Theoretical and Empirical Researches in Urban Management
Number 6(15) / May 2010

ANALYSIS OF THE COHERENCE OF LOGISTIC SYSTEMS FROM URBAN ENVIRONMENTS USING INFORMATIONAL INDICES

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Abstract

The paper introduces a series of analysis models of the flows of materials and products existent inside a logistic system, elaborated according to the entropic and informational indices introduced in the first part of the paper, which are: informational entropy, the quantity of information, the organization degree, the mutual information, the informational energy and the coefficient of informational correlation. The theoretical elements are used in case studies in the second part of the paper, case studies that treat aspects from the domain of logistic management, oriented especially towards the functions of organization, coordination and evaluation of the logistic operations.
The models introduced in the paper allow analyzing the structural and functional coherence of the logistic system and its dynamics, from the perspective of the organizational entities' synergy. By presenting these models in great detail, the presentation of the adapting, organizing and knowledge mechanisms of the logistic contemporaneous systems, characterized by a higher complexity degree, a consequence of their entering in the vast globalization process can be facilitated.

Keywords: informational entropy, logistic system, decision, logistical informational subsystem, logistic center.

JEL classification: C13, L81, L91, M10, M11

1. INTRODUCTION

Identifying some methods of evaluation of the informational flows, from the quantitative point of view, has become a necessity with the apparition and development at a fast pace of high technology, which had a fulminatory contribution to the volume and data diversity available for the users. Inside the logistic systems, these informational flows are the ground of the intra and inter-organizational activities and of driving the flows of materials and products.

In order to increase the efficacy of the decisional act it's necessary to limit the amount of information to the bare necessities. In order to do that, in the process of evaluation and information selection from the point of view of their importance, it's necessary to analyze the contribution each item of information has in the activities' optimal development. Using the information they have at hand, the logistic managers can correct, by taking the adequate decisions, the logistic processes' deviations from the normal course, which can influence the behavior of the entire logistic system. These deviations are related to the organization degree of the logistic system that resulted from the influence of the endogen and exogenous factors that operate on them. The intensity with which these factors manifest themselves determines the deviation level of the system's behavior.

A special interest is presented by the synergic analysis of the organization degree of a logistics system composed from several organizational entities with a different behavior. Therefore, we're talking here about the complex relationship between a whole and the elements that compose this whole, respectively between a whole and its parts (Constantinescu, 1990). The more organized a system is, the better the parts of the whole behave, in spite of the unpredictable behavior of the organizational entities that form the logistic system. Therefore, the measuring of the indetermination of the logistic system or of the organization degree, using some informational indices is extremely important. These kinds of indices are meant to measure the behavior of the logistic systems and the level of the informational flows that cross it.

Having in view the growing complexity of the current logistic systems, their management needs a multilateral approach that must have in mind the intra- and inter-organizational relationships, the hypotheses related to their evolution, their future capabilities and needs. The need of anticipating the effects, the advantages and disadvantages of the actions make the models represent valuable managerial tools that can be used in the decisional process (Malița & Zidăroiu, 1971), in which it must be achieved, with a good accuracy, the balance between the necessary and the potential, between the requirements and the resources available. In order to achieve a deep insight of the effects of the decisions taken, there must be numerous evaluations, measuring and tests with the help of some models, through which the evolution of the flows of any nature are studied. This evolution's simulation and study allow the measuring of the possible reactions to the decisions taken, which will be then manipulated and driven according to the direction the logistic managers want to follow.

The logistic system is influenced by some factors whose role is to provide the internal organization (the programs of endowment with equipment and installation, the scheme of the internal operational flows' development, the reception and goods' deliverance graphics), but also of some factors that tend to disorganize it (the resources' insufficiency, the tools' defaults, the traffic congestion). As a result, the more data and information about the states and functionalities of the entities from which the system is built are provided, the smaller is its indetermination degree. Therefore, the knowledge process decreases the indetermination degree of the logistic system, obtaining some information about it; the value of the respective logistic system stands in the novelty obtained about it. This novelty consists, in fact, from the amount of information resulted from the knowledge process.

The evaluation the informational flows from a *Λ* logistic system, formed from the organizing entities λ_i can be achieved with the help of the *informational entropy* formula (Shannon, 1948):

$$H = -\sum_{i=1}^{n} P_i \log_2 P_i \qquad (1)$$

where:

H – the amount of information;

P_i – the probability of the logistic system *Λ* to be in the status λ_i

$$\sum_{i=1}^{n} P_i = 1$$

i=1,2,…,n represents the number of possible events.

