Rational Air Transportation Technologies Resources Recombination on Condition of the Generalized Values

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Abstract

The presented paper is dedicated to the attempt of a theoretical description of the aviation transport technologies elements resources rational use. The maximal value of the generalized "positive" effect is chosen in the view of the optimization criterion. For two competing resources their optimal recombination is found at the segment of the mathematically linearly described solution obtained on condition of the fixed total amount of the production of the aviation transport technologies services. Such fixed total production amount acts like iso-perimeter constraint condition in the stationary problem with the constant capacities/productivities of the competing resources. On the other hand, the generalized "positive" effect parameter is also considered having two competing components, which values ensure yielding the optimal resources recombination. Illustrative example simulation is performed. Necessary diagrams are plotted.

Keywords

Aviation, transport, technology, resource, recombination, entropy, preferences, optimization, simulation

1. Introduction

Computer simulation of the aviation transport technologies elements is an urgent task. Airlines' and aviation business enterprises' resources rational use is important in regards with both aircraft technical operation [1] and the aircraft engines reliable functioning [2]. Based upon the ideas of [1, 2]–the aircraft and its powerplant elements reliability and maintenance require decent resources distributions and combinations. A significant amount of the resources are spent upon keeping the predictable level of the aviation risks in the acceptable margins [3, 4].

Analyzing the objectives of the aviation transport technologies elements functioning, it is possible to conclude that, in any case of the airlines operation, the management of the air companies pursues the goals that have some "positive" effects in the view of the managerial endeavors leading to the expected utilities of the individuals' choice [5, 6].

The required resources recombination, when running an aviation business, also happens at the circumstances of the more or less uncertainties of the different kinds, such as e.g., the aircraft types used, their number, applicable aviation transport technologies elements resources etc.. Those kinds of uncertainties can be evaluated with the use of the entropy approaches, likewise in the references of [7 – 9], having become very popular recently [10].

In conjunction with the economical models of [11], the entropy methods of [7 – 10] resulted in the subjective analysis theory [12], which allows solving various types of the applicable problems, similar to the stated in the references of [13 – 16].

Air transportation management and aviation transport technologies elements resources recombination basic problems have already been set in [17 – 20] implementing the provisions of the previous researches [1 – 12].

According with the described concepts of [1 – 12, 17 – 20] the scientific gap, which needs its resolution, is an elaboration of a plausible theoretical approach to the actual and important problems of the rational aviation transport technologies resources recombination setting,

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especially in regards with the analytical decision making process supporting based upon the computer modeling advantages.

The problem setting of the presented study is about the theoretical research centered upon the rational aviation transport technologies resources recombination, following the reference of [18].

Thus, the goals of the paper are generally describe possible optimization of the resources recombination and computationally illustrate the theoretically obtained solutions.

2. Resources recombination possible optimization

Optimization approach of the presented research is close, in the ideological considerations, to the conditional optimization, analogously to the problem settings implying the problem statements subject to the Lagrange uncertainty multipliers constraints. Nevertheless, herewith, the study uses acceptable simplifications that differ from variational problem of [18], yielding the same theoretical result, though, for the potentially possible resources distributions and combinations.

2.1. Basic concept

Amongst the multiple number of the aviation transport technologies elements is proposed to select and generalize such two competing ones that allow theoretically accumulate resources in considerations of the resources rational recombination.

In assumption that the mentioned above aviation transport technologies elements are determined in terms of the key resources, one can construct the following model, [18]:

1. The total amount of the aviation transport technologies services production:

$$N. \quad (1)$$

2. The capacity/productivity of the first competing aviation transport technologies elements resource is

$$p_1. \quad (2)$$

3. The capacity/productivity pertaining with the second competing aviation transport technologies elements resource is

$$p_2. \quad (3)$$

Obviously, using the introduced parameters of (1) – (3), one can obtain the following equations of the stationary case:

$$\frac{N}{p_1} = a, \quad (4)$$

where a symbolizes the number of the resources of the first nature required for the aviation transport technologies services production in order to realize the air transport technologies services total amount of N: parameter (1), on condition of the first nature resources capacity of p_1: parameter (2).

