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THE STRATEGIES OF THE AIRPORTS REGIONAL NETWORK DEVELOPMENT

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The variants of strategies for the development of the airports regional network are considered and an approach to the choice of alternatives in conditions of uncertainty is proposed.

Keywords: strategy, airports regional network, alternative, gains matrix.

Розглянуто варіанти стратегій розвитку регіональної мережі аеропортів, запропоновано підхід до вибору альтернативи в умовах невизначеності

Ключові слова: стратегія, регіональна мережа аеропортів, альтернатива, матриця виграшів.

Problem statement

Infrastructure is described as key competitive advantages of the Ukrainian regions in the research paper [1]. More than a third of the respondents of the company's heads determined it exactly so. Transport infrastructure is defined as the most problematic part of the infrastructure.

Despite the significant investments in the infrastructure of the main airports for Euro-2012 [2] the statistical data show, that passenger air traffic is still concentrated mainly in Kyiv.

In the Southern region (a priori accepted herein division into regions is substantiated by preliminary research of areas gravitation) two airports — «Simferopol» and «Odessa» — have the passenger turnover of approximately 1 million passengers. In the Eastern region the same passenger traffic is indicated in Donetsk airport. The air traffic in the Western region are carried out mainly through the airport «Lviv», in which passenger turnover is relatively small, being approximately 0.5 million passengers. In each region of Ukraine there are airports which do not function in general. Therefore the regional airport network development concept is actual problem for Ukraine and is required relevant methodological substantiation.

Analysis of recent research and publications

The transport network optimization methods are a considerable field of study. The basis of this researches are set out particularly in papers [3; 4]. Since the 1978 Airline Deregulation Act, perhaps the most significant innovation in the airline industry has been the adoption of hub-and-spoke systems. Flights from different origins to a same destination, or from a same origin to different destinations are consolidated via intermediate nodes called hubs. Hubs exploit economies of scale by allowing a smaller number of higher capacitated arcs to serve a large number of origin-destination pairs. Past studies on hub-and-spoke networks in the airline industries have appeared both in the area of airline economics and in the area of operations research/transportation science [5]. All models discussed above are based on the following rationale: economies of scale due to hubbing are explicitly and a priori modeled by having inter-hub transportation cost discounted. In addition, more elaborate models also indirectly consider the impact on aircraft loading, and thus on revenue. Flights between hub cities are assumed to have a constant 80 % load factor (percentage of seats filled by revenue paying passengers), and flights between hub and spoke cities a 60 % average load factor [6]. These approaches to a substantiation of the regional airports network development in Ukraine could be used under the conditions of not only international, but also domestic traffic stable growth.

In this paper three strategies of development of the airports regional network and approach to the choice of alternatives in uncertainty conditions are considered based on the calculation of the gains matrix.

The development strategies

In the strategy of the development of the regional airports network should take into account the level of the region's economic development, development of transport infrastructure as a whole. If the infrastructure «runs» forward, as a rule, it stimulates the development of the economy.

However, if the advance significantly, then the part of the infrastructure facilities may not be used, that is increasing the period of recoupment of capital investment in infrastructure.

The backlog of transport infrastructure (as well as the infrastructure as a whole) slows down the development of the economy, causes a decrease in the efficiency of production, and then it absolute decline.

Let's consider three possible alternatives for the development of the airports regional network in Ukraine.

Strategy 1. Development of the main regional airports under conditions of administrative management.

Taking into account the spatial position of Ukraine (the length of the Ukraine: from the West to the East is 1316 km, from the North to the South is 893 km) and the necessity to settle socio-economic problems of country development it would be advisable to consider the option of financial, technical and technological resources concentration on development of the dominant regional airports. In the Central region it is offered to develop «Borispol» (KBP) and «Kyiv» (Zhulyany) (IEV) airports, in the Southern region it is airport «Odessa» (ODS), in the Autonomous Republic of Crimea — «Simferopol» (SIP) airport, in the East — airport «Donetsk» (DOK), in West — airport «Lviv» (LWO,). Total are 6 airports. These airports are defined on the basis of analysis of the formed passenger traffic and the existing airports capacity.