Obviously, the informational entropy is non-negative: Hρ0.

If $P_i = 1, P_j = 0, i \neq j,$ then the system's entropy has a minimal value, respectively H=0. In this case, the logistic operations are developed in conditions of total certainty.

If all the events are equiprobable, then the system's entropy has the minimal value, respectively:

$$P_i = \frac{1}{n}, i = 1,2,\dots,n$$

the informational entropy has the maximal value expressed by the following equation:

$$H_{max} = -\sum_{i=1}^{n} \frac{1}{n} \log_2 \frac{1}{n} = \log_2 n \qquad (2)$$

The *amount of information* existent in the logistic informational subsystem, until the determination of the informational entropy, is calculated using the equation:

$$I = H_{max} - H \qquad (3)$$

Out of the third equation one can deduce that both the information *I* and the entropy *H* are limited by the maximal entropy, which can't be surpassed. It can be also noticed that, when the organizational entropy rises, the amount of information decreases. Dividing the expression (3) to the maximal entropy, we obtain:

$$\frac{I}{H_{\max}} = 1 - \frac{H}{H_{\max}} \qquad (4)$$

Therefore, if the amount of information decreases, the informational entropy and implicitly the disorganization will rise.

If we denote: $\Omega = \frac{I}{H_{\max}}$ (5)

We replace the notation (5) in the equation (4), obtaining an expression of the *organizing degree*:

$$\Omega = 1 - \frac{H}{H_{\max}} \qquad (6)$$

taking into consideration that $0 \le \Omega \le 1$

Therefore, the organization degree of a logistic system increases with the increase of the informational flow's volume and it decreases with the increase of the maximal informational entropy, respectively the complexity of the logistical operations.

In case in which the logistic managers decide to extend the logistical area, then, in order to maintain an informational entropy as low as possible, the entropic effect must be decreased, this effect being potentiated by the imminent rise of the logistic system's structural and functional complexity. This kind of decrease is possible only through the continuous increase of the organizational level, respectively through reaching a stable state point between the complexity degree and the organization degree of the logistic system.

If in the logistic informational subsystem's channel, the signals are transmitted from the source $x_i \in X$ to the receiver $y_j \in Y$ with a probability of $P(x_i, y_j)$ and if $P(x_i)$ represents the probability of input in the informational channel of x_i signal, and $P(y_j)$ represents the probability of output from the informational channel of the signal y_j, then the entropies of the fields from the channel input, respectively from the channel output, will be expressed by the equations:

$$H(X) = -\sum_{i=1}^{n} P(x_i) \cdot \log_2 P(x_i) \qquad (7)$$

$$H(Y) = -\sum_{j=1}^{m} P(y_j) \cdot \log_2 P(y_j) \qquad (8)$$

In this case, the entropy of the joint events will be (Shannon, 1948):

$$H(X,Y) = -\sum_{i=1}^{n}\sum_{j=1}^{m} P(x_i, y_j)\cdot \log_2 P(x_i, y_j) \qquad (9)$$

The entropy of the event fields X and Y, conditioned by the events y_j, respectively x_i, are calculated in the equations:

$$H_{y_j}(X) = -\sum_{i=1}^{n} P_{y_j}(x_i)\cdot \log_2 P_{y_j}(x_i) \qquad (10)$$

$$H_{x_i}(Y) = -\sum_{j=1}^{m} P_{x_i}(y_j)\cdot \log_2 P_{x_i}(y_j) \qquad (11)$$

they signifying the average uncertainty amount or the average information about the field of events X, respectively Y, when the event y_j and respectively x_i take place.