Analogously to (4), there is a possibility to describe the stationary process as

$$\frac{N}{p_2} = b, \quad (5)$$

where b portraits correspondingly the number of the resources of the second kind required, on the competing bases, for the aviation transport technologies services production in order to realize the air transport technologies services total amount of N: parameter (1), on the condition that the second type resources capacity is of p_2: parameter (3).

The discussed generalized case of (1) – (5) has a well-known linear solution [18] for a possible combination of the resources of both types.

Indeed, let us say the total amount of N: (1), is realized/produced with/by the resources of the two types together (simultaneously). That means

$$N = N_1 + N_2, \quad (6)$$

where N_1 is the portion of the total amount realized/produced with the help, or by the use, of the first competing kind of the resources; and N_2 is the rest of the total amount realized by the second type resources correspondingly.

Then, according to (2) and (3),

$$\frac{N_1}{p_1} = n_1, \tag{7}$$

where n_1 is the number of the units of the first competing kind of the resources that took part in the realization/production of the corresponding portion of N_1: (6), of the total amount of N on the stationary condition of their production/capacity abilities of p_1: parameter (2).

On the other hand, likewise in (7),

$$\frac{N_2}{p_2} = n_2, \tag{8}$$

where n_2 is the number of the units of the second competing kind of the resources that was required in/for the realization/production of the rest amount of N_2.

Substituting components obtained from (7) and (8) for their values into (6), it can be notated that

$$N = p_1 n_1 + p_2 n_2. \tag{9}$$

At the fixed values of (1) – (3), the relation of (9) allows researching dependencies between two variables of n_1 and n_2.

Considering one of those variables, for example n_1, as the independent variable, the other n_2 can be expressed from (9) as a function of it.

Namely,

$$n_2(n_1) = \frac{N - p_1 n_1}{p_2}. \tag{10}$$

In terms of (4) and (5) the equation of (10) can be rewritten as [18, (5)]:

$$n_2(n_1) = b - \frac{b}{a} n_1. \tag{11}$$

2.2. Optimization technique

The simplest solution of (1) – (11) opens a wide range of conditional optimization problems for the segment of $[b, a]$.

Rational air transportation technologies resources recombination on condition of pertaining to the segment of $[b, a]$ can be conducted based upon the options effectiveness assessments.

Using the options effectiveness assessments parameter in the view of

$$P = D - R, \tag{12}$$

where P is the "positive" effect parameter value; D is the "developmental" component; R is the "regressive" component.

The models implemented for the equation (12) components can of different nature and content; similar to, for instance, the proposed in [18, (6) – (11)] for the activities splitting.

As to the presented study

$$D_i = s_i p_i n_i, \tag{13}$$

where D_i is the i^{th} resource kind component, this refers to the corresponding feature of the additive factor for both resources, i.e.

$$D = D_1 + D_2; \tag{14}$$

s_i is the i^{th} resource type component coefficient/function influencing the "developmental" components of the resources; p_i and n_i are the parameters of (1) – (5) and (7) – (11) in respect.

As to the values entering (13), those can be functions of different interdependencies.

For the developed herewith computer simulation it is proposed the following

$$s_i = k_{s_i} \prod_{j=1}^{m} \left(n_i - n_{i_j} \right), \tag{15}$$

where k_{s_i} is an augmentation factor/index (also possibly a coefficient/function), for the i^{th} resource type component, scaling the effect of the parameter of n_i change/variation; n_{i_j} is the parameter of n_i value symbolizing the “zero” effect for the “developmental” components.

Concerning the “regressive” component R of the dependence (12), there are a few contemplations of the next sort.

$$R = \sum_{i=1}^{2} R_i , \tag{16}$$

where R_i is, similarly to (14), the “regressive” component of R in respect to the resources taken into consideration.

However, in regards with the “regressive” components constructions, the assumed models emphasize their features as

$$R_i = k_{R_i} n_i , \tag{17}$$

where k_{R_i} is a growth factor/index (also possibly a coefficient/function), for the i^{th} resource kind component, scaling the effect of the parameter of n_i change/variation.

In turn, the escalation factor/index of k_{R_i}, of formula (17), implies the peculiarities of its own possibilities to change depending upon the n_i change/variation.

