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DECISIONS OF HYPERMARKETS LOCATION IN DENSE URBAN AREA – EFFECTS ON STREETS NETWORK CONGESTION IN THE BUCHAREST CASE

Summary. The paper represents some partial results of the research carried out by the Transportation, Traffic and Logistics Department - University POLITEHNICA of Bucharest, funded by the Romanian Ministry of Research and Education through the National University Research Council. In this paper we provide: a brief description of the interrelation between the life style changes of Romanian people during the last decades and the car traffic congestion in large cities; the streets network modelling of a radial-circular urban structure (the characteristic of a historically developed city as Bucharest city is), in case of car traffic congestion; the assessment model of the additional car traffic congestion for certain locations with large attractivity. Having an important effect on the entire lifestyle of urban people, the decision of a hypermarket location might be a complex one, taking into consideration the new leisure and shopping tendencies but also the additional car traffic congestion caused by the chosen location.

ОПРЕДЕЛЕНИЕ МЕСТОПОЛОЖЕНИЯ СУПЕРМАРКЕТОВ В ЗОНЕ ПЛОТНОЙ ГОРОДСКОЙ ЗАСТРОЙКИ – ВЛИЯНИЕ СГУЩЕНИЯ УЛИЧНОЙ СЕТИ НА ПРИМЕРЕ БУХАРЕСТА

Резюме. Статья представляет некоторые частичные результаты исследований, выполненных кафедрой транспорта, дорожного движения и логистики Политехнического Университета Бухареста, финансируемых Румынским Министерством Науки и Образования через Национальный Университетский Исследовательский Совет. В этой статье мы предоставляем: краткое описание взаимосвязи между изменениями образа жизни румынских людей в течение последних десятилетий и автомобильной дорожных пробок в больших городах; моделирование уличной сети радиально-окружной городской структуры (особенность исторического развития города, такого как Бухарест) в случае автомобильной пробки на дороге; модель оценки дополнительной автомобильной дорожной пробки для определенных местоположений с большим привлекательностью. Оказывая важное воздействие на весь образ жизни горожан, определение местоположения супермаркета могло бы быть сложным, учитывая новый досуг и тенденции посещения магазина, а также дополнительную автомобильную пробку на дороге, вызванную выбранным местоположением.

1. INTRODUCTION

The beginning of the new millennium is characterized by the significant globalization and, in almost all the emergent countries of EU but not only, are experiencing the high rate of GNP increasing.

As a consequence, the rate of motor-vehicle ownership is quite high, especially in the large cities of those countries. Car ownership is one of the most important factors for shopping behaviour changing. The people left their daily shopping walk to the small grocery centre, "from the street corner" and drive to the hypermarket, weekly or more rarely.

To drive to the hypermarket is a particularity of the Americans because of the very dispersed rural areas. They have to drive for long drive to buy the necessary goods and because of the expensive travel cost the amount of the provision is quite large.

Is this type of behaviour sustainable one? A lot of literature try to answer and analyse that, and it is obvious that a certain and strong argued point of view is not offered by now.

The earlier studies reveal that the attractions of the off-centre opportunity dominate the shopping behaviour of the car-owning households and the lack of car is associated with elements of social disadvantages [2].

The necessity of a more comprehensive framework of analysis which covers not only effects on competitors but also impacts on consumer behavior and choice, travel patterns, and traffic flows of the off-centre shopping areas was outlined even more earlier. That paper identifies the major parameters influencing the extent and nature of impacts by a new retail development [14].

A comprehensive analysis of the reallocation of resources and power within the sphere of urban commerce, the emergence of new consumption landscapes, and the recomposition of urban form in relation to commerce is made for the Istanbul area [17].

A useful analyses of the commercial behaviour changes in case of large cities in South and South-Eastern part of Europe, named by their author "Mediterranean" cities, is made recently, in several papers [3,4], and also there is a strong interest to analyse the shopping location and shopping behaviour in the large cities of the latest entered EU countries (Prague, Warsaw, Krakow, Ljubljana…) and Associated Countries (Zagreb, Ljubljana) [3,7,9,13,15].