The *equivocation*, H(X6Y), respectively the measuring of the ambiguity that exists in the input field X, when the output field Y is known is determined with the equation:

$$H(X|Y) = \sum_{j=1}^{m} P(y_j)\cdot H(X|y_j) = \sum_{j=1}^{m}\sum_{i=1}^{n} P(y_j)\cdot P_{y_j}(x_i)\cdot \log_2 P_{y_j}(x_i) \qquad (12)$$

The *average error*, H(Y6X), respectively measuring the uncertainty of the events field from the output Y, when the input field is known, is calculated with the equation:

$$H(Y|X) = \sum_{i=1}^{n} P(x_i)\cdot H(Y|x_i) = -\sum_{i=1}^{n}\sum_{j=1}^{m} P(x_i)\cdot P_{x_i}(y_j)\cdot \log_2 P_{x_i}(y_j) \qquad (13)$$

Knowing that we have the conditioned (restrictive) probabilities:

$$P_{y_j}(x_i) = \frac{P(x_i, y_j)}{P(y_j)},\ P_{x_i}(y_j) = \frac{P(x_i, y_j)}{P(x_i)} \text{ and that },\ \sum_{i=1}^{n} P_{y_j}(x_i) = \sum_{j=1}^{m} P_{x_i}(y_j) = 1,$$

it can be obtained the amount of input information, determined according to the outputs, respectively the trans-information or mutual information, whose equation is (Ash, 1990; Gray, 1990):

$$\begin{aligned} I(X,Y) &= -\sum_{i=1}^{n}\sum_{j=1}^{m} P(x_i, y_j)\cdot \log_2 P(x_i, y_j) = -\sum_{i=1}^{n}\sum_{j=1}^{m} P(x_i)\cdot P_{x_i}(y_j)\cdot \log_2 [P(x_i)\cdot P_{x_i}(y_j)] = \\ &= -\sum_{i=1}^{n} P(x_i)\cdot \log_2 P(x_i) - \sum_{i=1}^{n} P_{x_i}(y_j)\cdot \log_2 P_{x_i}(y_j) = H(X) + H(Y|X) \end{aligned} \qquad (14)$$

By analogy, $I(X,Y) = H(Y) + H(X|Y)$. (15)

The trans-information represents the average value of mutual information that is sent through logistic system. If we balance the equations (14) and (15), it results the *informational balance*:

$$H(X)-H(X|Y)=H(Y)-H(Y|X) \qquad (16)$$

which represents, altogether, the *relation of conservation associated to entropy*.

The integrity and the accuracy represent two of the most important characteristics of information, which must be considered when the informational flows are supervised. That's why the *capacity of the communication channel* of the logistic informational subsystem is especially important; the capacity of the communication channel is calculated using the equation (Ash, 1990):

$$C=\max I(X;Y) \qquad (17)$$

The global information of the logistic system, which has the weights $p_1, p_2, \ldots, p_k$, can be expressed through the own *informational energy*, calculated using the formula (Onicescu & Ştefănescu, 1979):

$$E=\sum_{k=1}^{n} P_k^2 \quad \text{where} \quad \sum_{k=1}^{n} P_k = 1 \qquad (18)$$

This index measures the amount of information from the informational subsystem about the state of the logistic system, respectively its organization degree, before initiating the process of properly analysis. The informational energy reflects, in fact, that part of the logistic system's general behavioral characteristics that can be known by the specialists before starting the study.

Considering two logistic subsystems S_1 and S_2, which have *n* characteristics in common,

$\alpha_1, \alpha_2, \ldots, \alpha_n$ and the weights $P_1, P_2, \ldots, P_k$, respectively $Q_1, Q_2, \ldots, Q_k$, the correlation C_I between the two subsystems, from the point of view of the characteristics α, is defined using the expression (Onicescu, 1977):

$$C_I=\sum_{k=1}^{n} P_k Q_k \quad , \; 0 \le C_I \le 1 \qquad (19)$$

Normalizing the equation (19), we obtain the *correlation coefficient* of the subsystems S_1 and S_2, components of the logistic system Λ (Onicescu, 1977):

$$K_I=\frac{C_I}{\sqrt{\sum_{k=1}^{2} P_k^2 \cdot \sum_{k=1}^{2} Q_k^2}} \qquad (20)$$

2. THE CASE STUDY

The theoretical elements described above are illustrated through some examples, which exemplify the possible modalities of analysis and synthesis of the informational flows from the level of the logistic system. We consider that in a logistic centre are taking over the materials and products from several suppliers, that, according to the clients' demands, are matched and consolidated into units load. The stages in which the orders fulfillment can be, are the following:

- receiving and analysis (τ_1);
- in processing (τ_2);
- waiting to be grouped and delivered (τ_3);
- being transported to the beneficiary (τ_4).

The materials and the products from the logistic center are found in three stages: *palletized*, *packaged* (in individual or common packaging) or *bulk*.