The proposed model is

$$k_{R_i} = k_{R_i}^{(0)} + \Delta k_{R_i} k_{r_i}^{n_i} , \tag{18}$$

where $k_{R_i}^{(0)}$ is a boundary/basic value of the growth factor/index; Δk_{R_i} is the range/diapason of the growth factor/index possible change/variation; $k_{r_i}^{n_i}$ is the variated component of k_{r_i} raised to the power of the parameter of n_i value.

In order to investigate the uncertainty of the optimal recombination of the aviation transport technologies resources choice, it is proposed to apply the entropy approach developed and implemented in the works of [17, 18] based upon the entropy paradigm of [7 – 9, 12].

It implies the use of the relative hybrid pseudo-entropy function, i.e.

$$H_r(n_1) = \frac{H_{\max} - H(n_1)}{H_{\max}} \frac{\pi_1(n_1) - \pi_2(n_1)}{\left| \pi_1(n_1) - \pi_2(n_1) \right|}, \tag{19}$$

where $H_{\max}$ is the maximal value of the entropy, in the considered case it equals $\ln(2)$; $H(n_1)$ is the current value of the entropy defined by the expression of

$$H(n_1) = -\sum_{i=1}^{2} \pi_i(n_1) \ln[\pi_i(n_1)], \tag{20}$$

where $\pi_i(n_1)$ are the preferences functions:

$$\pi_i(n_1) = \frac{e^{\beta P_i(n_1)}}{\sum_{j=1}^{2} e^{\beta P_j(n_1)}} , \tag{21}$$

where β is the cognitive parameter essential to forming the objective functional with the preferences functions [7 – 9, 12, 17, 18]; $P_i(n_1)$ are the resource-centered effectiveness, defined as (12).

2.3. Simulation

The initial data for computer modeling are as follows:

$$N = 1000, \qquad p_1 = 10, \qquad p_2 = 20 . \tag{22}$$

Then, implementing the procedure of (1) – (11) one can obtain the linear solution results presented in the Figure 1.

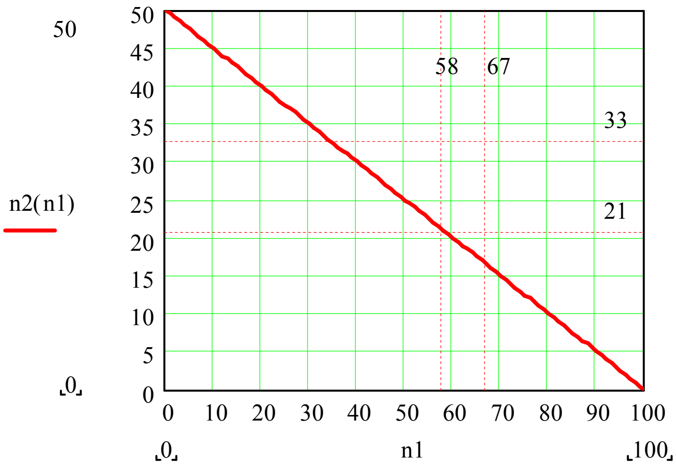

Figure 1: The resources interdependence

The segment of $[b, a]$ of the linear solution of (10) or (11) represented in the Figure 1 has the values of (4) and (5).

$$\frac{N}{p_1} = a = 100 \quad \text{and} \quad \frac{N}{p_2} = b = 50, \tag{23}$$

correspondingly depicted in the abscise n_1 and ordinate n_2 axes.

Now, the problem is to determine the optimal recombination of the resources along the solution segment of $[b, a]$.

In order to find the desired optimal air transport technologies resources recombination one can use the models of (12) – (18).

Concerning the "developmental" components of D, the accepted and used data are following:

$$k_{s_1} = -1, \quad n_{1_1} = 0, \quad n_{1_2} = 100, \quad k_{s_2} = -2, \quad n_{2_1} = 0, \quad n_{2_2} = 50. \tag{24}$$

The curves plotted for the augmentation functions of s_i, calculated by the formulae of (15), are shown in the Figure 2.

