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**INNOVATIVE MATHEMATICAL MODEL OF OPTIMIZATION  
THE TOUR OPERATORS NUMBER IN BOUNDARY REGIONS**

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**Abstract**

The article demonstrates the application of a mathematical model in a decision-making process of relevant committees and agencies of the Russian Federation subjects that control the tourist industry. The mathematical apparatus of the queuing theory is applied as an instrument of assessment of the organization level of the Trans-Baikal Territory tourism industry and used for optimizing the number of tour operators. The optimal number of tour operators for minimizing the total cost of the pursuit of activities by the subjects of tourism is defined. The developed model can be used in decision making by those authorities which are responsible for the developing tourism in the region. The efficiency of management of the Trans-Baikal Territory tourism industry with the use of the constructed model is assessed. The peculiarities of innovation activity in the tourism industry are shown as well. The application of the developed activities is shown by the example of the Trans-Baikal territory.

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**Keywords:** Management; innovation activity; tourism; tourism industry; queuing theory.

## 1. Introduction

*The Strategy for Innovative Development of the Russian Federation* until the year 2020 is based on the provisions of the Concept of Long-term Socio-Economic Development of the Russian Federation until 2020. It also sets guidelines for the development of innovative companies, including public authorities of all levels. According to the Strategy, innovative activities and innovation are instrumental and essential in the development of the economy. In domestic practice, innovation is considered as the final outcome (or just the result) of an innovative activity, and in foreign practice ("Oslo Manual") an innovation is considered an activity, as a process of change. In our view, one can propose the following definition of

the “innovation”: innovation is a result of innovative activity, embodied in the form of a new or improved product brought to the market, or a new or improved organizational-economic form providing the necessary economic and (or) social benefits (Panasiuk, 2007; Spiriajevas, 2008).

There are several key areas of the innovative activity in the tourism industry:

- Introduction of new products and services;
- The use of new technologies in the production of traditional products;
- The use of tourist resources not previously used;
- The use of advanced information and telecommunications technologies;
- Development of emerging markets (Monich, 2011).

## **2. Purpose of study**

Important aspects of innovation are the issues on how to optimize the parameters characteristic of the subjects of innovation. In this behalf, it is advisable to calculate the optimal number of tour operators in the region on the basis of relevant parameters.

Management of innovation activity includes design-basis justification of goals and objectives for the particular period of time. Thus, by the goal of management we mean the required or desired state of the system in the planning period, expressed as a set of economic, administrative, scientific and innovative features. The purpose of this work is application of the mathematical model of the queuing theory to the tourism industry of the frontier subject of the Russian Federation as part of innovative activity management in tourism. By the innovation activity we mean the implementation of organizational innovations. (Timothy, 2001; Vodeb, 2010). In accordance with the intended goal, we have identified the following objectives:

- to demonstrate the relevance of the application of the mathematical models for executive decision-making by the relevant committees and the ministries coordinating the tourism industry in the RF subjects;
- to estimate efficiency of management of the Trans-Baikal Territory tourism industry by the developed model and to determine the optimal number of tour operators with the aim to minimize the total costs of business entities as well as the characteristics corresponding to such an optimal number.

## **3. Research methods**

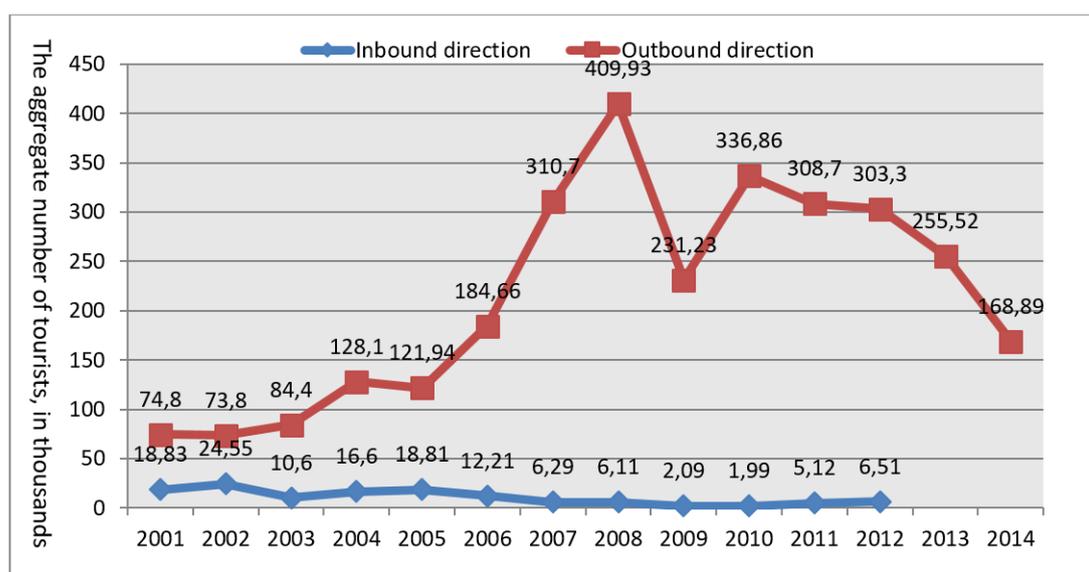
The mathematical apparatus of the queuing theory is applied as an instrument of assessment of the Trans-Baikal Territory tourism industry organization level and used for optimizing the number of tour operators.