Aggregate throughput of selected regional airport are approximately 41.8 million passengers per year: KBP — 21 million; IEV — 2 million; LWO — 6 million; DOK — 10 million; SIP — 2 million; ODS — 0.8 million.

Strategy 2. Development «Borispol» as international airport and regional airports as domestic.

In this case airports «Kharkiv», «Dnepropetrovsk», «Uzhgorod» could be added to the five above mentioned airports (in this paper is not considered a form of airports ownership).

In the issue 9 airports will actually function: 1 the international and 8 domestic airports. Airport «Kharkiv» and «Dnipropetrovsk» are already reconstructed, capa-city of each is between 1.5 and 2 million passengers per year.

Airport «Uzhgorod» requires reconstruction. At the moment, the airport has a terminal with capacity of 100 passengers per hour (0.2 million passengers per year) and one asphalt runway of 2038 meters length and 40 meters width.

This strategy requires an integrated approach with participation of airlines, which may be required to develop acceptable tariffs for flights with a transfer. In addition this strategy would entail significant investments for the ground transport infrastructure development for providing a fairly high rate of movement from the airport to the cities.

Strategy 3. All airports and aerodromes are developed on the assumption of full liberalization of the aviation market (approximately 30 airports could function).

The liberalization of air transportations market implies free access of any certified airlines in the world to any airports of Ukraine, privatization of airports which have not a strategic importance, free setting of airport charges for airports competition.

This model increases the probability of budget airlines entering into the Ukrainian market, which are promising to offer tariffs at the level of rail transport. This strategy is, apparently, real step to increase the level of domestic air traffic in Ukraine, taking into account the considerable demand for rail transportation. Of course, in this case there is a possibility that some air carriers registered in Ukraine will leave.

Choice of alternative development

Mathematical model of airports regional network development strategy choice problem under the conditions of uncertainty can be defined in the form of the following three objects

$$\langle X, Y, f \rangle,$$

where X is the set of feasible alternatives; Y is the set of possible environment states; $f : X \times Y \to R$ is the objective function.

The average annual demand is a sole parameter, which characterizes the state of environment.

Therefore, set of states of the environment can be described as $Y = \{1, ..., n\}$ million passengers.

The objective function $f\ x_i, y_j, z_i$ is a profit, which will be given to the regional network of airports for the year in a situation, when the defined strategy $x_i \in X$, where $i = \overline{1,m}$ is the number of strategies for the exploitation of the x airports.

The average annual demand is equal to $y_j \in Y$, where $j = \overline{1,n}$ is the number of environment states and z_i is assessment of the decrease in potential demand depending on the chosen strategy. It is necessary to choose one of three described above strategies of airports development.

Suppose that the reconstruction and construction of runway, modernization of air-traffic control, road building construction will be financed from the budgetary funds. These costs can be divided into:

(a) The costs do not depend on the choice of the strategy, required for the modernization of the other modes of transport infrastructure in the area of the gravity of the main regional airports. Proceeding from the analysis of expert estimations for the necessary investment for the infrastructure development of the other modes [6] accepts them equal to $ 50 million per year.

(b) The costs associated with the chosen strategy. These costs depend on the number of functioning airports are accepted equal to $ million; expenditures associated with the servicing of passengers at the airport are accepted equal to $13,85 *y*. Data are relative and basis on the analysis of the existing income and costs structures of airports of Ukraine and the main airport of Poland in Warsaw Frederic Chopin (WAW) (table 1).

Table 1

The calculation of input data for the choice of strategy in the conditions of uncertainty

The financial results of the activity of airports (according to ICAO data)								
item	IEV	KBP	HRK	ODS	DOK	LWO	WAW	average result
income, in US$ (000)	2431	125349	15973	13100	9760	6916	193269	
expenses, in US$ (000)	2425	73083	15617	9491	10811	5218	124547	
passengers, (000)	211,5	5793,935	1273,126	670,744	488,073	452,298	9750,654	
income per passenger.	11,49	21,63	12,54	19,53	19,99	15,29	19,82	17,19
expenses per passenger	11,46	12,61	12,26	14,14	22,15	11,53	12,77	13,85

It is also need to take into account the loss of profit. This is profit shrinkage because of the probability of a potential passenger decline to travelling by the plane.

