Optimization of advertising media placement on transport infrastructural sites on the basis of big data technologies

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Abstract. This paper shows that the integral socio-economic efficiency of the state-private partnership projects in the road maintenance sector is mainly determined by the effectiveness of three factors: fare payment; road service facilities; outdoor advertisements placed on buildings, located on the land plots designed to accommodate the road structural elements and road facilities structures. The paper content is devoted to solving the problem of algorithms constructing for integrated quantitative evaluation of outdoor advertising. It is shown that the effectiveness of advertising is determined not only by the number of individuals entering into visual contact with advertisement media, but also by the measure of conformity of characteristics of such individuals with the parameters of target audience of the advertising message. The methods of automated data collection are formulated, allowing the determination of these individuals’ characteristics, based on the vehicle fixation systems. The formulated methods significantly expand the possibilities of geo-targeting on the bases of not only the position of members of the target audience on the road, but also on the bases of the region of their vehicle registration. An algorithm is obtained that allows combining geo-targeting with social targeting, by describing the average socio-economic, gender and age characteristics of the target audience members. It is shown that the information necessary for the implementation of this algorithm can be obtained on the data basis of the region of vehicles registration. Furthermore, the objective function, the task of optimizing the effectiveness of advertising media are defined and its particular cases for commercial and various types of social and political advertising are obtained. As an example, the dependence of the effectiveness of social advertising on time is calculated, based on the target audience members moving across the Crimean Bridge in the first year of its operation.

Keywords: investments, transport infrastructure, state-private partnership, advertising activity, efficiency, targeting, monitoring, traffic flow.

1 Introduction
One of the methods to increase the effectiveness of state-private partnership (SPP) projects in the road maintenance sector is to carry out the marketing strategy, related to the advertising media placement on the land plots designed to accommodate the road structural elements and road facilities structures [1, 2]. This mechanism is used as an effective remedy of increasing the profitability of SPP projects and reducing their payback periods [3]. Additional revenues from the advertising activities can have a significant impact on socio-economic indicators of the project [4]. Especially strongly this effect is impacting the objects located near megalopolises, entrances to the airports and large resort zones [5].
This might be explained by the presence in the traffic flow of the majority of people, representing small and medium-sized businesses, along with the individuals belonging to creative and middle classes [6, 7]. Therefore, in order to improve the integral efficiency of SPP projects in the road maintenance sector, along with an assessment of the effectiveness of paying tolls, it is necessary to assess the effectiveness of road service and advertising structures placed along the routes located on the land plots designed to accommodate the road structural elements and road facilities structures [8, 9].

The effectiveness of advertising is not just proportional to the number of individuals potentially entering into visual contact with advertisement media boards, but also by the measure of conformity of the characteristics of such individuals with the parameters of the target audience of the advertising message.

2 Materials and methods

Let’s define the effective number of objects of advertising exposure as Eq. 1:

\[ N_E = \sum_{k=1}^{K} \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{r=1}^{R} v_{j,k} n_{i,j,r} c_{k,r}, \]  

where \( N_E \) – impactful (based on targeting) audience of the advertising message for the full duration of its placement contract. Index \( i \) indicates the time periods (weeks, months, quarters) of advertisement placement on media boards, during which traffic flows can be considered constant; parameter \( I \) is the total number of time intervals between advertising media boards on the road. Multiplier \( n_{i,j,r} \) – the number of vehicles of \( j \)-type (motorcycles, cars, buses, trucks, etc.) passing through the studied section of the road during the \( i \) time period, registered in the \( r \) – region; \( J \) – the number of vehicles types; \( R \) – is the total number of regions, where vehicles in the traffic flow are registered; \( v_{j,k} \) – the average number of individuals in the vehicle of \( j \)-type, with \( k \) – targeting parameter (e.g. average income, age, gender, etc.); \( c_{k,r} \) – a multiplier describing the correspondence of individuals in the vehicle to the parameters of the target audience advertisement. Namely this factor allows advertising targeting; \( K \) – is the total number of targeting parameters (e.g. age categories, professional categories, etc.). Collection and complete analysis of all necessary information is possible only within the framework of big data technology [10].