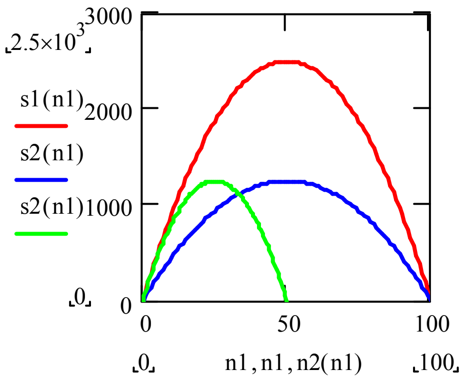

Figure 2: The augmentation functions for the "developmental" components

The third curve of $s2(n1)$, presented in the Figure 2, is plotted, as a phase portrait/curve (phase diagram) in the phase coordinates/space of $s2(n1)$ - $n2(n1)$, depending upon the phase coordinate of $n2(n1)$.

In such circumstances as (22) – (24), the computer modeling with the help of (13) and (14) gives the results illustrated in the Figure 3.

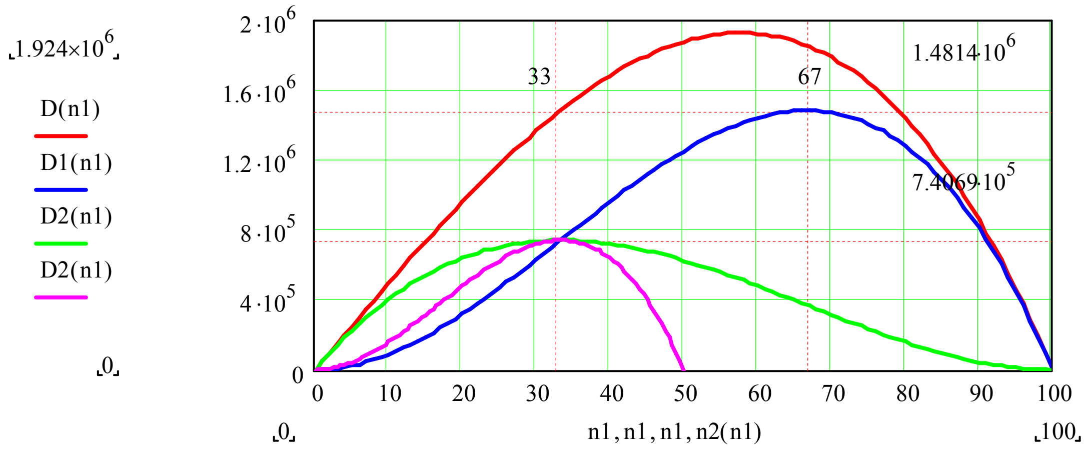

Figure 3: The "developmental" components of the aviation transport technologies resources recombination

The fourth curve of $\mathrm{D2}(\mathrm{n1})$, presented in the Figure 3, is plotted, as a phase portrait/curve (phase diagram) in the phase coordinates/space of $\mathrm{D2}(\mathrm{n1})$ - $\mathrm{n2}(\mathrm{n1})$, depending upon the phase coordinate of $\mathrm{n2}(\mathrm{n1})$.

It is also shown in the Figure 3, the extremal values of $D_1 = 1.4814 \cdot 10^6$ and $D_2 = 7.4069 \cdot 10^5$ which are ensured by the values of $n_1 = 67$ and $n_2 = 33$ correspondingly.

Those values are noticeable in the Figure 1 as well.

Next up are the "regressive" components of R.

The accepted data for the calculation experimentations with the parameters of the equations of (16) – (18) are following:

$$k_{R_1}^{(0)} = 2 \cdot 10^3, \quad \Delta k_{R_1} = 6 \cdot 10^3, \quad k_{r_1} = 0.954, \quad k_{R_2}^{(0)} = 3 \cdot 10^3, \quad \Delta k_{R_2} = 8 \cdot 10^3, \quad k_{r_2} = 0.9. \tag{25}$$

Thus, the results of the conducted computer modeling with the equations of (18) and data of (25) are presented with the diagrams in the Figure 4.

