

Considerations regarding the Formulation of the Organisational Strategy through Simulation Techniques

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Abstract

The complexity, dimension and the scope of the economic problems specific to the correct development of organisational strategies require, on the one hand, the structuring and systematisation of their entire simulation activity in view of solving them.

On the other hand, they require the adequacy of a relative independence resulted from the very nature of thinking, personality and professional education of those who want to promote a certain type of organisational strategy.

In other words, we can consider that the stages of creating a strategy simulation, although they are not compulsory, they cannot be entirely neglected, because there is minimum number of stages and sub-stages for which the optional character is not permitted. The entire decisional simulation cycle of a strategy obeys the three research levels: analysis, designing and management of the simulation activity.

Keywords: *simulation, strategy, status of strategy, status of entropy, process*

JEL classification: C00, D29

1. The storage of organisational strategies

Both in the theory and practice of economics, any strategy is characterised by a set of components, which are more or less continually changing, by dint of which one can have a clear view of “the status” of the economical system of the organisation. Those components are designed on a wider or narrower time horizon. Thus, they are designed for the short or long term. We mention that very seldom

are the effective and structural elements analysed and outlined so that there is at least one perspective if not a real correlation as close as possible to the potential of the strategy. This potential has to allow it to reach the planned objectives and, as a consequence, to minimise the distance between the future projections and the real statuses that the strategy will record.

The analysis represents the research process of the strategy's component with the purpose of highlighting the following issues: the role of the strategy within the economic system of the organisation; their horizontal and vertical interaction within the organisational structure; the status and decision variables – controllable or uncontrollable, which determines the running of the strategy; the identification of atypical behaviours and factors which influence the good running of the strategy and which cannot be included in the category of disruptive factors.

One of the major purposes of the analysis of socio-economic systems in general and of socio-productive systems in particular is to evaluate the extent to which the internal actions of the system can modify the status in a positive way and the extent to which this initiative depends on external factors. The management of the simulation activity represents the whole set of planned procedures in view of grouping structures, phenomena and processes analysed and/or designed. By dint of this management a concise and clear formulation results for: the object of the simulation; the purposes pursued; ways of achieving the simulation; preserving, maintaining and updating the essential information achieved as a result of the simulation.

Next, we will assign the programmed values of the strategy components as “**command vectors**”, and their effective values, “**response vectors**”. Obviously, any variation of the values of the command vectors from the values of the response vectors in **absolute** and **relative terms** will certainly highlight a certain “**status**” of the strategy and at least two main aspects:

1. the extent to which anticipations have considered the real status of the economical system of the organisation;
2. the extent to which the strategy is capable to respond to instructions at a certain moment and under certain circumstances (not in “any” given conditions).

Let us consider the general cybernetic scheme of the system of strategy elaboration (Figure 1) with the mention that, in its known form, it hides an essential aspect.

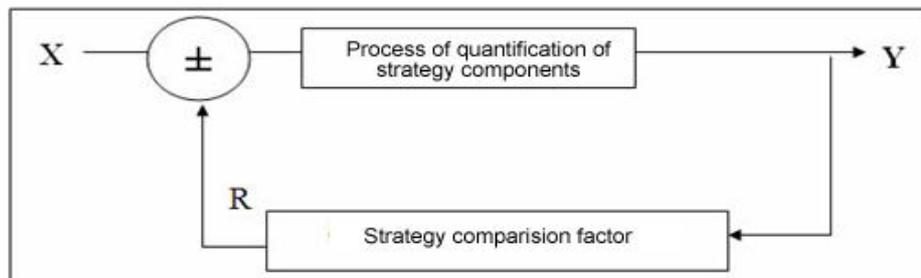


Figure 1

where:

- X – the command vector;
- Y – the response vector;
- R – the corrections vector.

The relation describing the running of the cybernetic system represented above has the following form:

$$Y(t_n) = F[X(t_n), R(t_n)]. \quad (1)$$

Usually, the size of the response vector does not correspond to the desired one (commanded or command). This causes the buyer to act as a regulatory element. Implicitly, any additional component (in a functional view) in the system will result in a “delay”. Given this, the above scheme will turn into Figure 2.