Let’s give examples of determining the targeting multiplier for various types of advertising. For commercial advertising, the multiplier \( c_r \) is determined by the solvency of individuals in the vehicle. Within the framework of the big data concept, the average solvency can be calculated for each region of vehicle registration. For social or political advertising, the target of which is the entire population, the factor \( c_r \) is identical to 1. For social or political advertising, whose target audience is determined by age category (e.g. specific advertising aimed at young people, retired people, working age people, etc.), the multiplier \( c_r \) is determined by the age of population distribution of the vehicle registration region. For the regional political or social advertising (e.g. advertisement of local elections or political figure; calling for improvement of the region’s ecology, etc.) the targeting multiplier \( c_r \) is rising to its maximum for the region of transport registration, corresponding to the region of political or social impact, and rapidly decreases (e.g. exponentially) with increasing distance from it [11].

3 Results

The algorithm of the \( c_r \) multiplier calculation is the same for the social and political advertising. Down the line both of these advertising types will be called social advertising. In this case, the parameter \( c_r \) depends on the traffic flow density and on the composition of the target audience. In the simplest advertisement case, addressed to the entire population of the Russian Federation (e.g. calls for the inadmissibility of religious or ethnic discrimination, political advertising of federal electoral companies, etc.) - \( c_r \equiv 1 \), thus formula Eq. (1) becomes simpler and takes the form of:

\[ N_E = \sum_{i=1}^{I} \sum_{j=1}^{J} v_{j,k} \sum_{r=1}^{R} n_{i,j,r} = N, \]  

where \( N \) – is the total audience for the full duration of contract of advertisement placement on the media board. If the social advertising is mainly focused on drivers (e.g. advertising of traffic rules and regulations, speed limits, etc.), then there is only one member of the target audience in each vehicle, which in its turn dictates the following requirements to formula Eq. (2):
1. The number of members of the target audience in a vehicle of any kind at any time interval is equal to 1 \((\nu_{j,k} = 1)\).

2. The total number of targeting parameters (in this case – occupations) is equal to 1 \((K = 1)\).

3. The advertising targeting parameter is equal to one \((c_k = 1)\).

These requirements significantly simplify the formula Eq. (2):

\[
N_E = \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{r=1}^{R} n_{i,j,r} = L. \tag{3}
\]

Here \(L\) – is the total number of vehicles (regardless of their type) the drivers of which come into the visual contact with the advertising medium for the full time of its placement [12, 13]. If social advertising is targeted at members of a certain age group, then the advertising targeting parameter \(c_k\) is determined by the proportion of the relevant age group in the population of the vehicle registration region:

\[
c_r = \frac{p_r^\rho}{p_r}, \tag{4}
\]

where \(p_r^\rho\) – is the number of the corresponding age group in the composition of the \(r\) – region population. \(P_r\) – population of \(r\)-region. For example, advertising for early intervention of drug and alcohol problems is aimed at youth audience [14]; the target audience for pension reform is aimed at the older age group; the party advertising is correspondently focused on a specific age category.

In the process of transport planning the monitoring of the traffic flow dynamics is an independent task [15, 16]. It provides an opportunity of not only assessing the current situation, but also determining the ways to optimize it. In addition, the objective data obtained allow confirming or denying the transport forecasts offered. Exactly, the video detection systems are characterized by the best function / cost ratio and have been intensively developing lately [17]. Already at the present, the geometrical parameters of automobile approaches to the Crimean bridge do not create any obstacles for the visual contact of the target audience with advertisements carriers. Therefore, the effectiveness of advertising is determined only by the technical parameters of the traffic flow and the socio-economic parameters of the target advertising audience, located in vehicles of the flow [19].

4 Discussions
The effectiveness of social advertising aimed at all individuals in vehicles is determined not only by the full traffic flow, but also by its composition, and does not depend on the parameters of the target audience [20]. It is necessary to take into account the number of individuals from the full composition of the target audience in vehicles of various categories (minimum number in freight transport and maximum in a bus), along with the uneven composition of flow during the entire year [21].

![Figure 1. Dependence of social advertising effectiveness (the target audience of which is members of the traffic flow crossing the Crimean bridge for the first year of its operation) on time.](image)
The calculations results are reflected in figure 1, where two maxima of the social advertising effectiveness with a wide target audience are clearly visible. Firstly, the main maximum, associated with the general increase in the traffic flow during the summer months. Secondly, the side maximum is observed, because of the local growth of tourist flow during the holiday periods. Therefore, the proposed methods and algorithms allow formulating the promising scenarios for the increase of commercial, political and social advertising effectiveness, depending on the projected change in the parameters of the automobile flow.

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