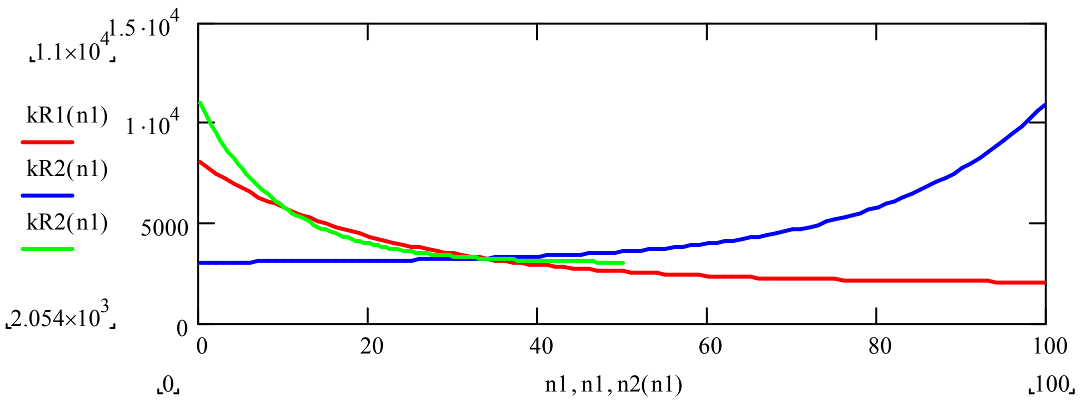

Figure 4: The escalation factors/indices of the "regressive" components of the aviation transport technologies resources recombination

The escalation factors/indices (as the functions of the aviation transport technologies resources units numbers) of k_{R_i}, of formulae (17) and (18), for k_{R_2}, depicted as $\mathrm{kR2}(\mathrm{n1})$ in the Figure 4, are shown in both dependencies; namely, for both, with respect to the only, so far, independent variable of n_1 and $n_2(n_1)$. The latter case, the curve number three as $\mathrm{kR2}(\mathrm{n1})$ in the Figure 4, is symbolized with the phase portrait/curve (phase diagram) in the phase coordinates/space of $\mathrm{kR2}(\mathrm{n1})$ - $\mathrm{n2}(\mathrm{n1})$, depending upon the phase coordinate of $\mathrm{n2}(\mathrm{n1})$.

Then, the diagrams of the "regressive" components of R, computed with the help of the formulae of (16), and (17), are shown in the Figure 5.

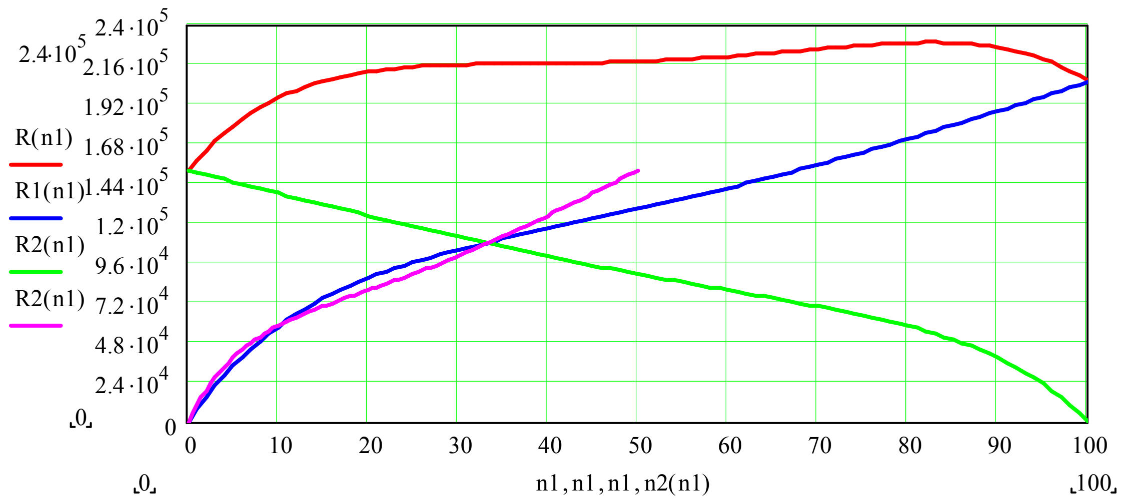

Figure 5: The “regressive” components of the aviation transport technologies resources recombination

The fourth curve of $\mathrm{R2(n1)}$, presented in the Figure 5, is plotted, as a phase portrait/curve (phase diagram) in the phase coordinates/space of $\mathrm{R2(n1)}$-$\mathrm{n2(n1)}$, depending upon the phase coordinate of $\mathrm{n2(n1)}$.