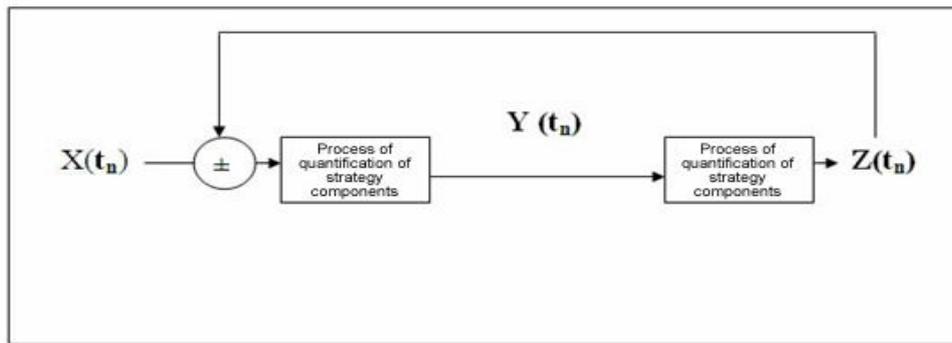


Figure 2

In this case, the function describing the system in Figure 2 are the following:

$$Y(t_{n+1}) = F[X(t_n), Y(t_n)] \quad (2)$$

$$Z(t_n) = G[X(t_n), Y(t_n)]. \quad (3)$$

If in relation (2) we substitute $n > n-1$, we obtain:

$$Y(t_n) = F[X(t_{n-1}), Y(t_{n-1})], \quad (4)$$

Substituting relation (4) into relation (3) we obtain:

$$Z(t_n) = G\{X(t_n), F[X(t_{n-1}), Y(t_{n-1})]\} \quad (5)$$

We notice that according to relation (5) the exit of the system (Z) at a point in time (t_n) depends both on the entries in the system at the given time and on its previous status $F[X(t_{n-1}), Y(t_{n-1})]$.

In other words, the strategy, no matter type and size, “store” their status, being a cybernetic system characterised by self-regulation ability. Therefore, we can state that strategies are “systems with storage”.

Based on the previous demonstrations, we can state the following principle: **any organisational strategy stores its status**. The corollary of this principle is that a **strategy cannot pass from one status to any other**.

2. The status of organisational strategies

The definition of the status variables are especially the quantification of an organisational strategy is, in the economic theory and practice, issues still insufficiently tackled and analysed. This is why, for the beginning, we will define the **status** of socio-productive systems (this concept is clearly outlined and defined, especially useful in natural sciences – Physics, Chemistry etc.)

In most of the economic analyses of some work processes a wide range of indicators is used (cost, profit, production, productivity etc.). These indicators have are threefold: from the point of view of the person performing the analysis and designing the components of the strategy on a time horizon they can be considered both entry and/or exit variables (in this case, the indicators are accompanied by certain performance indicators) and status variables. The status variables correspond to the set of values of some significant values, which characterise the evolution and dynamics of a strategy, at certain moments in time (initial, intermediary, final).

As an example, let us consider the indicator “the total cost of production” as a component of the organisational strategy, with the remark that the reasoning, conclusions and generalisation do not change if any other indicator are considered at a later stage.

In the economic practice, the cost generally represents a value indicator that expresses the effort of a production system from the standpoint of different resources consumption (entry variables), in order to achieve a certain production (exit variable). As a consequence, this indicator can be considered either an entry variable or an exit variable in a strategy. Using it, we will characterise the “status” of the strategy concerned and will transform this indicator into status variable.

To this purpose, we will consider a time span $[0, T]$ with the discrete time sequences $t_1, t_2, t_3, \dots, t_n$, so that $[T_k, T_{k+1}] \subset \dots$ Where $k=1, \dots, n$.

Let us consider the vector of planned costs C_p and the vector of the incurred costs C_r (the command and the response vectors) corresponding to these time spans.

Let us denote:

$C_p = [C_{1p}, C_{2p}, \dots, C_{np}]$, the command vector of costs

and

$C_r = [C_{1r}, C_{2r}, \dots, C_{nr}]$, the response vector

It is obvious that along the time span considered $[0, T]$ there is a certain variation between the two vectors, which regularly transmits just post-factum information. This means that at a specific moment the incurred cost is different from the planned one or that there is or there is not a certain level of “savings”. We set forward to identify, however, a variable that gives us additional information and probably more useful and with a diminished post-factum character. This variable has to convey information that, starting from the results obtained, can justify a

possible substantial cost-reduction policy for the next period. If we denote by p_i the probability that at the time moment t_i the incurred cost (of response) is equal or within given permitted limits as compared to the programmed one (of command)), then a measure of the running of the strategy under analysis over the time span considered “could be supplied” by the following relation:

$$H = - \sum_{i=0}^{\infty} p_i \times \lg p_i, \quad (6)$$

where H is the entropy of the strategy in relation with the total production costs.