At different moments τ_i the materials and products existent in the logistic center are found in various states, given by their characteristics, like components of the delivery orders, the weight of good's representation for the three states being specified in Table 1. For example, at the moment τ_1, at which the demands received from the clients are received and processed, in the logistic center 15% of the goods are palletized, 25% are packaged in common packaging and 60% from them are bulk. In the same time, in the moment τ_4, 90% of the goods in course of transport are palletized, 3% are in packaged and 7% are bulk transported.

TABLE 1 - THE PERCENTAGE OF GOODS FROM THE LOGISTIC CENTER, ON STATES, AT DIFFERENT MOMENTS IN TIME

State		τ_1	τ_2	τ_3	τ_4
Palletized	p_1	0,15	0,45	0,83	0,90
Wrapped	p_2	0,25	0,35	0,07	0,03
Bulk	p_3	0,60	0,20	0,10	0,07

Using the data from Table 1 we can determine the fluctuation in the informational entropy and the organization degree at the level of the entire logistic center, at different moments τ_i.

Therefore, with the equation (1) the informational entropy is obtained at the moment τ_1:

$$H_1 = -\sum_{i=1}^{3} P_i \log_2 P_i = -0{,}15 \cdot \log_2 0{,}15 - 0{,}25 \cdot \log_2 0{,}25 - 0{,}60 \cdot \log_2 0{,}60 = 1{,}3527$$

Considering that the maximal informational entropy has the value:

$$H_{max} = \log_2 n = \log_2 3 = 1{,}585 \,,$$

Using the equation (6) the following organization degree at the moment τ_1 is obtained:

$$\Omega_1 = 1 - \frac{H_1}{H_{max}} = 1 - \frac{1{,}3527}{1{,}585} = 0{,}1465$$

Proceeding in a similar manner, the informational entropy and the organization degree are obtained at different moments in time. The results of the calculations are written in Table 2, according to these being obtained the graphic from Figure 1.

TABLE 2 - THE INFORMATIONAL ENTROPY AND THE ORGANIZATION DEGREE AT THE LOGISTIC CENTER, AT VARIOUS MOMENTS IN TIME

Moments in time	τ_1	τ_2	τ_3	τ_4
Entropy H_i	1,3527	1,5129	0,8239	0,5571
Organization degree Ω_i	0,1465	0,0455	0,4802	0,6485

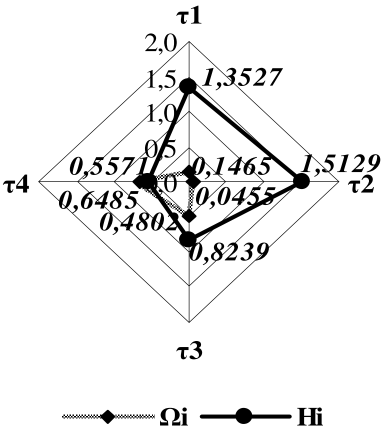

FIGURE 1 - THE INFORMATIONAL ENTROPY'S DYNAMIC AND MANNER OF ORGANIZING

Analyzing this graphic, it can be noticed that the greater organization degree is found in case of the goods that are in course of being transported, this fact being due to the fact that the goods are in their greater part palletized. The informational entropy is maximal, respectively the organizational degree has the lowest value at the moment τ_2, when the goods' state is especially heterogeneous, having in mind that in this moment the delivery orders are in course of processing towards the clients. A similar circumstance is also met at the moment τ_1, when the received demands' analysis is done, establishing the structure and the volume of the units load that will be constituted. In this moment, the goods are warehousing in various manners, according to the modality on which the suppliers delivered them.

Through the informational system, the logistic center informs the distribution centers with which they collaborate about the stage of orders fulfillment. Due to the some problems that might appear in the logistic center and at the suppliers' level, there is a probability of 10% that the dispatches to the distribution centers to be performed with delay, $P(E_1)=10\%$. In the same time, considering the great distances between the logistic center and the distribution centers, there is o probability of 5% that the goods not to be delivered to the distribution centers in due time.

Therefore, four cases can be met in the logistic system exemplified (we think that the cases are identical for all the distribution centers served by the logistic center:

1. The orders are sent out in time from the logistic center and they are received in time at the level of the distribution center (E_0R_0);
2. The orders are sent out with a delay from the logistic center, but they arrive in time at the distribution center (E_1R_0);
3. The orders are sent out with a delay from the logistic center and they arrive with delay at the distribution centers (E_1R_1). The delay's source can be the suppliers or the organizational issues from the level of the logistic center;
4. The orders are sent out in time from the logistic center, but they arrive with a delay at the distribution center (E_0R_1). The delay can be caused by the low organization degree of the carriers or by the bad weather, for example.