At last, the “positive” effect parameter values of P, computed by the equation (12) components, are illustrated in the Figure 6.

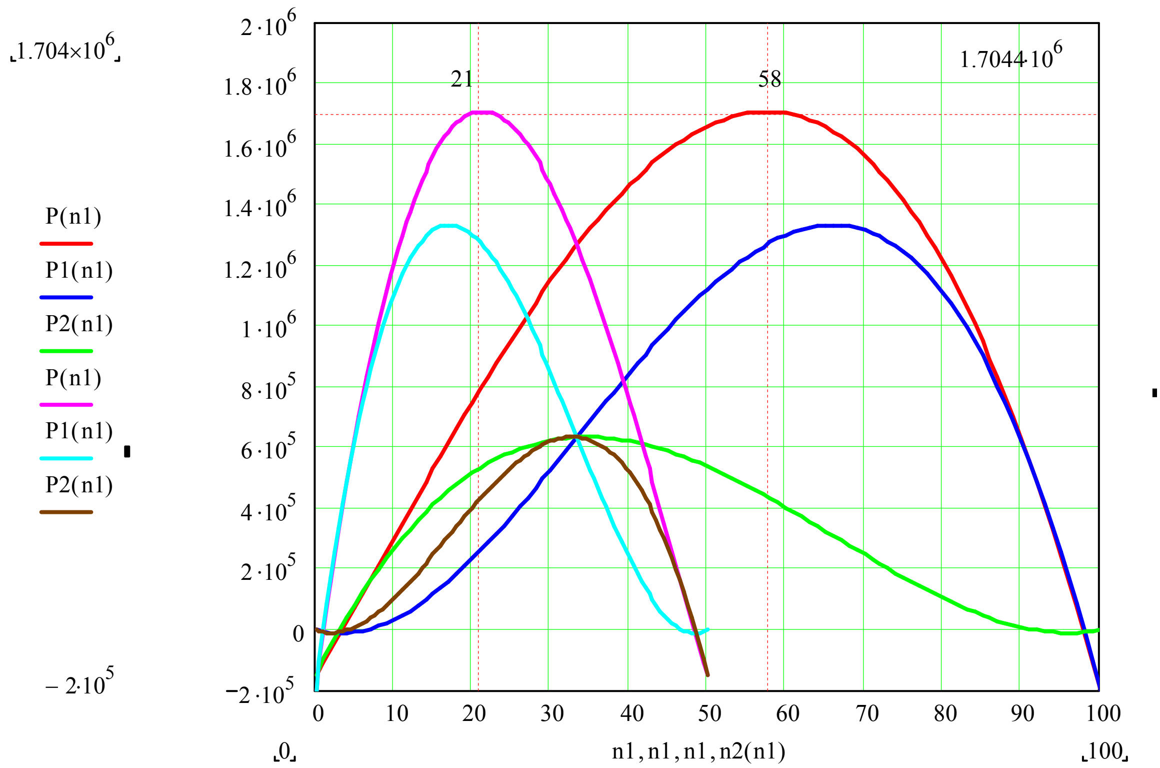

Figure 6: The “positive” effect parameter values of the aviation transport technologies resources recombination

The last three curves of $\mathrm{P(n1)}$, $\mathrm{P1(n1)}$, and $\mathrm{P2(n1)}$, presented in the Figure 6, are plotted, as the phase portraits/curves (phase diagrams) in the phase coordinates/spaces of $\mathrm{P(n1)}$-$\mathrm{n2(n1)}$, $\mathrm{P1(n1)}$-$\mathrm{n2(n1)}$, and $\mathrm{P2(n1)}$-$\mathrm{n2(n1)}$, depending upon the phase coordinate of $\mathrm{n2(n1)}$.

