Interactive algorithm for estimating consumer demand for tourism services for sustainable operation of the transport industry

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Abstract. The mass withdrawal from the tourism market and the bankruptcy of operators with many years of history show that there have been radical changes in this type of business. The digital economy, the rapid development of online services, aggregator sites change the structure of demand for travel, recreation and entertainment. First of all, it is necessary to take into account that the generation of zets becomes the most active consumer for these services. Since the global network has become the main source of information and a way of interaction for this age group, it is necessary to change the concept of supply. It is necessary to diversify the assortment sales matrix in addition to traditional vouchers. The expansion of the range of tourism products should be based not only on a deep analysis of market demand, but also on modern algorithms for processing large sets of consumer preference data. It is beneficial to take advantage of digital technologies. It is necessary to take into account a combination of two circumstances: on the one hand Internet surfing potential customers of tourist services, on the other the possibility of tour operators purchasing from search portals and sites aggregators of data on leads (lead), landing pages (Landing Page), CTR (Clickthrough Rate) and other tools of Internet marketing statistics. This work is devoted to the development of an algorithm for processing sets of data on consumer preferences and the development of an optimal market strategy for the supply of tourism services in a competitive business environment. Methods of stochastic optimization, mathematical theory of search for solutions in conditions of uncertainty, computer modeling have been used to solve the problem.

1. Introduction
Management decisions in the tourism industry should be made taking into account the balance of multidirectional indicators. In recent years, the development of online services allows the consumer to plan trips and provide himself with tickets, hotels and excursion programs independently. On the other hand, the experience of tourist companies allows to organize the trip more optimally and save clients time and funds. In addition, airbnb services, CouchSurfing and others already occupy a significant place in the hospitality market. Analysis of the market situation in the field of tourism services is necessary primarily to assess the prospects of attracting customers by tourist operators in conditions of uncertainty of demand. Today, the dynamically growing market offers an exceptionally large choice of
travel options. Competition for the consumer is very high. Risks also include political instability in many landmark regions for travellers. Traditionally, when assessing volatility and incomplete information about the circumstances of doing business, a formalized mathematical model is built. The linear methods highlighted in the literature do not give an acceptable result in the search for concrete recommendations on the economically sound market strategy of management of tourist firms.

2. Theoretical analysis

Issues of analysis of decision-making risks in conditions of uncertainty are solved by methods of operations research theory [1]. Since today’s younger generation, which is a potential traveler, is overwhelmingly Internet-centric, digital information sharing needs to be engaged to meet the challenge of this study. In general, preliminary information $W_k$ received from such large-scale search engines as Yandex, Google and others looks in the form of a set of vectors: $W_k = \{p_i, D_1, D_2, ..., D_N\}$, where $p_i$ - the share of the potential pool of consumers [2] of tourist services, $i=1,2, ..., M$, $\sum p_i = 1$.

$M$ -- number groups of clients studied; $D_k$ for $k=1,2, ..., N$ the name (type) of the proposed direction (Destination) of travel or tours, $N$ - the number of those directions for which the tourist firm has competence or its activity [3] is allowed. The vectors $W_k$ contain the ranked data. From the above data it is possible to form a matrix reflecting the statistics of preferences of a potential client pool on selection of desired directions of travel $P = \{p_{ij}\}$, $i,j=1,2, ..., N$, where elements show the share of preferences [4] in selection of $i$-th direction to $j$-th. The solution can then be divided into three options:

- offer options of directions of travel and rest on which the tourist firm has experience of work, established network of interaction with partners, personnel. At the same time it is possible to carry out the activities without spending money on promotion of new routes or on research of work of competitors. Also, time and money are not spent, which allows you to concentrate on your own competencies, but there may be losses due to uncertainty in the demand for tourism services;

- conduct a study of the current and prospective activities of other competing holiday firms with a view to determining their policies in attracting tourists as consumers of hospitality and recreation services. This approach requires additional costs;

- a mixed strategy [5] of continuing with the first option, while assessing the performance of competing holiday firms to determine the best offer for the next season.

Evaluation of the three options presented in terms of economic benefits [6] to enable the planning of tourism activities for the next planning period in an optimal manner.