We can consider that the measure of the strategy’s entropy “could be supplied” by relation (6) on the following ground: it is a sufficient reason that if the probability p_i is nil even for one single time span the relation cannot be applied anymore or the result is useless. In case the permitted limits of the variation between the incurred and the planned cost increase so that every p_i cannot be nil the following question arises: does the result obtained have a satisfactory level of accuracy, quality and confidence?

Let us also consider the case where all $p_i = 1$ and $H=0$. A nil entropy represents the fact that the strategy worked ideally over the time span considered and any type of uncertainty regarding the probability of obtaining equality between the incurred and planned cost is eliminated. Thus, we have decided upon at least two significant causes out of which resulted that a relation of type (6) is does not always hold true.

Resuming the issue of costs as status variables we will perform the following operations:

a. we introduce the ratio

$$I_{p,i+1}^i = \frac{C_{i+1,p}}{C_{i,p}} \quad (7)$$

where $I_{p,i+1}^i$ is the coefficient of variation of two subsequent components of the command vector of costs.

b. similarly we constitute the following ratio for the response vector of costs

$$I_{r,i+1}^i = \frac{C_{i+1,r}}{C_{i,r}} \quad (8)$$

where $I_{r,i+1}^i$ is the same coefficient, but concerning the response vector of total costs.

Using the two ratios, the vectors below are generated:

$$Ip = [I_{p,2}^1 I_{p,3}^2 \dots I_{p,i+1}^i \dots I_{p,n+1}^n],$$

and

$$Ir = [I_{r,2}^1 I_{r,3}^2 \dots I_{r,i+1}^i \dots I_{r,n+1}^n] \text{ respectively.}$$

We notice that the two relations highlight the evolution of the command vector (I_p) and of the one of the response vector (I_r). In other words, we have transferred the variable of total cost (of command or response) either at the entry or at the exit into the system, transforming in into a status variable.

We can consider the hypotheses which state that the quantitative and qualitative measurement of a strategy can be defined only if the following are known:

- a. The direction of evolution of the strategy (if the strategy is ordered to move in a certain direction, then the answer has to vary in the same way; otherwise the strategy is either uncontrollable or its management can be considered inefficient).
- b. The relative variation of the components of the response vector from the command one (this variation shows the extent to which the strategy is correctly commanded, which means if the command vector is in accordance with the status).
- c. The absolute variation of the components of the response vector towards those from the command vector.

Under this additional hypotheses we can go on to determine an indicator that can be a measure of the general status of a strategy.

3. The status entropy of organisational strategies

Let us consider a random strategy S that, at a certain moment, is characterised by an entry vector, a status and an exit one (Figure 3):

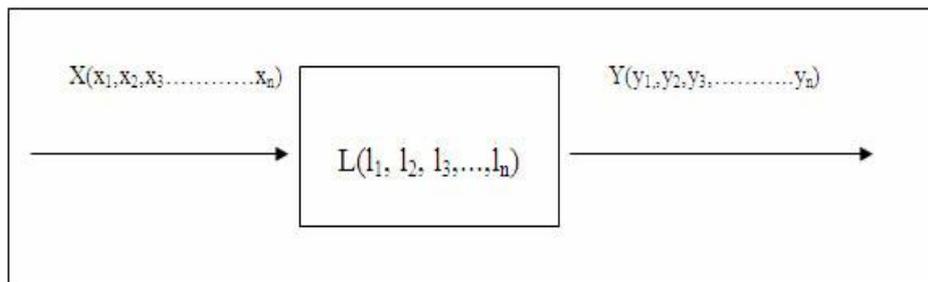


Figure 3

Let us define the **correctly estimated internal status** (L_0) as being the status of strategy for which we seek **the perfect conformance between values of the components of the command vector and the ones of the response vector**. In other words, there is a command variable $x_0(x_1^0, x_2^0, \dots, x_n^0)$ for which the answer $y_0(y_1^0, y_2^0, \dots, y_n^0)$ could be obtained only if the status of the system is $l_0(l_1^0, l_2^0, \dots, l_n^0)$.