It is visible from the plots illustrated in the Figure 6 that at a certain aviation transport technologies resources recombination (circumstances) the "positive" effect parameters values turn to the "negative" zone.

The optimal recombination of the aviation transport technologies resources is also depicted in the Figure 6, i.e. the extremal values of $P(n_1) = 1.7044 \cdot 10^6$ are ensured by the values of the optimal recombination for $n_1 = 58$ and $n_2 = 21$ correspondingly.

This optimal recombination of the aviation transport technologies resources is shown in the Figure 1 as well.

Computer modeling of the uncertainty situation with the help of (19) – (21) yields the results represented in the Figures 7 – 9.

The data accepted for the simulation are as follows:

$$\beta = 3.6 \cdot 10^{-6}. \tag{26}$$

The resource-centered effectiveness: $P_i(n_1)$, are defined by (12), (14), and (16) as

$$P(n_1) = D(n_1) - R(n_1) = D_1(n_1) - R_1(n_1) + D_2(n_1) - R_2(n_1) = P_1(n_1) + P_2(n_1). \tag{27}$$

Preferences by (21) and entropy by (20) are shown in the Figures 7 and 8 respectively.

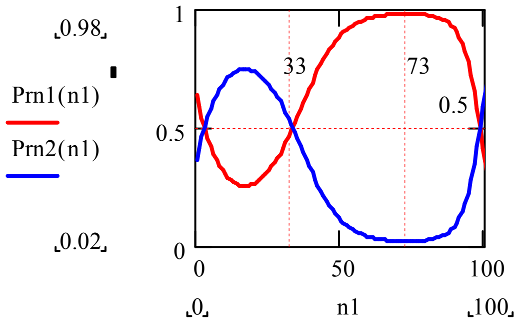

Figure 7: Preferences functions

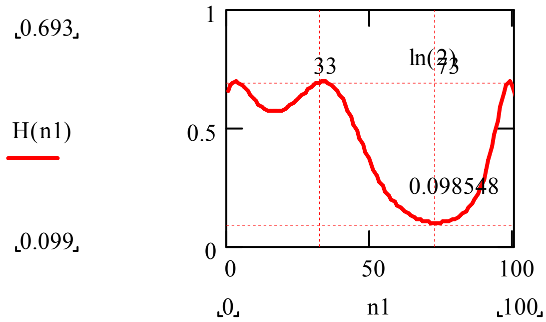

Figure 8: Entropy of preferences functions

The relative hybrid pseudo-entropy function by (19) in comparison to the traditional entropy is illustrated in the Figure 9.

3. Discussion

The demonstrated approach of (1) – (21) with the accepted data of (22) – (27) has a number of the generalized simplifying, although plausible, assumptions.

The simplified models make it easier finding the aviation transport technologies elements resources optimal recombination. It is accepted undisputable that the aviation transport technologies services production resources have their own subjectively preferred rational use as that was claimed in the references dealing with the individuals' choices, like in [5, 6], with respect to the economical issues marked at [11], subjective individual preferences uncertainty emphasized in [12].

One of the significant simplifications of the discussed model presented herein with this paper is the stationary condition. Dynamics of the resources optimal recombination must inevitably have its own consequences. Other important simplifications of the study are the suppositions of just one independent variable n_1 and independence of the resources capacities of p_i: (2) and (3) upon it. Introducing other independent variables, e.g. n_2, as well as implying all other parameters dependences upon n_i in more elaborated model constructions, it will predictably change the models relations (1) – (11) and results of simulation shown in Figures 1 – 6.

Since it has been supposed the additive properties of (6), (9), and (12), and their components, both in respect to the generalized resources types and kinds of the effect parameter values, the expected solution will be complicated as well if all that have possible multiplicative effects (see and compare Figures 2 and 4).

