Developing a Probabilistic Economic Model for Cost-Benefit Analysis on Installation Rural Advertising Signs (Case Study: Yazd-Mehriz Road, Yazd, Iran)

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Abstract

The aim of this article is to provide a probabilistic economic model for investigating the ratio of investment for installing advertising boards (billboards) on rural roads. An economic model has been developed based on probabilistic incomes over a time period of five years. Data has been gathered using a designed questionnaire and analyzed based on normal distribution function in terms of profitability and incomes over time period of investment. The main innovation of the article which makes different from the other studies is to investigate the cost-benefit ratio based on the view of investor who needs to advertise its product. One of the rural roads on Yazd province in Iran, Named Mehriz-Yazd road, has been selected as case study and the results revealed that the proposed model can be used for all business companies who are dealing with their products' advertising investment.

Keywords
Billboard Advertising Signs, Probabilistic Incomes, Engineering Economic, Profitability

1. Introduction

The city's perspective has the tightest connection with its audiences, namely the people. The perspectives of the passages and commercial and recreational sites, due to their compound usages, host more audiences, to the extent that even the people are deemed as a part of these spaces and the city's perspective. Nowadays, in the cities of Iran, like many other cities of the word, diverse adverts have occupied the margins of urban and intercity roads, and how to post, exploit and price these signs has been considered as a ubiquitous problem in the majority of the cities (Ghalenoee et al, 2012). In recent years, the flow of posting big and small advertising signs in the margin of urban roads has been accelerated in different cities. Regarding the increasing use of advertising signs as a part of urban elements and lack of comprehensive principles and instruction for pricing the elements on one hand and intensification of traffic congestion in urban roads on the other, the necessity of scrutinizing this problem has been dramatically increased (Ghalenoee et al, 2012). Those of advertisements which are posted and exploited in intercity roads and out of urban service areas are referred to as traffic advertisement (Ahmadi, 2011). Utilizing advertising signs in the cities and roads is currently increasing. The drivers usually spend many hours in roads to reach their destinations, hence the roads have the potential to be used for commercial advertisement. The advertising signs provide an opportunity to communicate an extensive gamut of addressees (Lithgow, 1999). On the other hand, those exploiting advertising signs believe that these signs have some singular advantages making them be preferred over

other media and that other media are feeble alternatives and if using them are banned, their relevant companies lose their sales (Taylor, 1997). Currently in Iran, advertising spaces are exploited by the government (municipality in urban areas, the province road and transformation office in intercity roads, etc.) and private sectors renting the sites based on their own rules (Saedi, 2016). Since the advertisements have an intangible effect on sale in the relevant market, and also advertising programs are proceeding in a path that they must be justified economically, the objective of this research is to provide a comprehensive and dynamic model specifying the price of renting advertising signs, with reliance on the customers' viewpoint.

2. Literature

The studies relevant to this topic have explained the role of advertisements in sale and trade, and also have detailed the advertising signs' conditions. In 2009, Farhangi et al. determined the association between advertisement and specific value of commercial name and that between advertisement efficiency and revenue enhancement. Also, having considered communication tools like advertisement and sale advancement, the accurate value of this association was determined through a mathematical formula and also, disparate models indicating the advertisement effect on the company's profitability were proposed, with regard to the company's sale alteration for investing in advertisement (Farhangi et al, 2009). In 2011, Dehghani and Fallahi evaluated the effect of concentration degree and advertisement cost on profitability of Iran industry sector and they came to the conclusion that each one percent increase in advertisement costs results in 21 percent increase in profitability (Fallahi & Dehghani, 2011). In 2013, Samadi et al. scrutinized the factors affecting commercial companies' interest in suburban advertising signs of Hormozgan province in Iran. Recognizing these determining factors provide some approaches to make the signs more appealing. The results derived from this research imply that the major identified factors relate to commercial companies, roads, advertising companies and advertising signs, and among these factors, the traffic congestion, the road type, the companies' perception of advertising signs and the profits earned from them are of higher importance (Samadi et al, 2013).

