

Analysing Tourism Expenses Using Mathematical Modelling

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Abstract: The article considers the ways a potential tourist would spend his/ her funds in three-day tour package in Samarkand city. For this purpose, a mathematical simulation model based on Monte Carlo method was used. As a result of the analysis, it was found that the total expenses of tourists were greatly influenced by the costs of transport and food.

Keywords: expenses, services, tourism, Monte Carlo, transport, food, model

Introduction

Tourism, which is considered an important field of service, is directly affected by the relationship between the service provider (entity) and the tourist (object). Modeling tourist behavior based on the need for quality service provides an opportunity to assess the potential income and profitability of the enterprise at the micro level and the network at the macro level. Mathematical simulation is very useful in the study of processes in complex systems. The word simulation here means the modeling of a certain phenomenon with the help of one or more artificial (controlled) experiments. Monte Carlo methods based on repeated random sampling can be cited as a form of simulation. Monte Carlo method was developed by Stanislav Ulam within the project of creating atomic bomb in the 1940s¹. The method was used to model uranium neutrons' initially random diffusion.

¹ https://en.wikipedia.org/wiki/Monte_Carlo_method

According to Sanovitz there are four main services in field of tourism: food catering, recreation, visiting and purchasing². He thought that above-mentioned services were fundamental in shaping the decision to travel to a particular destination. Correctly forecasting tourist expenditures, and predicting cost structure correctly can handle destinations a competitive advantage. As destinations get ready for possible scenarios, they will be able to bear minimal costs even in worst case scenarios. Based on this, we considered that tourist expenditure consist of transportation, food, accommodation, and guide services.

Literature review.

Currently, various econometric methods are widely used in the research of the tourism sector. For example, ARIMA, VAR in dynamic series forecasting models wide is used ³. In categorical (quality) or nominal data analysis probit and logit like models are used ⁴. But this methods cannot effectively model complicated systems.

The advantage of Monte Carlo methods over other econometric methods is that the variables distribution is not so much important and there is the possibility of assuming parallel occurrence of various events⁵.

Research methodology

During this study, a mathematical simulation of three-day tourist expenses was carried out using Monte Carlo methods, consisting of algorithms based on repeated random sampling. During the research, the data collected based on the observations made in the hotels "Nodir Samarkand", "Malika Prime", "Orient Star Samarkand" in the city of Samarkand was used. Mathematical simulation is based on the following apriori hypotheses:

A_0 –Three-day expenses of tourists are clearly planned, and the probability of unexpected expenses is very low;

A_1 –The probability of tourists using non-tour package services is around 40%;

A_2 –Tourists expenses values obey to the beta distribution .

Beta distribution can be said to be a sum of probability distributions formed using two alpha and beta parameters in the interval 0 and 1⁶.

Complying the above-mentioned conditions the model based on 100 iterations was developed.

Analyzes and main results

During the study, the average three-day expenditure of one tourist was taken as the main studied variable. The following were selected as variables describing the cost function:

X_{tr} - transportation costs, thousand soums;

X_{jx} - placement costs, thousand soums ;

X_{mg} - the cost of hiring a qualified guide, thousand soums;

X_{tpt} - expenses other than the tour package, thousand soums;

X_{oo} - food expenses, thousand soums ;

² SANOVICZ, E. (2011) Turismo feed Cidades . São Paulo: Campus.

³ Safarov B, Al- Smadi HM, Buzrukova M, Janzakov B, Ilieş A, Grama V, Ilieş DC, Csobán Vargáné K, Dávid LD. Forecasting the Volume of Tourism Services in Uzbekistan. *Sustainability* . 2022 ; 14(13):7762. <https://doi.org/10.3390/su14137762>

⁴ Safarov B., Mirzaev K., Janzakov B., Ruzibayev O. African Journal of Hospitality, Tourism and Leisure, 2022, Vol 11, 6, pp. 2052-2062.

⁵Gilbert, E. Investment Basics XLIX. An Introduction to Real Options," Investment 8 Analysts Journal, vol. 60, 2005, pp. 49-52.

⁶ Elderton , William Palin and Norman Lloyd Johnson (2009). *Systems of Frequency Curves* . Cambridge University Press

T - the tourist's alternative costs of searching for and choosing services, thousand soums.

Thus, we can make the cost function of a tourist's 3-day trip look like this:

$$f(x) = \alpha X_{tr} + \beta X_{jx} + \gamma X_{mg} + \lambda X_{tpt} + \nu X_{oo} + rT$$

i.e. here $\alpha, \beta, \gamma, \lambda, \nu, r$ are the corresponding coefficients.