The interests at European Union research and policy levels is increasing and some studies are carried out by the LUTR cluster, which links several different projects supported by the European Commission through the *City of Tomorrow* key action. The main LUTR themes are: land use and transportation interaction; impact on the environment [5]. The PROSPECTS project from the LUTR cluster is designed to help city authorities meet the challenges set in "The Common Transport Policy" which advocates the achievement of sustainable mobility.

The references related to the paper subject are dealing with travel behaviour variables (trip frequency, shopping duration, and modal split) disaggregated by key demographic characteristics (age, gender, income, car ownership, and household size). Several striking shifts are apparent: people shop less often and for longer periods of time and are less likely to walk to shopping locations.

Some of the municipalities from developed Western European countries are preoccupied about the shopping centre settlements and already promote the guidance rules for that [6].

The present paper provides an assessment model for the increasing of car traffic congestion in case of hypermarket location decision, taking into consideration the shopping behavioural changing following new world tendency, a certain urban structure – circular-radial one, changing of urban locations (zones) attractivity, the streets capacities, and the user's costs.

In the next section we present the most important specificities of the Bucharest city related to the new way of life and shopping behaviour, and the car congestion continuously increasing.

The third section is dedicated to the assessment model for the car traffic congestion in different cases of hypermarket locations, and in the last section we draw the important conclusions and point out the necessary research developments.

2. NEW LIFE STYLE IN BUCHAREST CITY

2.1. Car traffic congestion

Bucharest is a city with historical evolution as well as most of the European important cities. In the beginning it was extended on the river shore, then, incorporated both shores (as Vienna, Budapest, Paris etc.). The Bucharest street network has 5340 streets with a total length about 1820 km and a total surface about 228 sq km. The public surface route length (trams, buses and trolleybuses) is about 2,000 km, served by 1,500 vehicles per day (about 2 bill. of trips per day) having the public authority management.

There is also an underground network with 45 stations and 63 km length (average distance between stations - 1.5 km) and about 60,000 trips /day. The Bucharest City has a circular-radial street network structure with a major central boulevard from the North to the South of the urban area (see Figure 1).

Bucharest has about 2 million inhabitants and an average density population about 8107 inhabitants/sq. km, that is quite high comparing with other European capitals.

On Figure 1, one can observe the main arterial roads and the circles representing congested intersections.

Romania is a car producer and car importer. During the last years, we are faced with huge increased sales of cars (Tab. 1) [1]. Obviously, that has happened because of the continuously increasing general economic development (about 7-8% per year – average rate), and of GNP.

Table 1

The last years' sells of passenger cars [1]

Year	Total car sells	Variation (previous year/current year)
2002	88804	-
2003	106763	20.2%
2004	145106	35.9%
2005	215532	48.5%
2006	256364	18.9%
2007	315621	23.1%
2008*	144988	-0.9%*
	1273178	

*only for the first 6 month of the year.

Even if during the last 6 month of 2008 the car sales rate slows down, there is still an average amount about 200 thousand of yearly additional cars on the Romanian transport market. In Bucharest city in 2007 were running about 1.1 million cars and the car traffic in central zone was between 20,000 and 50,000 cars daily and it is continuously increasing.

The streets' infrastructure is almost blocked – there is no more additional space for the capacity developments. Moreover there was a quite slow rate of the rehabilitation works of streets surface. The public transportation has no high quality to attract people from daily car trips. A large portion of Bucharest's inhabitants are public transportation captives.

2.2. The life style changes

Under the previous regime, retail was limited, government owned, and centralized not spatially but administratively. There was an easy way to the market places structuring because the sales inventory, stock structure, management, pricing, and staff, and so on were all centrally controlled.

Many Romanian cities had small general stores near residential areas (most of them as multilevel small flats), but the goods inventory was very poor.