3. Practical example

We will demonstrate the order and algorithm of the solution on the problem of limited dimension. We will consider the four directions of travel $D_k$ (Destination) for $k=1,2,3,4$. Accordingly, we record the values of the vectors $W_k$. Their components are indicators of interest of potential tourists [7] in these directions in descending order of preference. Since in modern digital penetration conditions, the data necessary for calculation can be obtained [8] online, calculations can be carried out in real time, which will allow to move in planning to a modern system of leading indicators. As an example, consider the following distribution:

$W_1 = \{8\%, D_4, D_1, D_2, D_3\}$

$W_2 = \{22\%, D_2, D_1, D_3, D_4\}$

$W_3 = \{34\%, D_3, D_1, D_4, D_2\}$

$W_4 = \{36\%, D_3, D_4, D_1, D_2\}$
It is noted that the event group completeness condition (sum of $p_i$ equal to one for $M = 4$) is met. Computer processing allows you to construct an already complete preference matrix as follows:

$$
\begin{bmatrix}
* & 1 - p_{31} & 1 - p_{31} & 1 - p_{41} \\
1 - p_{21} & * & 1 - p_{32} & 1 - p_{42} \\
p_{31} & 1 - p_{32} & * & 1 - p_{43} \\
p_{41} & p_{42} & p_{43} & *
\end{bmatrix}
$$

where $p_{ij}$ is the degree of preference for the direction of travel $D_i$ before $D_j$, $i, j = 1, 2, 3, 4$. Finally form the following matrix according to the example:

$$
P = \begin{bmatrix}
D_1 & D_2 & D_3 & D_4 \\
D_1 & * & 36 & 70 & 92 \\
D_2 & 64 & * & 34 & 56 \\
D_3 & 30 & 66 & * & 22 \\
D_4 & 8 & 44 & 78 & *
\end{bmatrix}
$$

For abbreviation, and clarity, the percent sign is not specified in the matrix elements. The subsequent solution for the three options under consideration is based on the data presented.

4. **Solution of a task**

Let’s consider the case of competition [9] between two travel firms $U_1$ and $U_2$ in the process of attracting clients. Let $U_2$ can concentrate activities on directions $D_3, D_4$, and in turn the sphere of interest $U_1$ lies in directions $D_1, D_2$. For a mathematical model the name and its order are irrelevant. In the first version of work you can construct the following task view:

**Table 1.** The formal form 1 of the problem.

| The option 1 | $U_1$ | $U_2$ |
|--------------|-------|-------|
|             | $D_2$ | $D_4$ |
| $D_1$       |       | 36    |
| $D_3$       | 66    |       |
| $D_4$       | 22    | 78    |

The solution matrix [10] will be used by us as a solution to the dual linear programming problem to find Nash equilibrium. After putting the data in the computer, we get the following picture, Figure 1.

![Figure 1. Process of search of the solution.](image-url)
We will introduce the symbols: $\alpha$ - the share of the direction $D_i$ in the activity $U_i$, accordingly $\beta$ - the share of the direction $D_j$ in the activity $U_i$. Then by compiling a balance equation:

$$S = \beta [36\alpha + 66(1-\alpha)] + (1-\beta)[92\alpha + 22(1-\alpha)],$$

for a search of the decision $\alpha^*, \beta^*$, take the private derivatives:

$$\frac{\partial S}{\partial \alpha} = 0 \text{ and } \frac{\partial S}{\partial \beta} = 0.$$

From here $\alpha^* = 44, \beta^* = 70$ we get them in any of the equations $H_i^*$ to determine the values of the share of the tourism firm $U_i$ in the market as a percentage of the total number of potential consumers of tourism services and, accordingly, $H_j^*$ the share of the tourism firm $U_j$:

$$H_i^* = 36\times0.44 + 66\times0.56 \approx 52.8\%, \quad H_j^* = 100\% - 66\times0.7 - 22\times0.3 \approx 47.2\%.$$ 

This will give the desired figures for activity planning, derived from the condition of distribution of customer flow among competing tourism firms.