The vector x_0 , of components $(x_1^0, x_2^0, \dots, x_n^0)$ is called **command vector in utter conformance with the status**. Let us also consider the following

hypotheses: the application of a command vector in accordance with the state of the strategy cannot conduct to an answer $Y \neq Y_0$.

However, we assume that at a certain moment we apply a command vector $X \neq X_0$ and the answer is $Y \neq Y_0$. In this case the strategy records an uncontrollable variation resulting to certain extent in an **instantaneous impairment of its internal status**. To this status we associate the concept of **status entropy** (which is different from the entropy from thermodynamics despite the fact that it leads to the variation speed of the former as we can see below).

Next, we will try to build a computation methodology of status entropy, an evaluation, a measure of the internal status of a strategy and not an “indicator” of these statuses. This would not be possible for a simple reason: we do not possess a technology capable of measuring such a status. We are going to show it next that, even if we had one, this would be impossible to achieve due to the infinite number of statuses that could be reached even in a small and relative simple system. This would be even more complicated in a large and complex system like the one behind a strategy. Let us start by setting the goal of determining the number of statuses that a system with 10 components can go through (serial, parallel or mixt), given that there can only be two relations among the components. Graphically, such a system would look like Figure 4.

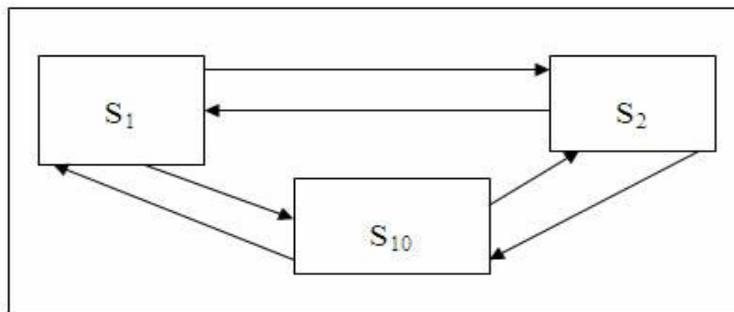


Figure 4

Under the conditions of such a system – with small dimensions and a minimum number of connections among the components the number of possible statuses will be:

$$2^{n(n-1)} = 2^{10(10-1)} = 2^{10 \cdot 9} = 2^{90} \approx 1,3 \cdot 10^{27}$$

It results that for a small and relatively simple system, associated with a strategy, a number of statuses in other forms cannot be imagined. In this, we will have to reduce this number to an adequate one, which is especially necessary from a practical standpoint. The problem to be solved is the following.

Let us consider a time span $[0, T]$. We will generate subsequent and discrete time spans (t_k, t_{k+1}) , $k = \overline{1, n}$ (the fact that the time spans are considered to be discrete or continuous does not influence the degree of generality of the solution). On each of these time spans we apply the commands x_k to system A and we obtain the response measures y_k . We seek to estimate the status entropy of the system under analysis.

In order to solve this problem we consider the following:

a. we denote the status vector "a" with the components: a_1, a_2, a_3 , the vector: $\|a\| = [a_1 a_2 a_3]$ where components a_i , $i = \overline{1, 3}$ can only take the binary values 0 and 1.

b. the components of vector "a" have the following meaning:

- a_1 defines the conformance between the direction of evolution of the command and that of the response;

- a_2 defines the conformance between the relative variation of the response as compared to the planned one;

- a_3 defines the conformance between the absolute variation of the response as compared to the planned one.

c. the components of the status vectors can take the following values:

$$a_1 = \begin{cases} 0, & \text{if the evolution direction of the response is the same as the one of the command;} \\ 1, & \text{otherwise;} \end{cases}$$

$$a_2 = \begin{cases} 0, & \text{if the variation of the response in relative values is smaller than a maximum permitted value (let us denote it by p);} \\ 1, & \text{otherwise;} \end{cases}$$

$$a_3 = \begin{cases} 0, & \text{if the variation of the response in absolute values is smaller than a maximum permitted value (let us denote it by p);} \\ 1, & \text{otherwise.} \end{cases}$$

d. we define the vector in utter conformance with the status as being: $\|a\| = [000]$.