In the presented cases, the following probabilities can be deduced:

- $P(E_0)=90\%$ – the probability of sending out in time of the orders toward the distribution centers;
- $P_{E_0}(R_0)=P_{E_1}(R_1)=95\%$ – the probability of receiving the goods in time, in case in which the goods were sent out in time, respectively receiving with a delay, when the goods were sent out with a delay by the logistic center;
- $P_{E_1}(R_0)=P_{E_0}(R_1)=5\%$ – probability of receiving in time, despite the fact that the goods were sent out with a delay, respectively of receiving with a delay in spite of the goods being sent out in time by the logistic center.

Based on the data received, it can be estimated that the probability of arriving in time of the orders at the distribution centers is *(the calculations are performed using the formula of the total probability)* (Trandafir,1979):

$$P(R_0) = P_{E_0}(R_0) \cdot P(E_0) + P_{E_1}(R_0) \cdot P(E_1) = 0{,}95 \cdot 0{,}90 + 0{,}05 \cdot 0{,}10 = 0{,}86$$

Obviously, the probability of delaying the delivering to the distribution centers is :

$$P(R_1) = 1 - P(R_0) = 1 - 0{,}86 = 0{,}14$$

From time to time, the specialists in logistics must analyze the manner of developing the flows of materials and products from inside the logistic system and to transmit to the collaborating organizations the results obtained. These items of information constitute the fundaments of the decisions taken at the level of each organizing entities from the logistic system, for the continuous improvement of the specific activities.

The analysis performed in the presented case led to the following conclusions *(the calculations are performed using the Bayes' formula)* (Trandafir,1979):

- If the distribution centers receive the goods in due time, then the probability of sending out the goods in time from the logistic center is:

$$P(E_0 R_0) = \frac{P_{E_0}(R_0) \cdot P(E_0)}{P_{E_1}(R_0) \cdot P(E_1) + P_{E_0}(R_0) \cdot P(E_0)} = \frac{0{,}95 \cdot 0{,}90}{0{,}05 \cdot 0{,}10 + 0{,}95 \cdot 0{,}90} = 0{,}9942$$

- If the distribution centers receive the goods in due time, then the probability of sending out the goods with delay from the logistic center is:

$$P(E_1 R_0) = \frac{P_{E_1}(R_0) \cdot P(E_1)}{P_{E_0}(R_0) \cdot P(E_0) + P_{E_1}(R_0) \cdot P(E_1)} = \frac{0{,}05 \cdot 0{,}10}{0{,}95 \cdot 0{,}95 + 0{,}05 \cdot 0{,}10} = 0{,}0058$$

- If the goods are delivered with a delay in the distribution centers, then the probability of the logistic center (and implicitly its suppliers) to deliver the goods with a delay is:

$$P(E_1 R_1) = \frac{P_{E_1}(R_1) \cdot P(E_1)}{P_{E_0}(R_1) \cdot P(E_0) + P_{E_1}(R_1) \cdot P(E_1)} = \frac{0{,}95 \cdot 0{,}10}{0{,}05 \cdot 0{,}90 + 0{,}95 \cdot 0{,}10} = 0{,}6785$$

- In the case in which the goods are transported with a delay to the distribution centers, then the probability of the logistic center (and implicitly its suppliers) to deliver the goods in time is:

$$P(E_0 R_1) = \frac{P_{E_0}(R_1) \cdot P(E_0)}{P_{E_1}(R_1) \cdot P(E_1) + P_{E_0}(R_1) \cdot P(E_0)} = \frac{0{,}05 \cdot 0{,}90}{0{,}95 \cdot 0{,}10 + 0{,}05 \cdot 0{,}90} = 0{,}3215$$

The obtained data are centralized in the Table 3.