These costs are depending on the chosen strategy too. Lost profits may be determined as the product of the profit per 1 passenger and the number of passengers who refused from air transportation.

The percentage passengers who could decline to travelling by the plane denote by Z_i. Assume, that if the first strategy would be realized then $Z_1 = 1$ %, if the second one — $Z_2 = 5$ %.

Implementation of the third strategy envisages the maximum satisfaction of the potential demand, i.e. $Z_3 = 0$ %.

Let's assume that the income of an airport network is \$17,19 million for 1 million passengers. Then the objective function for the decision-making problem will have the form:

$$f\ x_i, y_j, z_i\ = 17{,}19 - 13{,}85\ \left[(y_j - y\right]_j\ z_i - x_i - 50$$

or

$$f\ x_i, y_j, z_i\ = 3{,}34\ 1 - z_i\ - x_i - 50.$$

Next, take the $f\ i, j\ = a_i^j$ and we will interpret the number of a_i^j as the *gain* of the decision-making in a situation i, j .

Then the objective function is specified in the form of a table called *gains matrix* [7].

When building a gains matrix to select the strategy of development of the airports regional network in Ukraine (table 2) it was taken into account the following environmental conditions: the total passenger traffic at the airports of Ukraine is 14 million passengers for pessimistic forecast, 16 million passengers for the most probable forecast, 18 million passengers is for optimistic forecast and 22 million passengers for over optimistic forecast. As criteria to choose an alternative it was used the criterion of the Laplace

$$L\ i\ = \frac{1}{m}\sum_{j=1}^{m} a_i^j$$

and Wald test

$$W\ i^*\ = \max_i W\ i\ = \max_i \min_i a_i^j\ .$$

Table 2

Gains matrix of the airports regional network development strategies

	j		1	2	3	4	$L(i)$	ER_i
		p_j	0,3	0,45	0,2	0,05		
i	*x* \ *y*	z_i	14	16	18	22		
1	6	0,01	**–9,71**	–3,09	3,52	16,75	**1,87**	**–2,76**
2	9	0,05	–14,58	–8,23	–1,89	10,81	–3,4725	–7,9147
3	30	0	–33,24	–26,56	–19,88	–6,52	–21,55	–26,226

We can also make assumptions about occurrence probabilities of each possible state of the environment (p_j).

Then the expected result from the realization of the *i*-th strategy ER_i is calculated by the formula

$$ER_i = \sum_{j=1}^{m} a_i^j p_j .$$

The decision maker should choose a solution that would maximize the expected result:

$$ER_{i^*} = \max_j ER_i .$$

Conclusions

The results of the performed calculations have shown a clear advantage strategy №1 ($L(1) = 1{,}87$, $W(1) = -9{,}71$, $ER_1 = -2{,}76$), *if economic indicators is selected as the criterion of effectiveness*.

In any case, the need for significant costs for airport ground access systems modernization, fixed costs for airports operation lead to a negative economic effect of the airports regional network functioning.

The positive effect is achieved only in the case of a strategy № 1 under demand of not less than 18 million passengers.

Reducing the number of airports in the strategy № 2 up to six, we get the same economic effect, however, revenues of the regional airports, except the airports of the Central region, will be formed only at the charges of the domestic flights service. And this increases the risk of the forecasted traffic flow decrease, as passengers can choose alternative modes of transport.

If the criterion of efficiency of the airports regional network development is the satisfaction of social needs, increasing the degree of air transportation access for the population of Ukraine, and there is a possibility of providing with public investment for reconstruction of the majority of airports, grants (subsidies) then it is possible realizing the strategy № 3.

Under specified conditions, when the level of demand will run up to 24 million passengers this strategy has a positive effect.

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