From the presentation above we can notice that at the level of a strategy (regardless the size and nature) a standardised number of maximum 8 statuses has been obtained (Table 1).

Table 1

No.	Status vector	Binary status of the components of the status vector	Binary complement	Decimal correspondent (c_z)	Modified decimal correspondent (C'_z)
(0)	(1)	(2)	(3)	(4)	(5)
1.	a_0	0 0 0	1 1 1	7	8
2.	a_1	0 0 1	1 1 0	6	7
3.	a_2	0 1 0	1 0 1	5	6
4.	a_3	0 1 1	1 0 0	4	5
5.	a_4	1 0 0	0 1 1	3	4
6.	a_5	1 0 1	0 1 0	2	3
7.	a_6	1 1 0	0 0 1	1	2
8.	a_7	1 1 1	0 0 0	0	1

We associate the complement and its decimal correspondent to each binary status, obtaining the data in columns (3) and (4).

We define the modified decimal correspondent (C'_z) according to the relation:

$$C'_z = C_z + 1 \quad (9)$$

Using relation (9) the last column of Table 1 is filled.

We define the probability that at a given time moment (t_k) the strategy was in the status a_0 (the utter conformance of the command status). It is the ratio between the modified correspondent of the vector a_j and the one corresponding to the vector a_0 .

$$p_k = \frac{C'_{z_{jk}}}{C'_{z_0}} \quad (10)$$

where $j = \overline{1,7}$

4. Example of simulation of the status of a strategy

Over a quarter, a company sets the following strategic goals:

1. diminishing costs by 2-5%;
2. the costs reduction should be 1,3 - 2 billion lei;
3. increasing the physical production by 1,5% - 2%;
4. the additional value of production should be 2,5 - 3 billion lei.

We estimate the status entropy of the strategy related to the goals set knowing that:

1. the cost reduction was 1,57%;

2. the value of the reduction was 1,2 billion lei;
3. the physical production increased by 1,3%;
4. the additional value of production was 2,8 billion lei.

We will make computations at two levels: the cost level and the physical production level.

From the point of view of costs, we have the following comparisons:

- point 1 was partially achieved: $a_1=1$ și $a_2=0$
- point 2 was not achieved: $a_3=0$

It results that the costs status vector has the components $[100]$, and its modified decimal correspondent is 4 (corresponding to a_4). The probability to have had a command in conformance with the status is:

$$p_1 = \frac{4}{8} = 0,50$$

Similarly, the same is applied for physical production and we obtain the vector of components $[101]$ ($a_1=1, a_2=0, a_3=1$)

And thus:

$$p_2 = \frac{5}{8} = 0,40$$

The status entropy has the form:

$$h = - \frac{\sum_{i=1}^n p_i \cdot \lg p_i}{n} \quad (11)$$

where: n = the number of factors considered.

For our hypothetical situation ($n=2$) it results:

$$h = 0,5 * \lg 0,5 + 0,4 * \lg 0,4 \approx - 0,5 * (-0,30103) + 0,4 * (-0,39794) \approx 0,31$$

which shows a low level of the status entropy. Furthermore, we can state that:

- the status of the strategy is relatively good (the commands were responded to)
- the decision factor did not reach the quality level intended.

We now own a computation tool useful for indicating with a high probability what can be expected and not from a certain strategy from different angles.

We consider that we already know the maximum status entropy within the given system $\{h_{max}\}$ and we introduce the ratio

$$R = \frac{h}{h_{max}} \quad (12)$$

Obviously, $0 \leq R \leq 1$. With the aid of this ratio we introduce the concept of **effectiveness** of the strategy, shown by the relation:

$$r = 1 - R. \quad (13)$$

For eliminating any confusion between the terms effectiveness and status entropy we consider that additional explanations are useful.

We can draw the conclusion that the status entropy occurs instantaneously as a consequence of nonconformance situations between commands and the real status of the strategy at a given moment. These situations of nonconformance first of all display at the level of the structure of the system by transferring them from the coordinates of a normal running to those of “overuse” or “underuse”. These variations between relatively or extremely opposed statuses negatively and strongly influence the potential of the system, basically leading to the systematic increase in the variation between the planned and the incurred levels of costs and production.