TABLE 3 - THE PROBABILITIES OF RECEIVING THE GOODS IN THE DISTRIBUTION CENTERS, ACCORDING TO THE WAY IN WHICH THE GOODS WERE SENT OUT FROM THE LOGISTIC CENTER

No.	Case	Probability
1.	Orders are sent out in time from the logistic center and they are received in time by the distribution centers	$P(E_0R_0)=99{,}42\%$
2.	Orders are sent out with delay from the logistic center, but they arrive in time at the distribution centers	$P(E_1R_0)=0{,}58\%$
3.	Orders are sent out with a delay from the logistic center and they arrive with a delay at the distribution center	$P(E_1R_1)=67{,}85\%$
4.	Orders are sent out in time from the logistic center, but they arrive with delay at the distribution centers	$P(E_0R_1)=32{,}15\%$
5.	The probability of arriving in time of the orders in the distribution centers	$P(R_0)=86\%$
6.	The probability of delaying the orders in the distribution center	$P(R_1)=14\%$

The average indetermination of receiving the goods in the distribution centers, no matter when the goods were sent out is:

$$H_E(R)=-\sum_{i=0}^{1}P(E_i)\cdot\sum_{j=0}^{1}P_{E_i}(R_j)\cdot\log_2 P_{E_i}(R_j)=-\sum_{i=0}^{1}\sum_{j=0}^{1}P(E_i)\cdot P_{E_i}(R_j)\cdot\log_2 P_{E_i}(R_j)=$$
$$=-(0{,}90+0{,}10)\cdot(0{,}95\log_2 0{,}95+0{,}05\log_2 0{,}05)=0{,}2864$$

Calculating the informational entropy about the goods' sending out from the logistic center's point of view, it results that:

$$H(E)=-\sum_{i=0}^{1}P(E_i)\cdot\log_2 P(E_i)=-(0{,}90\log_2 0{,}90+0{,}10\log_2 0{,}10)=0{,}469$$

Knowing the fact that the maximal informational entropy of the logistic informational system takes the value:

$$H_{\max}=\log_2 n=\log_2 2=1$$

the amount of information existent in the logistic informational subsystem, about the orders fulfillment until the moment of determining the entropy is:

$$I(E)=H_{\max}(E)-H(E)=1-0{,}469=0{,}531$$

By analogy, the informational entropy about the goods' arriving at the level of the distribution center is:

$$H(R) = -\sum_{j=0}^{1} P(R_j)\cdot \log_2 P(R_j) = -(0{,}86\log_2 0{,}86 + 0{,}14\log_2 0{,}14) = 0{,}5842$$

and the amount of information existent in the logistic informational subsystem, about the orders' arriving to the distribution centers, until the moment of determining the entropy, will be:

$$I(R) = H_{max}(R) - H(R) = 1 - 0{,}5842 = 0{,}416$$

In this case, the trans-information, respectively the average amount of information obtained by the distribution centers about the shipping status from the logistic center, having in mind the existent uncertainties, will be:

$$I(E;R) = H(R) - H_E(R) = 0{,}5842 - 0{,}2864 = 0{,}2978\ ,$$

and the capacity of the logistic informational subsystem:

$$C = \max I(E;R) = \max[H(R) - H_E(R)] = 1 - 2864 = 0{,}7136$$

The organization degree of the logistic center and of the distribution centers will be Ω(E) = 0,531, respectively Ω(R) = 0,416.

Each of the three distribution centers (DC_i) served by the exemplified logistic center covers a certain logistic area. A series of goods flows take place between them, as exemplified by the matrix from Table 4, flows that are developed in order to improve the activity at the level of the entire logistic system; it's taken into consideration the fact that each of the logistic centers has a series of specific capabilities, different from the others. For an evaluation of the logistic system's functionality, it must be determined the level of the material and product flows inside each distribution center and the values of the informational entropy, of the organization degree and of the trans-information from each center.

TABLE 4 - THE MATRIX OF THE FLOWS FROM THE DISTRIBUTION CENTERS

	DC_1	**DC_2**	**DC_3**
DC_1	0,70	0,20	0,10
DC_2	0,15	0,80	0,05
DC_3	0,10	0,15	0,75

From the matrix presented in Table 4 it results that the distribution center DC_1 delivers straight to the clients 70% from the units load, as orders, while 20% from the units load are delivered to the distribution center DC_2, while 10% are delivered to the distribution center DC_3, for a post-processing inside these centers. The elements from Table 4 can be transposed in the matrix:

$$A = \begin{pmatrix} 0{,}70 & 0{,}20 & 0{,}10 \\ 0{,}15 & 0{,}80 & 0{,}05 \\ 0{,}10 & 0{,}15 & 0{,}75 \end{pmatrix}$$