In 2015, having considered the current rules and available information, Ghasempour and Mashhadi proposed a comprehensive and dynamic model for pricing each square meter of advertising signs in the margin of highways with regard to traffic relationships, volume and vehicles' speed (case study: Tehran highways). Applying this model, one can estimate the price of each square meter of advertising signs in Tehran highways with regard to associated factors, say, the volume of passing vehicles in different times, the vehicles' average speed and the displayable surface area of each sign (Ghassempour & Mashhadi, 2015). In 2008, Gupta evaluated the effect of advertisement costs on industries' performance and concluded that the advertisement intensity has a significant and positive effect on three industries, automobile, textile and food in India between 1997 and 2006, while the effect of advertisement on profitability of food and textile industries was significant and negative (Gupta, 2008). Based on a research carried out by High in 2009, it was concluded that to enhance the revenue of posting advertising signs, there are some critical factors: providing the district map (including the variables like the posting location, the district traffic congestion, and the sign's durability), content and configuration of the sign, definition analysis, modifying income resources, analyzing the market's prosperity ways and sale by advertisement through each network of DOOH signs (High, 2009).

Siemasko, in 2013, categorized the business activities taking the biggest profits from advertising posts as local business, expensive stuff business, products or services of mass market and innovative business, and specified the relevant features for each (Siemasko, 2013). Based on a research by Prosser in 2015, two principal factors, say, the number of people caring about that sign and being affected by that and the population of audiences for that sign, affect the cost associated with advertising signs (Prosser, 2015).

The relevant research carried out so far has referred to the positive and negative effects of advertisement on profitability, and the amount of rent paid for the sign has seldom been studied based on product sales profit, in other words, the economic efficiency of renting the advertising signs from the viewpoint of those demanding for advert (i.e. customer) is yet to be studied, thereby, in this paper, the revenue standpoint of economic institute is discussed. It means that we evaluate whether the amount of money paid by that organization during the rental interval is equal to the revenue resulted from advertisement or not.

3. Developing the economic model in probabilistic conditions

The necessity of considering the probabilistic problems of the revenue specification while taking economic decisions, is stated in the format of problem definition. Since it's not relatively easy to discover the parameters' changes and to calculate their probabilities, we usually try to develop the relevant problem by considering the revenue probability distribution function (Abbaszade & Ghasemi, 2013), hence in the developed model, it is supposed that the revenues are probabilistic.

3.1. The plan's costs and revenues

The cost is the money paid for renting the advertising sign and the revenue here is derived from selling the products advertised using the signs. The cost is paid at the first of rental period and the revenue is made in upcoming years. Fig.1 depicts the relevant cash flow diagram.

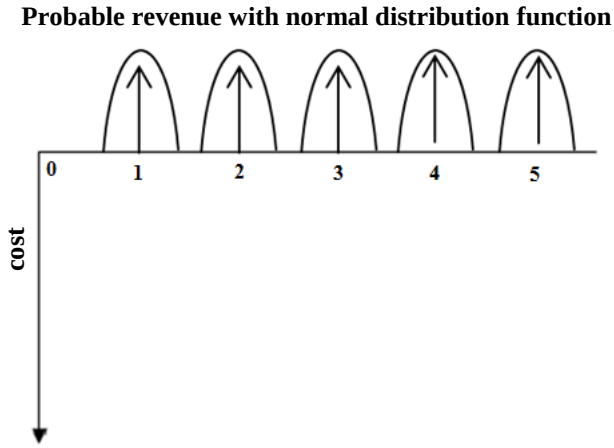

Figure1: Relevant cash flow diagram

3.2. How to calculate the revenue

The number of products being purchased due to the effect of advertising signs during a specific year is calculated through multiplication of the number of people seeing the sign in a one year period and the number of times they purchase, as shown in equation (1).

$$N_G = N_A \times N_B \quad (1)$$

Where, N_G is the number of products bought by the people who see the sign during a specific year and purchase the product due to that advert, N_A is the number of people who see the signs and N_B shows how many times they purchase. In the first phase, the number of the people seeing the advertising sign is calculated through multiplication of four parameters, as shown in equation (2).

$$N_A = P_a \times M_a \times L^*_a \times (\mathrm{T} \times \mathrm{V}) \quad (2)$$