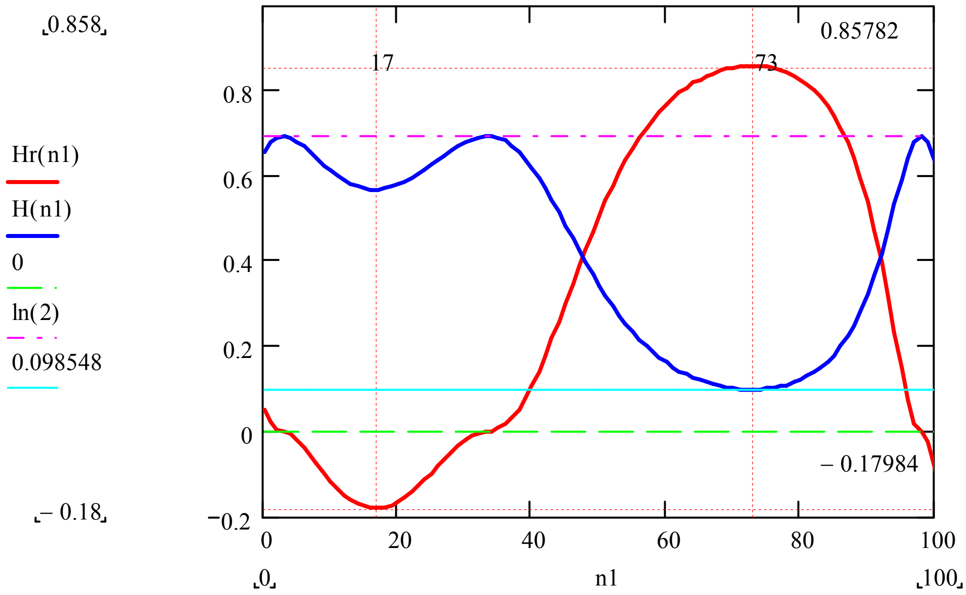

Figure 9: Entropy of preferences functions

Models of (13), and their components can differ in mathematical expressions. Herein it has been studied the "parallel" models, identically mathematically expressed.

Multiplicative effects are probable with the consideration of the individuals' subjective preferences [12] in combinations with the dynamical issues. The study of the subjective preferences entropy influence upon the desired optimal air transport technologies resources recombination looks like a huge separate problem with the internal applicative incentives.

In this sense, the potential challenges and limitations associated with the implementing the proposed model in the diverse aviation contexts can be applicably demonstrated in the optimal distributions of the aircraft numbers of a certain or specified types over the airlines' fleets. Such problems are supposedly prospective in the studies that are going to be prolonged in the future considerations dealing with the problem settings of conditional optimization.

Thus, the rational recombination may not belong with the solution presented in the Figure 1.

In conditions of the stated problem the solution with the values of $n_1 = 67$ and $n_2 = 33$ is impossible since it is not in the solution fragment (see Figure 1). It happens because that is not in the compliance with the theoretically developed model dependencies (1) – (21) and accepted calculation data of (22) – (25) too; although the mentioned above impossible solution delivers maximal values to the "developmental" components of D (see and compare Figures 1 and 3).

As to the uncertainty of the optimal recombination of the aviation transport technologies resources choice, it is worth saying that (19) – (21) used the parameter of (26) on the purpose of the contrast distinguishing between two alternatives of (27); the corresponding values of the preferences functions and entropy are visible in the Figures 7 and 8.

Herewith, it should be noted that the traditional view entropy of (20): [7 – 9, 12], is incapable to distinguish the directions of the certainty or uncertainty between the alternative preferences around the designated points (see Figure 8).

Such a lack of the informative deficiency is supposed to be compensated with the relative hybrid pseudo-entropy, for instance, around the argument values of "17" and '73'; "bad", that is "negative", vs. "good", for the represented case study computer modeling "positive", relative certainty (see Figure 9). In the illustrated interpretation zero value of the pseudo-entropy corresponds to the situation of the complete uncertainty.

4. Conclusion

The developed theoretical approach allowed discovering the rational aviation transport technologies resources recombination as a kind of an optimal solution in regards with the generalized values. The segment of the linear solution has a maximal value of the generalized "positive" effect parameter in the framework of the accepted suppositions for the technologies fixed production. Computational intelligence and modeling are the indispensable aids in the optimization techniques for taking into account the operational alternatives subjective preferences uncertainty.

The dynamics of the desired optimal air transport technologies resources recombination selection process as well as some more developed models implementing operational alternatives subjective preferences entropy are proposed to be investigated in the further studies.

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