Fig. 1. The main roads network and urban structure of Bucharest area
Рис. 1. Основная дорожная сеть и городская структура зоны Бухареста

Beginning in the mid 1990s, however, and within less than a decade, a substantial portion of retail purchases was taking place in hundreds of hypermarkets. These are large (sale space of over 2500 sq.m.), modern and many of them luxurious. Many of them were located at the edge of or even outside the municipal boundaries. All of them have foreign owners as large West European retail chains. This changing in retail structure, scale, ownership, and location was experienced for all post-socialist countries in Europe. Table 2 shows this changing of ownership type, and of shops number by surface area [8] in Romania. The small shops from the ground floor of the residential blocks from the large city changed ownership from state to private one and also changed the activity profile (small business, small offices, banks...). The small shops still remain in rural area.

Table 2

Changing of the commercial network of retail shops

Area category	Number of shops			of which, by type of ownership					
				Public owner d			Private owner d		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
Up to 120 sq.m.	127486	124727	139992	1555	45	28	125931	124682	139964
121-399 sq.m.	5942	8795	6748	62	17	13	5880	8778	6735
400-999 sq.m.	1177	1119	1235	9	6	7	1168	1113	1228
1000-2499 sq.m.	387	252	305	7	2	1	380	250	304
2500-4999 sq.m.	38	70	91	-	-	-	38	70	91
5000-9999 sq.m.	33	25	41	-	-	-	33	25	41
10000 sq.m. and over	9	15	15	-	-	-	9	15	15

After 2001 there was a location period of these large hypermarkets into the inner centre of Bucharest city because of the lack of investment for road capacity developments, especially those going to the suburbs. Having or not enough parking spaces for customers, without any car traffic studies, a lot of hypermarkets settled straight in the most important congested intersections.

The labour forces market changed also: new well paid jobs entered; young generation is forming the so called „middle class"; the job productivity is increasing and people need more leisure and rest time than previously; Romanian people are travelling a lot out abroad.

Even the lower class people were tempted to go to the large shopping centres: the prices are lower, for the most of food goods, but not only; the quality in most cases is better and guaranteed; there are a lot of leisure places located in the same shopping centre.

3. ASSESMENT MODEL OF CAR TRAFFIC CONGESTON WITH REGARD TO A HYPERMARKET LOCATION

3.1. Circular-radial streets network model

The goal of the section is to meet the specificities of the Bucharest city, without compromising the generalities in case of other cities having the same structure. We consider for that an unoriented graph with links and nodes. The graph links have different lengths, capacities and cost functions. We consider four length categories: $l_3 > l_2 > l_1 > l_0$ [11], starting from the current situation in Bucharest, but any other taxonomy is allowed (the model generality is preserved). The links characteristics are shown in Table 3.

The users' costs function, per km and hour is:

$$c_i = c_{0i} + \alpha\left(f_i / q_i\right)^7 \ [10^{-2} \text{ monetary units/km/h}], \quad (1)$$

where c_i - the utilization cost per km and hour for a passenger car unit (pcu) in average conditions; the exponent 7 was selected according to literature [16], adding a surplus of 2 units to the 5 recommended, for outlining some external effects generated by car traffic, c_{0i} – the free flow utilization cost, related to the link type and capacity (the link capacity is influenced by the maximum legal speed authorized, which is related to the road pavement status) for a passenger car unit (pcu), α - a coefficient whose

level balances the standard trip time value during the working day hours with the travel lost time value of an average driver in Bucharest [12].