Where, the first parameter relates to the number of the people who see the signs while moving in the road. The second parameter represents the proportion of the people who care about the content of the sign when they see it. The third parameter indicates the number of the persons sitting in the car, namely the driver plus other passengers. The fourth parameter is calculated through summing multiplication of daily traffic volume and the share of watching the sign in day with multiplication of nightly traffic volume and the share of watching the sign at night. This parameter represents the whole volume of traffic in relevant roads. Regarding these parameters, the whole number of the people who care about the advert sign is obtained through equation (3).

$$N_A = P_a \times M_a \times (L_a + 1) \times \{(T_d \times V_d) + (T_n \times V_n)\} \quad (3)$$

Where, P_a is the proportion of the people who see the advert signs while moving in the road, M_a is the number of the people who pay attention to the sign content when they see it, (L_a+1) represents the whole number of the people in the car (including driver), T_d is the volume of daily traffic, V_d is the share of watching the sign in day, T_n is the volume of nightly traffic and V_n is the share of watching the sign at night. In the second phase, the number of the times they purchase is calculated through multiplication of three parameters, say, the mean number of the products purchased because of advertisement, the mean number of the times they think of buying the stuff upon they see the advert and the mean number of the times they have seen a daily need on the sign, as shown in equation (4).

$$N_B = N_b \times N_t \times N_v \quad (4)$$

Where, N_B shows how many times they purchase, N_b is the mean number of the products purchased based on advert, N_t is the mean number of the times they think of buying the product as they see the advert, and N_V is the mean number of the times they observe a daily need on the sign. In the final phase, the revenue resulting from advert is

calculated by multiplying the number of the products purchased by the people who see the sign and pay attention to that during a year by the profit resulting from selling the products, using equation (5).

$$I = N_G \times PR \tag{5}$$

Where, symbol I indicates the income due to advertisement, N_G is the number of the products purchased by the people who see the sign and care about it during a year and PR represents the sale revenue. What is meant by the cost here is the expense of renting an advertisement sign, shown in equation (6).

$$C_T = C_R \tag{6}$$

Where, C_T is the total cost and C_R is the cost of renting the sign. Using income formula, each person's income is calculated, then the mean and variance of all the people's incomes are calculated. Regarding the point that the majority of contracts in this scope hold a five-year period, in this research, a five-year interval for incomes is probabilistically considered.

3.3. Determining the expected value, variance and standard deviation of cash flows

Considering $E(F_K)$ as expected value of pure cash flow in the k^{th} year, the expected value of PW is obtained as depicted in equation (7) (Seyed Hoseini, 2011):

$$E(PW) = \sum_{K=0}^{5} (P/F)_K^r \times E(F_K) \tag{7}$$

In which $E(F_K)$ is the expected value of pure cash flow in the k^{th} year, $(P/F)^r_k$ is the financial factor converting the future value of payment into present value of payment in the k^{th} period with interest rate r. Also, to calculate variance of PW, equation 8 is used in which $Var(F_K)$ is the variance of pure cash flow (Seyd Hoseini, 2011). The standard deviation is also obtained using equation (9):

$$Var(PW) = \sum_{K=0}^{5} [(P/F)_K^r]^2 \times Var(F_K) \tag{8}$$

$$SD(PW) = [Var(PW)]^{\frac{1}{2}} \tag{9}$$

If PW is normally distributed with pre-specified mean and variance, the probability of rejecting a project is probability that IRR is less than MARR and this is equivalent with the probability that PW is less than zero. Exploiting standard normal distribution, the probability of rejecting the project is calculated using equations (10) and (11) (Oskunezhad, 1997) and the probability that the project is accepted and profitable is obtained through equation (12) (Masoudi, 2007). According to aforementioned phases, the probability of rejecting the project is found and if the probability is more than the confidence interval considered by the customer renting the sign, this project will be profitable for them and it's economical for them to rent the sign for advertising their products.