## **4. Analyzing outbound flow from Trans-Baikal Territory**

Currently, testing and commissioning the bilateral IT system of electronic document management and online security in the framework of the Visa-Free Travel Agreement between Russia and China are conducted. This system can be regarded both as a product innovation and as an innovative service offered to tour operators operating in China and specializing in formation of tourist groups (Monich, 2011). Such changes in the follow-up of the Agreement can affect the organizational form and structure of the tourism of regions bordering with China, including the number of tour operators there. When it comes to

managing the tourist industry in the RF subjects bordering with China, *the question arises* in relation to the necessary or optimal number of tour operators being parties to the Agreement between the Government of the Russian Federation and the Government of the People's Republic of China on visa-free group tourist trips as of February 29, 2000 (Jusoh, & Mohamed, 2006).

We are going to investigate the period from 2006 to 2010. In this period, in 2009, the tourist flow had reached the maximum value and then started decreasing which is still continuing. According to the destination structure of the outbound flow from the Trans-Baikal Territory, the share of tourists sent to China has been increasing steadily, and by 2008, it reached 97.1% of all served tourists. It should be noted that in 2008, the number of tourists who went from the Trans-Baikal Territory to China amounted to 420,379 people, among them 409,930 (97.5%) travelled under the Agreement. Thus, in 2008, the tourists flow under the Agreement amounted to  $(0.971 * 0.975) * 100\% = 94.7\%$  of the total number of outgoing tourists. We have chosen 2008 as the peak year for outbound flow to the People's Republic of China.



**Fig. 1.** The number of tourists under the Agreement between the Government of the Russian Federation and the Government of the People's Republic of China on visa-free group tourist trips passing through the Transbaikal territory

Every year, the lists of tour operators being parties of this Agreement are published on the websites of the State Administration and the China National Tourism Administration (CNTA, China). The number of tour operators included in the Agreement is the biggest in the border regions. For a Trans-Baikal Territory company, there must be a letter of the *Ministry* of Cooperation and External *Economic* Connections and Trade for its inclusion into the list of companies having a visa-free regime with China. Furthermore, the question of the tourist industry management effectiveness arises, as well as the question of finding the optimal number of tour operators minimizing the costs of maintenance of tourists, on which the Department of the Ministry of International Cooperation, Foreign Economic Relations and Tourism can rely (Monich, & Kisloschaev, 2014). In our opinion, a suitable mathematical apparatus for this purpose is the mathematical queuing theory that we suggest using as a tool for assessment of the level of process flow in various branches of activity. We will apply this mathematical tool for the tourism industry.

## 5. The mathematical model for optimization of the number of tour operators

The analyzed system qualifies as the regret function for waiting systems which is as follows:

$$F_{n,wait} = C_{expect}M_0 + C_{dt}N_0 + C_e n \quad (1)$$

where  $C_{wait}$  is total loss as a consequence of waiting for services;  $M_0$  is the average number of tourist groups, waiting for services;  $C_{dt}$  is the cost of downtime of the tour operator in unit time (if there are no applications for a tour);  $N_0$  is the average number of companies that have no application for registration of a group;  $C_e$  is the operation cost per time unit;  $n$  is the number of tour operators;

In order to determine values of the  $C_{wait}$ ,  $C_{dt}$  and  $C_e$  costs, 10 executives of Trans-Baikal Territory tour operators were surveyed.