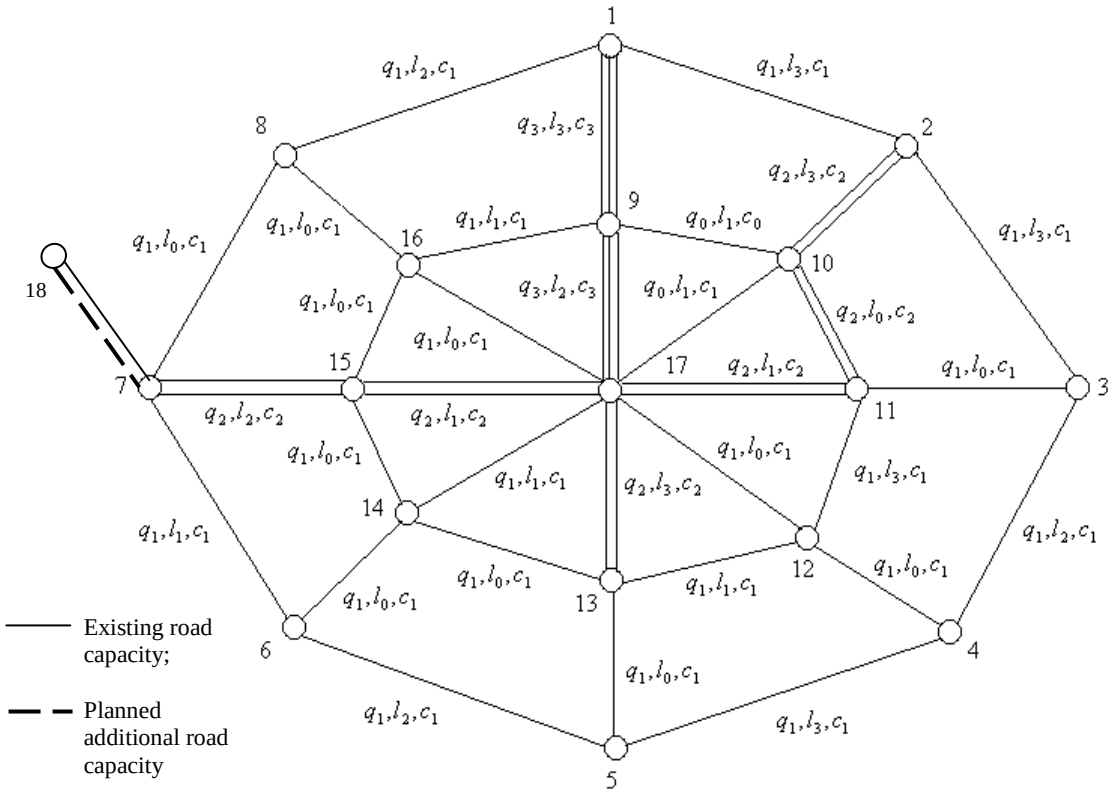

Fig. 2. Simple radial-circular street network (q_i – *capacity*, l_i – *length*, c_i – *cost function*)
Рис. 2. Упрощенная радиально-окружная уличная сеть (q_i – *вместимость*, l_i – *длина*, c_i – *функция цены*)

Table 3

Links characteristics: type, capacity and users' cost function

Type	Capacity [pcu/h/way]	Unit users' costs function [10^{-2} monetary units/km/h]
Three or more lanes per way	6,000 (q_3)	$3 + 3.6\left(f/q_3\right)^7$ (c_3)
Two lanes per way	4,000 (q_2)	$3.2 + 3.8\left(f/q_2\right)^7$ (c_2)
One lane per way	2,000 (q_1)	$3.36 + 4.04\left(f/q_1\right)^7$ (c_1)
One way	1,500 (q_0)	$3.36 + 4.04\left(f/q_0\right)^7$ (c_0)

The trips are assigned on the network itineraries, using an incremental traffic assignment method [10], assessing the users' costs for each of the new traffic increment is added, in different location of shopping centres strategies. The total users' cost during the average hour for entire streets network is computed.

3.2. Different hypermarket locations and the effects assessment

We consider as the assessment model's hypotheses the following issues, to assure no other influences on congestion extending except link types, links capacities and user cost functions:

- each of the streets network's node represents also the zone centroid; the entire network has N centroids, equal to the network's nodes,
- each of the centroid, j has the same generation and attraction potential, only for the shopping purposes; let us denote them with G_j and respectively A_j,
- when a new hypermarket location is chosen (i.e. the *k* node), the attached zone centroid to the node *k* node will have the attraction potential several times higher then "no-hypermarket-location" case, $A_k = n \cdot A_j$, where $n \in \Re^+$ $(n > 1)$,

  The added attractivity potential of the *k* node is then $\Delta A_k = nA_j - A_j = (n-1)A_j$
- all the other nodes *j*, with $j \neq k$ will have a higher and equal shared generation potential comparing to "no-hypermarket-location" case, in order to balance the additional attractivity of the *k* node; $\Delta G_j = \frac{\Delta A_k}{N-1}$.