If the status entropy is a measure of instantaneous impairments resulted from the lack of conformance between command and system status, the **effectiveness** is a measure of increasing or decreasing “variations”. Thus, this represents a measure of the capacities of the system to be efficient.

It is practically impossible to have utter conformance between the command and the response vector because like any other type of system the strategy needs some kind of flexibility in its running (in case it does not exist, it is implicitly achieved). In other words, it is desirable that to keep a certain “margin” when computing the value of the command vector instead of rendering it “inflexible” unsuccessfully trying to cancel the effects of the status entropy.

The connectivity of strategy components assume the propagation of the entropy from one component to another (Figure 5).

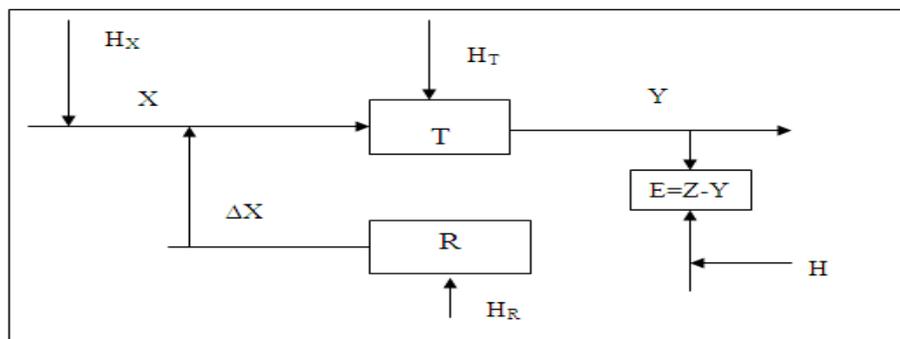


Figure 5

H_X = the entropy propagated by the components of the strategy;

H_T = the internal entropy of effective sub-systems;

H_Z = the entropy of the macro-system (distribution markets, stock exchanges, financial environment etc.);

H_R = the entropy of the management system of the organisation.

The socio-productive entropy systems with constant objectives in time can be described (Figure 5) by the following matrix relations:

$$\Delta X = \bar{R}[\bar{Z} - Y] \quad (14)$$

where:

$$\begin{aligned} \bar{R} &= R * H_R \\ \bar{Z} &= Z * H_Z \end{aligned}$$

ΔX - The change of the entry values in order to obtain a process leading to the stability of the strategy.

Next, we obtain:

$$Y = \bar{T}(\bar{X} + \Delta X) = \bar{T}(\bar{X} + \bar{R}(\bar{Z} - Y)) \quad (15)$$

or:

$$Y = \frac{\bar{X} + \bar{R} * \bar{Z}}{1 + \bar{T} * \bar{R}} * \bar{T} \quad (15')$$

where:

$$\begin{aligned} \bar{T} &= T * H_T \\ \bar{X} &= X * H_X \end{aligned}$$

Substituting Z, T, R and X we obtain:

$$Y = \frac{T * H_T [X * H_X + R * H_R * Z * H_Z]}{1 + T * H_T * R * H_R} \quad (16)$$

In order to highlight the relation between the four types of entropy we resort to the following simplifications:

- X, T, Z, R will be considered unitary scalars (equal to 1);
- The matrix functions of the entropies are also matrix with one element (of constant value). Setting the condition that Y=1, we will obtain:

$$1 = \frac{H_T * H_X + H_T * H_R * H_Z}{1 + H_T * H_R} \quad (17)$$

or:

$$H_R = \frac{H_X - \frac{1}{H_T}}{1 - H_Z} \quad (17')$$

Setting some values for H_x , H_T and H_z , by simulation we can obtain the behaviour of the strategy regarding the regulating factors as well as an extremely important managerial principle (Table 2).