Now let ’s look at the second option, where the costs of exploring the activities of other participants in the tourism market were made in order to participate most profitably in the campaign to attract customers. In this embodiment, the task is presented as follows:

**Table 2. The formal form 2 of the problem.**

| The option | $U_1$ | $D_1$ - $D_2$ | $D_3$ - $D_2$ | $D_1$ - $D_4$ | $D_1$ - $D_4$ |
|------------|-------|----------------|----------------|----------------|----------------|
| $U_2$     | $D_1$ | 36             | 36             | 92             | 92             |
|           | $D_3$ | 66             | 22             | 66             | 22             |

In this case, the solution is searched according to Nash ‘s theorem. Respectively for $U_i$ we have:

$$\min_{\alpha} \max_{\beta} = 36 \text{ for } U_i \quad \text{ we have: } \min_{\alpha} \max_{\beta} = 36.$$ 

Since there is a clear balance in this case, the enterprise $U_i$ needs to pay maximum attention to the development of the direction of travel $D_i$, in turn the enterprise $U_i$ needs to pay maximum attention to the development of the direction of travel and recreation $D_i$ based on the information received about the activities of another.

In the third version, there is a more complex [11] picture. Since for the first period, for example during the season, an analysis of the activity of the tourist market is carried out, accordingly part of the total pool of potential clients with a volume of $r$ percent, will be interested in other offers from $U_2$ and lost for $U_1$.

In the third version the task of determining the share of interested in rest is as follows:

**Table 3. The formal form 3 of the problem.**

| Waiting, assessment of situation | $U_1$ | $D_2$ | $D_2$ | $D_4$ | $D_4$ | $D_2$ | $D_4$ |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                  |       | $r^+$ | $r^+$ | $r^+$ | $r^+$ |       |       |
| $U_2$                            | $D_1$ | 36(1-r)| 36(1-r)| 92(1-r)| 92(1-r)| 36    | 92    |
Setting as a numerical example $r = 20\%$ we should put the data in the computer and get the following diagram:

![Diagram](image)

**Figure 2.** Option 3 Solution Diagram Set.

In Figure 2, the arrow marks the Nash equilibrium variant, which gives the desired solution. To find it, you must solve the equation: $0.488\,\alpha + 0.376(1-\alpha) = 0.36\,\alpha + 0.66(1-\alpha)$ from where we will receive $\alpha^* \approx 0.689$.

Now you can define the values $H^*_1$ of the share of the travel firm $U^*_1$:

$$H^*_1 = 0.488 \cdot 0.689 + 0.376 \cdot (1-0.689) \approx 45.3\% , \quad H^*_2 \approx 54.7\%$$

The results can be summarized in a table now:

| Share | Version 1 | Version 2 | Version 3 |
|-------|-----------|-----------|-----------|
| $U_1$ | 52.8%     | 36%       | 45.3%     |
| $U_2$ | 47.2%     | 64%       | 54.7%     |

The data presented in the table show the distribution of the total number of potential consumers of tourism services interested in recreation directions of competing firms of travel organizers. It should be noted that all reasoning, as well as mathematical formalisms were built on the basis of data of statistics of preferences of consumers of tourist services. The role of the management of the tourism firm is to economically calculate the costs of organizing activities in these areas, as well as activities to study the situation in the competitive environment.

**5. Conclusion**

Modern digital technologies make it possible to plan the activities of the tourist segment of business and other enterprises of recreation organization on a long term. As the share of travellers of generation z is now increasing, as well as in a large part the clients are representatives of generation zero, the main source of information for them is the Internet and social networks. At the same time, the capabilities of Web 4.0 networks provide extensive feedback to collect statistics on future customers preferences, segmentation them on a variety of topics, such as geography, age, travel experience, background, range of interests, and other information. Calculation using evidence-based methods will provide a foundation for increasing the conversion of costs for the promotion of tourist destinations, optimization of such important cost indicators as CPM (Cost Per Millenium), CPA (Cost Per Action) and other relevant Internet marketing indexes. The trend towards the use of mathematical models and
artificial intelligence systems will allow to make optimal management decisions in the process of planning the work of tourist operators from an economic point of view and to adjust their activities to the requirements of the tourism services market.

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