We determined the minimum, average, and maximum values that each variable can take using a questionnaire and observations (Table 1). In this case, we used a mathematical simulation method of the Perth distribution (the private case of the beta distribution). Because exactly the Perth distribution has the parameters including minimum, average and maximum values and is widely used in modelling real-world events⁷. Perth distribution can be described as follows:

a – the minimum value, b – the average value, c – the maximum value,

$$\alpha = \frac{4*b+c-5a}{c-a};$$

$$\beta = \frac{5c-a-4b}{c-a}$$

Above α and β values are the parameters of the following Beta distribution:

$$f(p, \alpha, \beta) = \frac{p^{\alpha-1}(1-p)^{\beta-1}}{\int_0^1 u^{\alpha-1}(1-u)^{\beta-1} du}$$

Here p – the probability of an event occurring (random number between 0 and 1), u – value between 0 and 1⁸.

Table 1
Potential expenses of tourists during a three-day trip

Cost types	The probability of the event	Minimum value , thousand soum	Average value , thousand soum	Maximum value , thousand soum	Occured (1) or not (0)		Final value
Transportation costs		80	1500	9000			1644.02
Hotel expenses		120	150	2000			293.55
Qualified to the guide expenses		500	1200	1800			987,673
get up from the package except to the service expenses	40%	0	250	1200	0	575.7414	0
Food food expenses		200	1200	6000			3468.54
Tourist the service to look for gone alternative expenses		0	50	120			72.75
Unexpected expenses	5%	0	500	1500	0	396.8075	396.81
Total							6466.5

Table 1 was created by using data from hotels “Nodir Samarkand”, “Malika Prime”, and

⁷RODRIGUES, EM; NUNES, RV; ADRIANO, NA (2010) A simulação de Monte Carlo como instrumento para a analyses economic-financeira feed investimentos de risco - O caso de uma investment decision _ neither abertura de uma filial para revenda de equipamentos pesados no Estado do Ceará . In: CONGRESSO BRASILEIRO DE CUSTOS, 17, Belo Horizonte, Proceedings... Belo Horizonte: CBC, 2010.

⁸ Clark CE (1962) The PERT model for the distribution of an activity. Operations Research 10, pp. 405406

“Orient Star Samarkand”. In this case, the observations for domestic and foreign tourists were added, so the maximum values, in some cases, received much larger values than expected. Expenditures for non-tour package services do not always occur, therefore, we took the probability of occurrence of these events as 40%. It was mathematically modeled whether they would occur or not using the cumulative Bernoulli distribution and taking the corresponding values using the Perth distribution⁹.

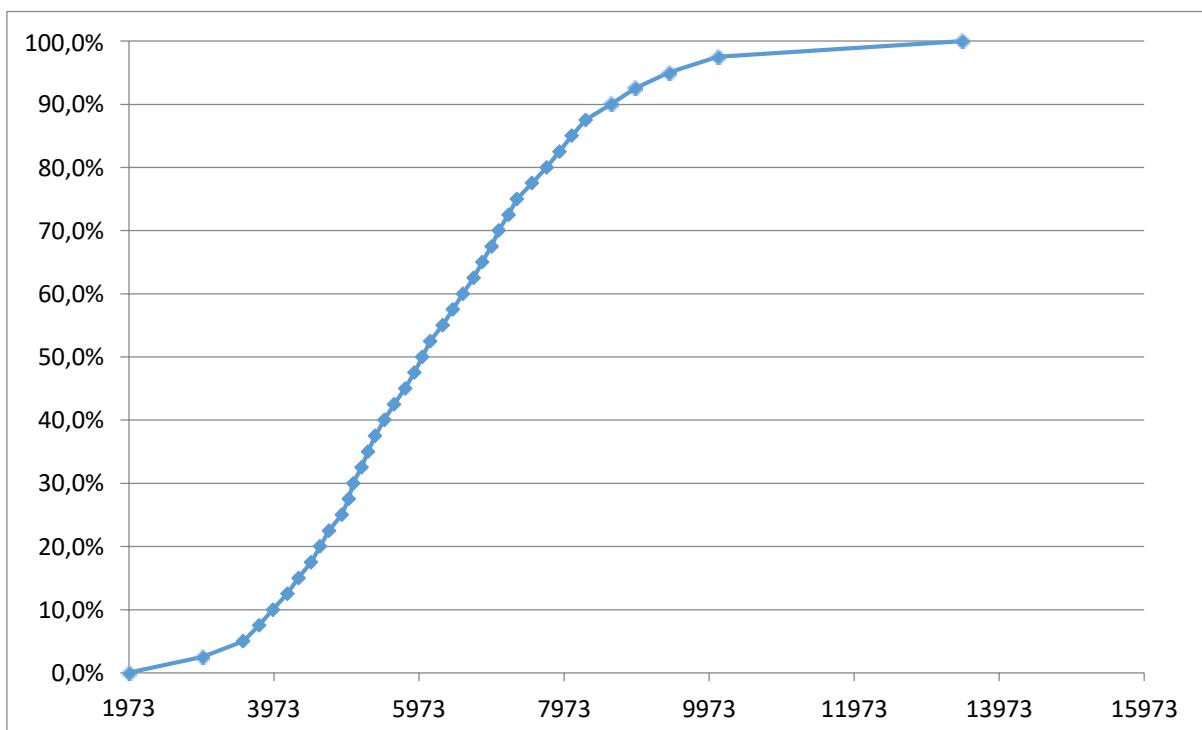
In this case, the cumulative Bernoulli distribution has the following form:

$$F(k, n, p) = \Pr(X \leq k) = \sum_{i=0}^k \frac{n!}{i!(n-i)!} p^i (1-p)^{n-i}$$

Here k – given threshold value, n – total number of observations, p – probability of occurrence of the event¹⁰.