Table 2

H_Z	H_X	H_T	$\frac{1}{H_T}$	$H_X - \frac{1}{H_T}$	$1 - H_Z$	H_R
0,8	1,0	1,0	1	0	0,2	0
		0,8	1,25	-0,25	0,2	-1,25
		0,6	1,67	-0,67	0,2	-3,35
	0,8	1,0	1	-0,2	0,2	-1
		0,8	1,25	-0,45	0,2	-2,25
		0,6	1,67	-0,87	0,2	-4,35
	0,6	1,0	1	-0,4	0,2	-2,0
		0,8	1,25	-0,65	0,2	-3,25
		0,6	1,67	-1,07	0,2	-5,35
0,7	1,0	1,0	1	0	0,3	0
		0,8	1,25	-0,25	0,3	-0,83
		0,6	1,67	-0,67	0,3	-2,23
	0,8	1,0	1	-0,2	0,3	-0,67
		0,8	1,25	-0,45	0,3	-1,5
		0,6	1,67	-0,87	0,3	-2,9
	0,6	1,0	1	-0,4	0,3	-1,33
		0,8	1,25	-0,65	0,3	-2,16
		0,6	1,67	-1,07	0,3	-3,57
0,6	1,0	1,0	1	0	0,4	0
		0,8	1,25	-0,25	0,4	-0,625
		0,6	1,67	-0,67	0,4	-1,675
	0,8	1,0	1	-0,2	0,4	-0,5
		0,8	1,25	-0,45	0,4	-1,125
		0,6	1,67	-0,87	0,4	-2,175
	0,6	1,0	1	-0,4	0,4	-1
		0,8	1,25	-0,65	0,4	-1,625
		0,6	1,67	-1,07	0,4	-2,675

By briefly analysing the data in the table above it results that the influences on the regulating capacity decrease in the following order:

- objectives
- necessary resources
- entries.

5. Conclusions

In the specialty literature, regarding the mathematical theory of information it is proven for the first time that it is possible to define a measure of information with major impact on the communication theory and the theory of cybernetic systems regulations, in general, and those associated with strategies, in particular. The importance of this study is significant from at least two points of view:

- a. many important problems regarding the correct formulation of strategies can be successfully tackled in the light of regulation theory;
- b. theoretical approach is most often useful even though it does not have immediate and discreet applicability in the management practice, because it

highlights main issues concerning the behaviour of systems, whose neglect or ignorance may trigger negative consequences.

The results of the above-mentioned reasoning allow us to define the **principle** according to which in order to maximise the results of the management system of the organisation, has to pursue **objectives stability** in the first place, followed by **the stability of production capacities** and finally **the stability resources availability**.

Within such an approach, we consider that the **effectiveness of a strategy is bestowed by the extent to which the components of the strategy ensure the achievement of some performance indicators, as well as its ability, safety and her credibility in order to globally and utterly answer to the requirements of an efficient command vector.**

References

1. Bar-Yam Y., (2001) *Introducing Complex Systems*, New England Complex Systems Institute, Cambridge, MA.
2. Brillat J.L., (1994) *Modelisation Econometrique, Principes et Tehniques, Economica*, Paris,
3. Chaitin G.J., (2003) *Algorithmic Information Theory*. Third Printing, Cambridge University Press
4. Davis, J.P., Eisenhardt, K.M. & Bingham, C.B. (2007) “Developing Theory with Simulation Methods”. *Academy of Management Review*, 32(2)
5. Druker P., (1992) *Managing for the Future*. Truman Talley Books, New York
6. Greven A., *Entropy* (Princeton Series in Applied Mathematics), Princeton University Press, 2003
7. Harrison, J. R., Lin, Z., Carroll, G. R., & Carley, K. M. (2007). “Simulation Modeling in Organizational and Management Research”. *Academy of Management Review*, 32, 1229–1245
8. Lant, T., & Mezias, S. (1990) “Managing Discontinuous Change: A Simulation Study of Organizational Learning and Entrepreneurship”. *Strategic Management Journal*, 11
9. Law, A. M., & Kelton, D. W. (1991) *Simulation Modeling and Analysis* (2nd ed.). New York, NY: McGraw–Hill
10. MacKay D., (2003) *Information Theory, Inference, and Learning Algorithms*, Cambridge University Press
11. Nelson, R. R., & winter, S. G. (1982) *An Evolutionary Theory of Economic Change*. Cambridge, Massachusetts: Belknap – Harvard University Press
12. Nielsen A. Chuang I.L., (2000) *Quantum Computation and Quantum Information*, Cambridge University Press
13. Radu I., Vlădeanu D., (2002) *Fundamentarea deciziilor complexe prin tehnici de simulare*, Editura Economică, București
14. Repenning, N. (2002) *A Simulation-Based Approach to Understanding the Dynamics of Innovation Implementation*. *Organization Science*, 13(2)
15. Wolfram, S. (2002) *A New Kind of Science*. Champaign, IL: Wolfram Media