Modelling Organizational Knowledge Dynamics: Using Analytic Hierarchy Process (AHP)

Constantin Bratianu, Adriana Agapie, and Ivona Orzea
Academy of Economic Studies, Bucharest, Romania
cbratianu@yahoo.com
adriana.agapie@clicknet.ro
ivona.orzea@gmail.com

Abstract: Modelling Organizational Knowledge Dynamics (OKD) is important in developing knowledge strategies within the framework of strategic management. We present in this paper a new perspective on modelling OKD based on the dynamic equilibrium equation of the organizational knowledge, and on using the Analytic Hierarchy Process (AHP). The dynamic equilibrium equation is considered for a time interval ΔT, and contains the following terms: the level of total organizational knowledge variation ΔK, the knowledge creation variation ΔC, the knowledge acquisition variation ΔA, and the knowledge loss variation ΔL. Since each of these terms has a different relative importance in the organizational knowledge balance, it is necessary to find a way of evaluating their weighting factors. For this purpose we use the AHP mathematical model developed by Saaty for the managerial decision making. AHP requires a structuring of the field of knowledge, and we considered a structure composed of three levels: (1) the goal level – increasing the level of organizational knowledge; (2) the strategies level – the strategy for increasing knowledge creation (S1), the strategy for increasing acquisition of new knowledge (S2), and the strategy for reducing knowledge loss (S3); (3) the activities level – hiring new valuable human resources (A1), developing training programs (A2), creating a performing motivation of employees (A3), and purchasing books, journals, software programs, and other information materials (A4). This structured model of AHP has been applied as an empirical research within a large company. We sent questionnaire to a number of 500 employees, and received valid answers from 173 respondents. The AHP method is based on paired comparisons of strategies with respect to the goal of increasing the level organizational knowledge, and then on paired comparisons of activities with respect to each strategy we defined. These paired comparisons yield matrices that lead to systems of eigenvalue equations whose solutions compose the vector of priorities for strategies, and for activities with respect to each strategy. Values of the vector of priorities for strategies are the weighting factors for the equilibrium equation components.

Keywords: analytic hierarchy process, knowledge acquisition, knowledge creation, knowledge dynamics, knowledge loss

1. Introduction

In science we deal with *dynamics* and *thermodynamics.* Newtonian dynamics refers to the time rate of change of the uniform and linear motion of a generic object under the influence of forces. Since mechanics deals with two forms of energy, *potential energy* and *kinetic energy*, dynamics reveals actually the continuous transformation of these forms of energy, one into the other, under the influence of a field of forces. Thermodynamics is much more complex since involves also the *thermal energy*, and the change of mechanical energy into thermal energy and vice versa, under the influence of a field of forces. Using a metaphorical analysis, Bratianu demonstrated that we may associate to each organization a field of forces and a field of knowledge, and extending the basic ideas from dynamics and thermodynamics to knowledge management we may construct a new and complex dynamic interpretation of the organizational knowledge (Bratianu, 2008a; Bratianu, 2011a; Bratianu, 2011b). In this new perspective, *knowledge dynamics* is a very complex and multidimensional process. It can be defined and studied at the individual, group, or organizational level. Knowledge dynamics refers to the time rate of change of knowledge fields, under the action of organizational integrators (Bratianu, 2008b). At the organizational level we deal with the *organizational knowledge dynamics (OKD)*. The main processes which can be integrated into the complex process of OKD are the following: knowledge creation, knowledge acquisition, knowledge loss, knowledge sharing, knowledge storage and retrieval, knowledge diffusion, conversion from one form of knowledge into another form of knowledge, and organizational learning (Bratianu & Andriessen, 2008; Geisler & Wickramasinghe, 2009; Hawryszkiewycz, 2010; Lakoff & Johnson, 1999; Nonaka & Takeuchi, 1995; Nonaka, Toyama & Hirata, 2008; Ortenblad, 2001; Pinker, 2007; Szulansky, 1996). Due to complexity of integrating together all of these processes, many researchers developed models for individual processes, like knowledge creation, knowledge sharing and so on. One of the first comprehensive knowledge dynamics models able to deal with several processes is that created by Nonaka and his co-workers (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, 1998; Nonaka, Konno & Toyama,

Reference this paper as: Bratianu, C, Agapie, A and Orzea, I. "Modelling Organizational Knowledge Dynamics: Using Analytic Hierarchy Process (AHP)" *The Electronic Journal of Knowledge Management* Volume 9 Issue 3 (pp236-247), available online at www.ejkm.com

1998; Nonaka, Toyama & Byosiere, 2001). This model has been developed progressively and it is one of the most cited model in the literature.