We have in view the dynamic matrix $D = A - I$, where I represents the identity matrix. The elements of the matrix D comply with the following restrictions:

for $i \neq j \quad 0 \leq d_{ij} \leq 1$;

for $i = j \qquad -1 \leq d_{ij} \leq 0$

$$\sum_{i=1}^{n} d_{ij} = 0 \qquad i = 1,2,\ldots,n$$

The dynamic matrix will cover the following elements:

$$D = A - I = \begin{pmatrix} 0{,}70 & 0{,}20 & 0{,}10 \\ 0{,}15 & 0{,}80 & 0{,}05 \\ 0{,}10 & 0{,}15 & 0{,}75 \end{pmatrix} - \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} -0{,}30 & 0{,}20 & 0{,}10 \\ 0{,}15 & -0{,}20 & 0{,}05 \\ 0{,}10 & 0{,}15 & -0{,}25 \end{pmatrix}$$

The matrix D’s transposition will be:

$$^{t}D = \begin{pmatrix} -0{,}30 & 0{,}15 & 0{,}10 \\ 0{,}20 & -0{,}20 & 0{,}15 \\ 0{,}10 & 0{,}05 & -0{,}25 \end{pmatrix}$$

From the transposed matrix D, in which we substitute the elements of the first line with 1, we build the matrix M, whose form will be:

$$M = \begin{pmatrix} 1 & 1 & 1 \\ 0{,}20 & -0{,}20 & 0{,}15 \\ 0{,}10 & 0{,}05 & -0{,}25 \end{pmatrix}$$, whose algebraic complements will be:

ξ_{11}=0,0425, ξ_{12}=0,065, ξ_{13}=0,03, and $\sum_{j=1}^{3} \xi_{1j} = 0{,}1375$

The elements of the permanent status vector are:

$$\Gamma_{(\infty)} = (\xi_{11} \quad \xi_{12} \quad \xi_{13}) \cdot \frac{1}{\sum_j \xi_{ij}} = (0{,}045 \quad 0{,}065 \quad 0{,}03) \cdot \frac{1}{0{,}1375} = (0{,}310 \quad 0{,}472 \quad 0{,}218)$$

It results that, at the downstream of the logistic system, in permanence regime, the distribution center DC_1 fulfillments 31% of the orders, the distribution center fulfillments 47,2% of the orders and the distribution center DC_3 fulfillments approximately 21,8% of the orders.

With the equations (1), (6), (15), (18) and using the data from Table 4, the informational entropy, the organization degree, the trans-information and the informational energy from the three distribution centers are calculated. These calculations' results are mentioned in Table 5., and, as a graphic, in Figure 2.

TABLE 5 - THE DISTRIBUTION CENTERS' INFORMATIONAL INDICES

Index	DC_1	DC_2	DC_3
Entropy H_i	1,1568	0,8842	1,0540
Organization degree Ω_i	0,2702	0,4421	0,3350
Transinformation I_i	0,4282	0,7008	0,5309
Informational energy E_i	0,540	0,665	0,595

Analyzing the graphic from Figure 2, we notice that the informational entropy's maximal value is enlisted in the distribution center DC_1, which has in the same time the lowest organizational degree. The distribution center DC_2 has the maximal weight in the direct delivery of the orders to the clients, a fact that is reflected by that that this distribution center is the most organized of all and implicitly, it has the lowest level of informational entropy from the three distribution centers. Moreover, this center obviously possesses the greatest amount of information about the deliveries from the logistic system's downstream, before determining the informational entropy. The informational indices of the distribution center DC_3 are the closest by those of the distribution center DC_1, an obvious result, considering the similitude between the distributions of the weight of the deliveries of the two distribution centers (Table 5).

In the same time, it can be noticed that the informational energy has low values when the entropy is high and implicitly, when the organization level is low. Therefore, the distribution center DC_2 , which has the lowest entropy level, benefits from the highest value of the informational entropy. Therefore, the evolution of the materials and products flows inside this center is a lot easier to be predicted that in the case of the other centers.