$$z = \frac{PW - E(PW)}{SD(PW)} \tag{10}$$

$$Pr\{PW \leq 0\} = Pr\{Z \leq z\} \tag{11}$$

$$Pr_P = 1 - Pr\{Z \leq z\} \tag{12}$$

4. Case study

Using the questionnaires' results and the method of calculating revenue, and assuming that the revenue of selling each advertised product is equal to 100 thousand rials (Iranian currency), and that the traffic congestion of Mehriz-Yazd road, based on statistics elicited from transportation and road administration of Yazd province, is 25000 vehicles, each person's income is computed, and the income mean and standard deviation are calculated using the

well-known software of Excel. It is assumed that the mean and standard deviation relate to the first year. Hence, in the first year, the probabilistic revenue is distributed normally with mean 3577 millions and standard deviation 11203 millions. We assume that the interest rate equals 18 percent and the cost of posting and renting the sign is currently one billion (1000 million) rials. Based on aforementioned formulas, the average and variance of the current pure value of relevant cash flow with a five-year period is obtained using equations (13) and (14):

$$E(PW) = \sum_{K=0}^{5} (P/F)_K^r \times E(F_K) = -C_T + \sum_{k=1}^{5} \mu_k F({}^{P}/_{F}, i\%, k) \quad (13)$$

$$VAR(PW) = \sum_{K=0}^{5} [(P/F)_K^r]^2 \times Var(F_K) = 0 + \sum_{k=1}^{5} \sigma_k^2 F\left({}^{P}/_{F}, i\%, k\right)^2 \quad (14)$$

In which C_T is the sign's rent, μ_1 is the mean of income's normal distribution function in the first year, μ_2 is the mean of income's normal distribution function in the second year which has increased by 12 percent since the first year, $б_1$ is the standard deviation of the income's distribution function in the first year and $б_2$ is the standard deviation of the income's distribution function in the second year, which is assumed to have increased by 12 percent since the first year. By taking down these assumptions, equations 15,16,17,18 and 19 are computed, and based on the results, one can declare that this project will be rejected with 0.32 probability and will be profitable with 0.68 probability.

$$E(PW) = 1.27 \times 10^{10} \quad (15)$$

$$VAR(PW) = 3.69 \times 10^{20} \quad (16)$$

$$z = \frac{PW - E(PW)}{\sqrt{VAR(PW)}} = \frac{3576865000 - 12691377248}{19230508567.4524} = -0.474 \quad (17)$$

$$Pr\{PW \leq 0\} = Pr\{Z \leq z\} = Pr\{Z \leq -0.474\} = 0.32 \quad (18)$$

$$Pr_P = 1 - Pr\{Z \leq z\} = 0.68 \quad (19)$$

5. Conclusion

As explained before, in this research, having proposed an Economic model developed and completed 101 questionnaires and also having considered a five-year period for the relevant cash flow and with the aid of present value method when incomes are probabilistic, the project's profitability likelihood was estimated.

1) With regard to the research's assumptions and 18 percent interest rate and 1 billion rials rental and 12 percent annual increase in income, this project is estimated to be profitable with 68 percent probability, in other words it is worth renting the sign.
2) All the organizations willing to rent advertising signs in any part of the city can check whether it is profitable for them to rent the sign or not, using the model acquired.
3) If the project's interest rate is less than 18 percent, perusing the assumptions, the project's profitability probability increases, and if this rate is more than 18 percent, this probability declines. The most critical point to be considered in this type of economic analysis is risk, so we recommend the researchers to expand the model, with regard to the income's risk and the point that the costs are probabilistic.

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Biography

Abbas Mahmoudabadi, corresponding author (mahmoudabadi@mehrastan.ac.ir), is Ph.D. in Industrial Engineering and director of Master Program in Industrial Engineering at MehrAstan University, Guilan, Iran and deputy of Planning and Coordination in Transport and Fuel Management Centre, at Road Maintenance and Transport Organization, Tehran, Iran. He achieved his Ph.D. degree in January 2014 in the field of optimization in Hazmat transportation and received Thesis Dissertation Award from IEOM society in March 2015, Dubai, UAE. He has published near 60 journal or international conference papers and one book chapter published in the field of industrial engineering, transportation, traffic and road safety. He teaches transportation and industrial engineering courses at universities and has around 25 years of executive experiences on traffic and road safety planning in developing countries. He has also strong cooperation with national and international agencies traffic safety and more with international agencies in the field of industrial engineering. Some national transportation projects have been implemented under his supervisory roles with the results of fatality reduction in intercity transportation.

Behnaz Fotouhi has Bachelor and Master of Science degrees in Transportation Engineering. She graduated from Kharazmi University, Tehran, Iran in May 2016. Her thesis dissertation is on studying cost-benefit ratio on road advertising and published her papers in this field.