The purpose of this paper is to present a new perspective in modelling OKD of the human capital by using the *Analytic Hierarchy Process (AHP).* The research approach is both theoretical and empirical. The theoretical approach is based on the dynamic equilibrium equation of the level of organizational knowledge, and on the AHP mathematical model developed by Saaty (1994, 2009).

2. Organizational knowledge dynamics models

We shall describe firstly the most known OKD model elaborated by Nonaka and his co-workers. The model covers two individual processes of knowledge conversion, and two organizational processes of knowledge sharing. It is structured on three layers: knowledge assets, the *Ba* platform, and the SECI conversion structure. These three layers interact one to each other generating the knowledge spiral. The knowledge assets layer generates the inputs for the other layers and receives their outputs. It is the controlling process layer. The *Ba* platform is the dynamic context of knowledge creation. The SECI (Socialization-Externalization-Combination-Internalization) layer constitutes the engine of knowledge creation in the virtual space determined by the epistemological and ontological dimensions. The driving force of the knowledge dynamics model is the knowledge vision which gives a direction of knowledge creation. "*It also gives the firm direction with respect to the knowledge to be created beyond the firms' existing capabilities, and therefore determines how the firm evolves in the long run*" (Nonaka & Toyama, 2007, p.18). The knowledge vision is intrinsically related to the value system of the firm, which defines what is truth, goodness and beauty for the whole organization. The whole model is based on the two knowledge forms: tacit knowledge and explicit knowledge. *Socialization* is the process of transferring tacit knowledge through social interaction. Tacit knowledge is highly personal and hard to formalize, making it difficult to share with others. Tacit knowledge sharing meets several individual and organizational barriers, among them stickiness being the most important (Szulansky, 1996; Szulansky & Jensen, 2004). Socialization is conceived not only for workers from the same team or department but also for meetings of firm employees with their customers and suppliers. *Externalization* is the process of conversion tacit knowledge into explicit knowledge. It is an individual process done on the epistemological dimension of the OKD model. The effectiveness of this process depends on the intelligent use of metaphors, analogies and cognitive models (Andriessen, 2006, 2008; Lakoff & Johson, 1999; Nonaka & Takeuchi, 1995; Pinker, 2007). According to Nonaka, Toyama & Byosiere (2001, p.495), "*Of the four modes of knowledge conversion, externalization is the key to knowledge creation because it creates new, explicit concepts from tacit knowledge*". The most used process in OKD is combination. It is the process of transferring explicit knowledge through social interaction. Combination is a process of creating new network structures of explicit knowledge by integrating pieces of explicit knowledge into new integral structures. According to Nonaka, combination is an integration of other three processes: a) explicit knowledge is collected from inside or outside the organization and then combined; b) the new explicit knowledge is disseminated among employees; c) explicit knowledge is edited or processed in order to make it more available and usable. *Internalization* is the process of structuring the explicit knowledge as tacit knowledge. It is an individual process, reciprocating in a way the process of externalization. Internalization is very close to learning-by-doing. Knowledge is internalized through an integration process in the already known knowledge. If necessary, this integration will re-structure the old knowledge. This new internalized knowledge increases the level of individual understanding and his absorptive capacity. Also, it increases the chances of individual participation in a socialization process, and in sharing the tacit knowledge contributing this way to the upward development of the knowledge spiral. Thus, internalization is closing the circle of knowledge creation.

The foundation of the SECI model for knowledge conversion is *Ba,* a Japanese concept that can be translated approximately by "place". Nonaka et all. (2001, p.499) define *Ba* "*as a context in which knowledge is shared, created, and utilized, in recognition of the fact that knowledge needs a context in order to exists*". Knowledge held by a person can be shared, re-created, and enriched only when that person is active in *Ba*. We may say briefly that *Ba* is a dynamic context of interactions between individuals, or between an individual and his environment. Externalization and internalization on one hand, and socialization and combination on the other hand need a specific context of meanings and a framework of same thinking patterns in order to be operational. The Nonaka's model of knowledge dynamics is an important contribution to the field of organizational knowledge dynamics. However, there are some inherent limitations we have to be aware of when using this model in practice (Bratianu, 2010; Gourlay, 2006; Nissen, 2006). For instance, the SECI cycle leads to a *knowledge*

perpetuum mobile, a mechanism of knowledge generation functioning for ever without consuming any resources. In the energy field such a mechanism is impossible.