With this distribution, binary data can be represented as a function that takes a random value.

The mathematical simulation model of tourists' travel expenses was implemented using the XLRISK software package in MS Excel.



Picture 1. Tourists' three daily total expenses' cumulative distribution, thousand soums

We carried out 100 iterations (putting different random values into the model) were performed and the three-day tourists' cumulative spending distribution presented in Figure 1 was generated. That is, for example, in the case of 80% of the iterations of tourists three daily cost did not exceed 7 million 973 thousand soums. Or else, in 10% of the iterations did not exceed 3 million 973 thousand soums. Another important indicator can be considered the correlations among the components of costs (Fig. 2).

⁹ Uspensky, James Victor (1937). *Introduction to Mathematical Probability*. New York: McGraw-Hill. p. 45

¹⁰ Johnson, NL; Kotz, S.; Kemp, A. (1993). *Univariate Discrete Distributions* (2nd ed.). Wiley. ISBN 0-471-54897-9.

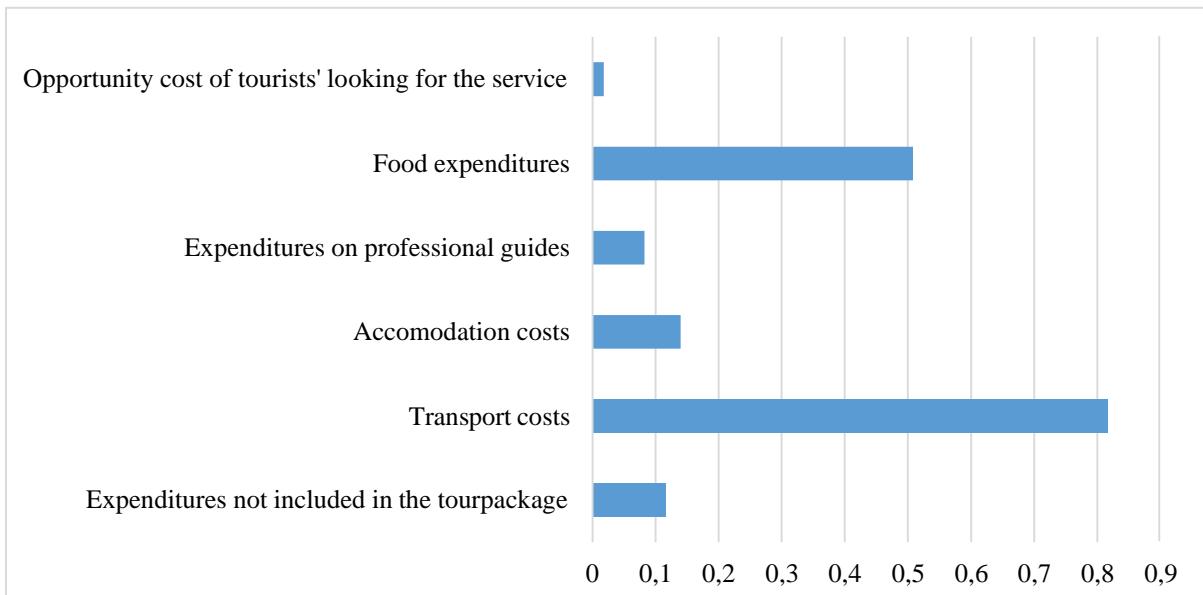


Figure 2. The degree of correlation with total costs and types of costs

Figure 2 shows a strong correlation between total expenditure and transport as well as food expenditure. That is, the contribution of these expenses to the growth of the total expenses of tourists turned out to be large. It can be seen that the rest of the services have a much lower correlation with total spending, around 10% or less.

Conclusions and suggestions

In general, this model is based on a priori assumptions and the cost values are assumed to obey the Beta distribution. Therefore, this model cannot be applied to all cases. But using this model, it is possible to calculate the income and expenses, as well as potential risk values for the tourism enterprise in different scenarios. Of course, there may be errors in each calculation, because in real life, the level of tourist demand is influenced by many factors that are difficult to measure. Nevertheless, by using Monte Carlo methods, firms will be able to develop action strategies in one or another market situation.

Based on the above, the following should be taken into account when making macroeconomic decisions on the development of tourism:

1. To increase the number of tourists, take measures to reduce transport costs, increase benefits in the transport system, reduce prices by creating a competitive transport network;
2. Development of cafes and restaurants that meet the needs of tourists, increasing the range of food;
3. Taking measures to reduce the costs of the tourist looking for services, that is, creating and developing services such as websites, bots;
4. It is important to conduct demand assessments by conducting rapid tourist behavior observation studies and building appropriate simulation models.

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