We used a gravity distributional model for the second step of the demand modelling. The deterrence function is a power function on the minimum length between the origin-destination (O-D) pairs of nodes, with – 3 as parameter

For the assignment step we used an incremental model, usual in case of congested networks. The increments had typical values: 40%, 30%, 20% and 10% of total amount of the O-D trips [10].

Strategy I: "no hypermarket location" (no H) – retails have uniform spatial distribution.
Strategy II: "hypermarket location in the 15 node" (H15) – retails concentrated in the inner centre of the city (see Figure 2).
Strategy III: "hypermarket location in the 7 node" (H 7) – retails concentrated outside the inner centre of the city.
Strategy IV: "hypermarket location in the 18 node" (H 18) – retails concentrated outside the urban area into the 18 node/zone centroid; the node 18 is connected to the 7 node by the link (18,7) with 2.5 km. length and one lane per way.
Strategy V: "hypermarket location in the 18 node with easy access" (H 18A) - retails concentrated outside the urban area into the 18 node/zone centroid and the link (18,7) has a developed capacity from one to two lanes per way.

Table 4 depicts the results of the car traffic assignment for the test values of the attractivity and generation.

Table 4

The total users' cost of the streets network in different hypermarket location strategies

The hypermarket location strategy	Zone's attractivity [pcu/h]	Zone's generation [pcu/h]	Total users' costs for the entire network [10^{-2} monetary units/h]	Total users' costs for the inner circle area of the network [10^{-2} monetary units/h]
No H	500	500	51993	-
H15	2100	600	61624	25812
H7	2100	600	63043	21468
H18	1700	600	76536	21237
H18A	1700	600	73865	21237

If we consider the decision problem of a single hypermarket location, the results of the model indicate in short that the users' cost and the car traffic congestion at the entire network level increase with respect to the distance from the city centre (node 17). The car traffic congestion diminishes on the inner circle area of the street network if the hypermarket is located towards the external circle of the network. A single hypermarket located outside of the city will produce even more car congestion. The

congestion level depends on the capacity of the road linking the city area and the suburban hypermarket location.

4. CONCLUSION AND FURTHER RESEARCHES

Most cities from the emergent economies have to face a high rate of car ownership rate, usage and car addicting. The car dependency is even higher for the shopping purpose. The new life style in large urban area in developing countries is accompanied by the following major difficulties:

- high general development rate and an increasing rate of work productivity – short time for rest, leisure and shopping for an increasing number of inhabitants,
- high density of activities and car congestion in the city centre,
- no important development funds for the transport infrastructure towards the suburbs,
- increasing attractivity of the land market and new and larger hypermarkets developments, which are less often small and close to residential area shops.

The paper points out the necessity to asses the decision's effects of the new hypermarket location of large and dense urban area in developing counties, especially as the car traffic congestion increases.

A new hypermarket location changes the generation and attraction potential of the entire area and produce additional car traffic related to the distance from the city centre. The car traffic congestion diminishes on the inner circle area of the street network if the hypermarket is located towards the external circle of the network. A single hypermarket located outside the city will produce even more car congestion, and its level depends on the road capacity linking the city area and the suburban hypermarket location.

For a comprehensive modeling of the effects assessment in case a new hypermarket location is decided, the further researches have to be considered:

- modeling of the location decision in case of more than one already acquired hypermarkets locations and their influences on car traffic congestion, taking into consideration only the dedicated zone for the shopping activity,
- the influences of the car parking spaces (property of hypermarket) on the car traffic congestion,
- the real preference of the customers regarding the type of goods, introducing the type of goods and the distribution of shopping circle periods on car traffic congestion and structure.

The core model presented in this paper is used for the simulation with real data, using the TransCAD software packages, for the Bucharest city case.

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