The losses associated with waiting for inception of services by tourists groups at a time ( $C_{wait}$ ), were usually associated with the loss of profits in connection with business of all operators of a company and their inability to accept an application for a tour registration. In such situation, a group could refer to a competitor and thereby deprive the tour operator of profits.

In the course of calculating the cost of the tour operator downtime in unit time ( $C_{dt}$ ), we summed up costs on commercial activity in case of absence of requests. The following parameters were considered:

- wages fund;
- rent of premises and transport vehicles;
- financial guarantee;
- miscellaneous costs (advertisement, renovation of technical basis, contracts maintenance costs, Internet access);

The operation cost per time unit ( $C_e$ ) was associated with pursuit of travel company activities during providing customer service. Generally, the following elements were included:

- $C_{dt}$ ;
- additional costs for emolument, depending on managers' performance indexes, the number of served tourists, etc;
- transaction costs for settlements with foreign partners;
- telephone payments;
- other costs (services related to the use of technical facilities etc.).

The executive of each company identified averages for these costs. The ratio between the parameters for all tour operators is clearly expressed and is appropriate to the following proportion:  $C_{wait} : C_{dt} : C_e = 0.004 : 0.880 : 1$ . According to the mathematical model, when calculating the cost function, we used disjunction of conjunctions (see Eq. 1). In terms of calculations, the ratio of costs parameters is more important than their absolute figures in rubles. We took the average values of ten companies as indicators:

$$C_{wait} = \frac{\sum_1^{10} C_{wait,i}}{10} \approx 12(\text{thous.rub./day}) \quad (2)$$

$$C_{dt} = \frac{\sum_1^{10} C_{dt,i}}{10} \approx 2700(\text{thous.rub./year}) \quad (3)$$

$$C_e = \frac{\sum_1^{10} C_{e,i}}{10} \approx 3060(\text{thous.rub./year}) \quad (4)$$

In addition to the costs parameters described above, the following original values were also taken as input data.

1. The number of tour operators in 2006-2010 and the number of served tourists for this period under the Agreement. The relevant data are given in Table 1.

2. The number of tourist groups and the average service time for one group. Inflow of application from a tourist group is random. Statistics of the arrival rate showed that the incoming requests form the Poisson stream. It is expedient to introduce the groups to the tourists number ratio,  $k = 100$ .

**Table 1.** The number of tour operators and the number of tourists served under the Agreement in an outbound direction

Year	The number of tourists under the Agreement	The number of tour operators included into the Agreement
2006	184'656	13
2007	310'668	13
2008	409'928	14
2009	231'238	17
2010	336'857	27

To determine the optimal number of tour operators and relevant assessments of their workflow management in 2010, a software package under Microsoft Visual Studio 2010 coded in C# developed by the authors was used. The description of assessments and the results are shown in Table 2. The assessments were calculated using the following formulas:

$$P_0 = \frac{1}{\sum_{i=0}^{n-1} \frac{\alpha^i}{i!} + \frac{\alpha^n}{(n-1)!(n-\alpha)}}, \quad (5)$$

where  $P_0$  is the likelihood that all tour operators are free;

$n$  is the number of tour operators in the system,  $\alpha$  is reduced density of the requests flow;

The average number of busy tour operators in the system ( $N_b$ ) is equal to the reduced density of the requests flow ( $\alpha$ ):

$$N_b = \alpha \quad (6)$$

$$N_0 = P_0 \sum_{k=0}^{n-1} \frac{n-k}{k!} \alpha^k, \quad (7)$$

where  $N_0$  is the average number of companies that have no requests.

$$K_b = \frac{N_b}{n}, \quad (8)$$

where  $K_b$  is the load factor of a tour operator.

$$K_{dt} = \frac{N_0}{n}, \quad (9)$$

where  $K_{dt}$  is the downtime factor of a tour operator.

$$M_0 = \frac{\alpha^{n+1}}{(n-1)!(n-\alpha)^2} P_0, \quad (10)$$

where  $M_0$  is the average number of groups waiting for the start of tour forming.

$$\overline{t_{wait}} = \frac{M_0}{\lambda}, \quad (11)$$

where  $\overline{t_{wait}}$  is the average waiting time before the start of tour forming;

$\lambda$  is the number of tourist groups.

$$P_{s \geq n} = \frac{\alpha^n}{(n-1)!(n-\alpha)} P_0, \quad (12)$$

where  $P_{s \geq n}$  is the likelihood that all companies are engaged in the formation of the tour;

$$M_T = N_b + M_0, \quad (13)$$

where  $M_T$  is the average number of groups in the course of service and in wait for service;

