results comparison

The table 2 provides information of the travel time for each prototype and to each modeling approach. Based on the previously mentioned figure and taking into account the mentioned time as the criterion for election of the measures to implement, it is known that:

The modelling approach does not end up to the same conclusions. While the focus of the static one needs the creation of a pedestrian zone in the city center (figure 1) to go with other measures (figure 2), for the dynamic focus, measures contribute to marginal improvements (reticular network) and can even increase the travel time (circular network).

The relation among the induced improvements, in terms of travel time, in the reticular and circular networks is independent of the focus of simulation when the actions on the network are equivalent. This conclusion is verified by the relation: average travel time in the reticular network against that in the circular network represented in the column "RET/CIRC" of table 2, since for scenery SC, BC, 1 and 2 have values of around 1.06. Sceneries 3 and 4 differ completely from each one of the networks (see section 5). That is why the measures implemented are not equivalent.

Table 2: Results by simulation approach based on total average travel time comparison.

Scen.	**STATIC APPROACH**			**DYNAMIC APPROACH**			**STAT/DYN**	
	Circr	Grid	G/C	Circ	Grid	G/C	Circ	Grid
NC	5.06	5.35	1.06	5.00	5.28	1.06	1.03	1.03
BC	8.13	8.56	1.05	**6.35**	6.87	1.08	*1.28*	1.25
1	8.50	8.90	1.05	6.72	7.02	1.05	1.27	*1.27*
2	**8.04**	**8.51**	1.06	6.40	**6.86**	1.07	1.26	1.24
3	9.04	10.21	**1.13**	8.80	8.28	**0.94**	1.03	1.23
4	9.40	10.18	1.08	6.98	7.71	1.10	1.35	1.32

6.4. Additivity of effects

In terms of travel time, the implemented measures do not always induce positive effects; the aforesaid effects vary according to the modelling approach that is being used. Table 2 shows that, for scenery 2 and according to the static focus, the additional measures improve the conditions of circulation with regard to the "current situation" and to the situation where traffic circulation in the CBD was prohibited. Therefore, the positive effects are added. It is not established in sceneries 3 and 4, whose measures worsen the conditions obtained in scenery 1. In the dynamic approach, the additional measures do not contribute to both beneficial nor additional effects.

For the dynamic approach, the MOE's are not always directed on the additivity of effects. In the figure 3, it can be observed that, except for a cell, the MOE's values are over the "current situation" (base case), this shows that any taken measure will come to worsen the circulation conditions. On the other hand, the minimum values of the indicators for each network do not always belong to specific scenery. This justifies the need to employ a multicriteria analysis to make hierarchical the TDM measures.

Table 3: MOE's for dynamic approach where results were normalized to "current situation" values

	GRID				RET			
Scen.	Time [min]	Cost [$]	Congest [%]	Veh-km	Time [min]	Cost [$]	Congest [%]	Veh-km
1	1.02	1.09	1.18	1.00	1.06	1.03	1.22	0.99
2	**1.00**	**1.07**	1.23	**0.98**	**1.01**	**1.00**	1.13	**0.98**
3	1.20	1.25	1.50	1.19	1.39	1.24	2.58	1.10
4	1.12	1.18	**1.12**	1.17	1.10	1.06	**1.05**	1.09

6.5. Scenery ranking

There is some information about the multicriteria analysis in tables 4 and 5 applied to the circular and reticular networks respectively. In order to obtain the final note of sceneries considered, the value of a specific MOE was normalized in respect of their average value in the analysed scenery. Subsequently normalized value was affected by a *K* factor. Finally, these values were added up, so that the minimum value belongs to the best alternative. The mentioned tables permit to verify that none of the sceneries obtains a better rang than the present situation. Only scenery 2 presents the closest testing to the present situation, for both the reticular and the circular networks. It could be said that the two simulation approach match in indicating that scenery 2 is the one with the most "benefits".

Table 4: Ranking scenary for the grid network (dynamic approach)

GRID	Time	Cost	Congest	Veh-km	Narcs	Ranking
Scen.	[min]	[$]	[%]			
K	5	4	3	2	1	
Average	7.00	2.58	20.7	0.41	5.99	15.0
NC	5.28	2.31	0.0	0.36	5.38	10.0
BC	6.87	2.36	20.6	0.39	5.76	14.4
1	7.02	2.57	24.3	0.39	5.79	15.4
2	6.86	2.52	25.3	0.38	5.67	15.3
3	8.28	2.94	30.9	0.46	6.73	18.4
4	7.71	2.77	23.06	0.46	6.62	16.5

Table 5: Ranking scenery for the reticular network (dynamic approach)

GRID	Time	Cost	Congest	Veh-km	Narcs	Ranking
Scen.	[min]	[$]	[%]			
K	5	4	3	2	1	
Average	7.00	2.58	20.7	0.41	5.99	15.0
NC	5.28	2.31	0.0	0.36	5.38	10.0
BC	6.87	2.36	20.6	0.39	5.76	14.4
1	7.02	2.57	24.3	0.39	5.79	15.4
2	6.86	2.52	25.3	0.38	5.67	15.3
3	8.28	2.94	30.9	0.46	6.73	18.4
4	7.71	2.77	23.06	0.46	6.62	16.5

7. Final comments

The results obtained allow showing that, to spatial distribution of continuous trips, the effects induced by the TDM depend so much on: the network configuration, the evaluation criterion chosen and the simulation approach used. In the static model case, it is clear that the access interdiction of motorists to the city center have to be compensated by other measures. In the dynamic model case, the preceding idea is not verified in reference to the type of measures proposed. Nevertheless, the effects of other flexible measures, such as fixing a toll on fuel or the implementation of flexible arrival schedules, are topics to explore. There are some other non-analyzed alternatives:

The spatial distribution patterns of trips. In our analysis, we considered a fixed volume and trip spatial distribution. Nevertheless, it is necessary to evaluate whether the described conclusions are still valid for other levels of demand (consequently different infrastructure's saturation levels) and another kind of spatial distributions.

Spatial distribution of effects. The comparative analysis of the induced effects by sceneries analysed was based on the addition of the total travel time. However, the distribution of these effects in each zone and the definition of criteria that allows gathering together this kind of considerations, have not been analyzed in testing benefits as an alternative.

Evaluation of effects on a multimodal system. The O/D matrix considered corresponds only to the trips in private cars. In a more realistic case, we need include alternative transportation modes. This would modify aforementioned conclusions. Thus, it is recommended to include, in further analysis, multimodal transportation networks

Situation for each individual. Differing from the static one, the dynamic focus allows knowing, individually or in a separated way, a wide variety of performance rates that inform about the measurements used and that affect all kind of users. Therefore, an analysis of this kind, would allow defining measurements according to the needs of all people.

All the aforementioned represents a fascinating field of investigation which will be explored in future works.

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