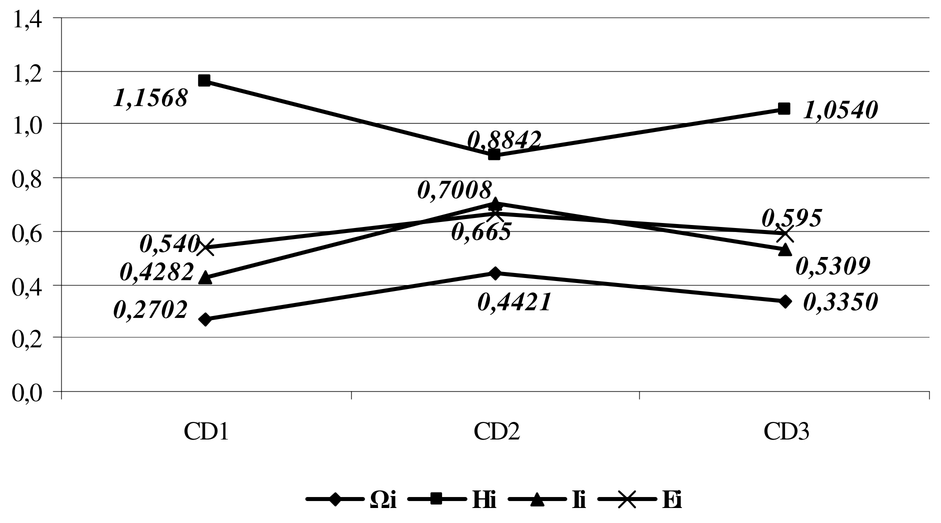

FIG. 2 - THE VALUES OF THE THREE DISTRIBUTION CENTERS' INFORMATIONAL INDICES

Knowing the weight of the deliveries for each distribution center, the capabilities of orders' processing and the transport capabilities (Table 6), it can be calculated the informational correlation and its coefficient.

TABLE 6 - THE WEIGHT OF THE MAIN INDICATORS OF THE GOOD'S DELIVERIES FROM THE THREE DISTRIBUTION CENTERS

Indicator	DC_1	DC_2	DC_3
Delivered orders (P_k)	0,310	0,472	0,218
Orders' processing capability (Q_k)	0,250	0,600	0,150
Transport capability (R_k)	0,250	0,550	0,200

Adapting the equations (19) and (20) to the number of the distribution centers, the informational correlation value between them is obtained:

$$C_I = \sum_{k=1}^{3} P_k Q_k R_k = 0{,}0193 + 0{,}1557 + 0{,}0065 = 0{,}1816$$

The coefficient of informational correlation that corresponds to these correlations is:

$$K_I = \frac{C_I}{\sqrt[3]{\sum_{k=1}^{3} P_k^3 \cdot \sum_{k=1}^{3} Q_k^3 \cdot \sum_{k=1}^{3} R_k^3 \cdot}} = \frac{0{,}1401}{\sqrt[3]{0{,}1453 + 0{,}2350 + 0{,}1900}} = 0{,}9740$$

The high value of the informational correlation coefficient proves that, at the level of the three distribution centers there is a tight connection between the capacities of orders' processing, the transport capacity and the volume of orders fulfillment.

The information is the main resource of the logistic system which ensures the rational organization of its specific activities, including the adapting to the other resources – material, human, financial – to the partner organization's needs. The endogen and exogenous factor's actions over the information can determine informational distortions, which will produce a series of important deregulations at the level of the entire logistic system. The information exchange between the partner organizations assures a permanent regulation of the mobilization degree of the resources in the purpose of using their potential in an efficient manner.

Information provides an infusion of novelty in the system, a novelty that bestows value to the information. The evolution in time of the variables that characterize a certain component of the logistic system or the entire system in its whole constitutes a source of information. These evolutions can refer to the past or to the future, each of them having its own value, according to the manner in which they are substantiated.

While the necessity of extending the logistical area at the international level accentuates, in order to increase the profitability and to exploit some larger opportunities, the intense competition and the ever-changing environment are factors that impose to the logistic system a maxim intern visibility, that could offers to this system, a supplementary and consistent source of competition. For maintaining under control the intra- and inter-organizational behavior, it's necessary to be used study models of the strategic options – important tools of prediction, organizing and coordination of the logistic operations.

The rapid rhythm of development of the information and communications technology provided the conditions for implementing and using this technology inside the logistic systems, in order to obtain a great volume of information about the members of the logistic systems, information used in adopting the best decisions. This way, the inventory, which involve spending a lot of money and need large warehouses, are successfully substituted by the information stocks grouped in data bases that generate profit.

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