**Table 2.** Estimates of the level of tourist activity organization at the Trans-Baikal Territory in 2010

Estimates of the level of organization	Number of tour operators, n		
	11	12	13
P <sub>0</sub> (the likelihood that all tour operators are free)	7.47*10 <sup>-5</sup>	8.75*10 <sup>-5</sup>	6,63*10 <sup>-5</sup>
N <sub>3</sub> (the average number of busy tour operators)	9	9	9
N <sub>0</sub> (the average number of tour operators with no requests)	2	2.76(~3)	3,76(~4)
K <sub>3</sub> (the load factor of a tour operator)	0,84	0,77	0,71
K <sub>dt</sub> (the downtime factor of a tour operator)	0,16	0,23	0,29
M <sub>0</sub> (the average number of tourists groups waiting for start of group forming)	2,52	1,01	0,32
T <sub>wait</sub> (the average waiting time of a tour formation)	6,57 h	2,62 h	49 min
P <sub>s&gt;=n</sub> (the likelihood that all tour operators are engaged in the formation of tours)	0,48	0,303	0,13
M <sub>r</sub> (the average number of groups in the entire system)	11,75	10,24	9,55
C <sub>dt</sub> N <sub>0</sub> (thous.rub.)	4777,6	8100	10800
C <sub>e</sub> n (thous.rub.)	33660	36720	39780
C <sub>wait</sub> M <sub>0</sub> (thous.rub.)	11037,6	4423,8	1401,6
The amount of costs (thous.rub.)	49475,2	49243,8	51981,6

## 6. Findings

We can make the following conclusions based on the data obtained from Table 2.

1. The increase in the number of tour operators leads to a slight change in the likelihood that the tour operators will be idle (P<sub>0</sub>).
2. The average number of idle tour operators is growing in correlation with their total number increase.
3. The number of groups waiting for start of tours forming (M<sub>0</sub>) and the waiting time (t<sub>wait</sub>) fluctuate significantly with the increase of the number of operators.
4. There is likelihood that the number of all the companies engaged in the formation of travel (P<sub>s>=n</sub>) will decrease substantially when going from 12 to 13 tour operators. For n=12, it equals 30.3%, for n=13 — 13%.
5. The calculations show that the optimal number of tour operators equals 12. Also, the total industry costs are minimal and amount to 49,243.8 thous. rub.

The actual costs of the company may not be the same as reflected in statistical reports. Therefore, the developed model can be improved by taking into account the impact of the shadow economy on tourism (Burov, &Atanov, &Andrijanov, & Sudakova, 2014).

## 7. Conclusions

We applied the software package for calculation of the optimum number of operators for a period of 5 years from 2006 to 2010. We provide the obtained data in Table 3.

**Table 3.** Optimal and actual number of tour operators

Year	Actual number of tour operators	Optimal number according to the model
2006	13	7
2007	13	11
2008	14	14
2009	17	8
2010	28	11

The sharp increase in the number of tour operators for the period from 2009 to 2010 happened due to the fact that many subdivisions of tour operators decided to work with China by their own, by creating separate companies. Similar restructuring trends are nationwide (Stepanova, 2016). For example, under the annex to the Agreement, the following entities of the Moscow Region being de facto integrated under the single brand were added in 2011: "Pegas", "Pegas Tours", "Pegas touristic".

Such businesses can be regarded as one single tour operator with a variety of sales channels. Similarly, the divisions of the Chinese Society for Tourism (CST) in Manzhouli and Hailar are registered as two independent companies and are included into the list of the Chinese part. In 2008, the optimum and the actual numbers of tour operators were equal. The 2008 was a year of prosperity of tourism related to the Chinese direction. The subsequent decline in tourist flow and an increase of the number of tour operators in 2009 and 2010, respectively, affected the entire tourism industry negatively. Currently, management of the tourism sector in the Trans-Baikal Territory is not effective enough. Such restructuring of the tourism industry and fragmentation of tour operators to the large number of small tour operators, has led to price competition. Tourism focused on price reduction instead of competing by improving tourism products (Kovács, & Nagy, 2013)

The urgency of application of mathematical apparatus for management of innovative activity in the tourist sector is revealed. The efficiency of management of the Trans-Baikal Territory tourism sector with the use of the constructed model is assessed. The optimal number of tour operators for minimizing the total cost of pursuit of activities by the subjects of tourism is defined.

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