Nissen (2006) developed the *knowledge flows model* for the organizational knowledge dynamics. Nissen expended practically the Nonaka's model into a three dimensional framework, and including time as an independent fourth dimension. He introduces two new concepts: life cycle and flow time. Both of them helps Nissen to explore the variation of knowledge in time. The life cycle activities are associated with the SECI knowledge conversions: socialization, externalization, combination and internalization. Thus, Nissen associates tacit knowledge sharing to socialization, and the flow is directed from individual toward the group. The next sequence is externalization, which is associated with the flow of knowledge from tacit to explicit. Actually, this is a knowledge conversion. Once the knowledge becomes explicit, the flow can be visualized at the group level. Combination is associated with the flow of explicit knowledge from group toward the whole organization. Here there are several activities which can be identified: knowledge storing, retrieval, codifying, disseminating, re-structuring and re-contextualizing. Finally, internalization is associated to the knowledge flow from explicit toward tacit knowledge. The extended model proposed by Nissen brings in new dimensions and extended possibilities of analyzing knowledge dynamics.

Another extension of the Nonaka's model has been performed by a group of researchers formed of: Gregorio Martin de Castro, Pedro Lopez Saez, Jose Emilio Navas Lopez and Raquel Galindo Dorado (2007). They considered knowledge dynamics in both epistemological and ontological dimensions, at four distinct levels: individual, group, organizational and interorganizational. The name of the model is EO-SECI, and it comes from: E - epistemological dimension, O – ontological dimension, S – socialization, E – externalization, C – combination, I – internalization. The main characteristics of this extended model are the following: (a) keeping the four processes from Nonaka's model; (b) knowledge develops along the ontological dimension from one phase to another, without intermediate transformation; (c) considering two simultaneous adjacent streams of knowledge with respect to the main upward stream, reflecting the feedforward and feedback of the whole process. These two adjacent streams lead to a self-reinforcing loop, which represents a better description than the knowledge spiral from Nonaka's model. According to the authors of this model (Castro et al., 2007, p.61), "*Knowledge creation entities are granted learning capabilities as they are conceded an own SECI cycle to develop internally. This SECI, taken directly from the work of Nonaka and Takeuchi (1995) explains knowledge creation within each of these entities, through 16 processes. We argue that an internal cycle of knowledge conversion takes at each ontological level, so each level becomes an entity with learning and knowledge creating capabilities"*.

3. The new organizational knowledge dynamics model based on the AHP philosophy

In any organization the level of total knowledge is changing in time as a result of the following factors: (a) knowledge creation inside the organization; (b) knowledge acquisition from the external environment; (c) knowledge loss. Knowledge creation has been researched both at the individual and organizational levels, most of its characteristics being incorporated into the models presented above (Bratianu & Orzea, 2010). Knowledge creation is related with the organizational learning (Garvin, 2000; Senge, 1992) since the flow of knowledge along the ontological dimension involves both knowledge transfer processes and organizational learning. Knowledge transfer does not enter as a basic factor in organizational knowledge level variation since it does not contribute with new knowledge to the existing one, but it contributes to the flow of knowledge across organization according to the entropy law. Knowledge acquisition has been less explored, although it is an important way of increasing the organizational knowledge level. Basically, an organization may buy books, journals, databases, software programs, expertise, patents and many knowledge embedded products. Each of these activities contributes to the increase of the total knowledge of the organization, although each activity brings in knowledge of a different quality. Knowledge acquisition has the advantage of time since knowledge already exists as explicit knowledge and it can be incorporated immediately without any further transformation. Knowledge loss is a relatively new issue in knowledge management research. According to DeLong (2004, p.4), "*Leaders will have to address the challenges of knowledge retention if they hope to avoid the unacceptable costs of lost knowledge*". Thus, knowledge retention and knowledge loss reduction must enter the balance of organizational knowledge. Knowledge loss, especially as tacit knowledge, is directly related to the retirement of employees or their movement from one organization to another. During economic crises many companies go through a downsizing process, which means firing out hundreds or even

thousands of employees. Similar results may happen when a company goes through a reengineering process (Hammer & Champy, 1995; Hammer, 1996). O good quantity of tacit knowledge is lost with these downsizing and reengineering processes. Since managers are focused on short term financial results, they do not count the long term effects of knowledge loss. However, the loss of knowledge may become a vulnerability of any company that is ignoring these phenomena.

Knowledge creation and knowledge acquisition will have a positive contribution to the level of total organizational knowledge, while knowledge loss will have a negative contribution since it represents a vector crossing the organization interface toward the external business environment. An illustration of these contributing factors to the equilibrium equation is shown in figure 1.

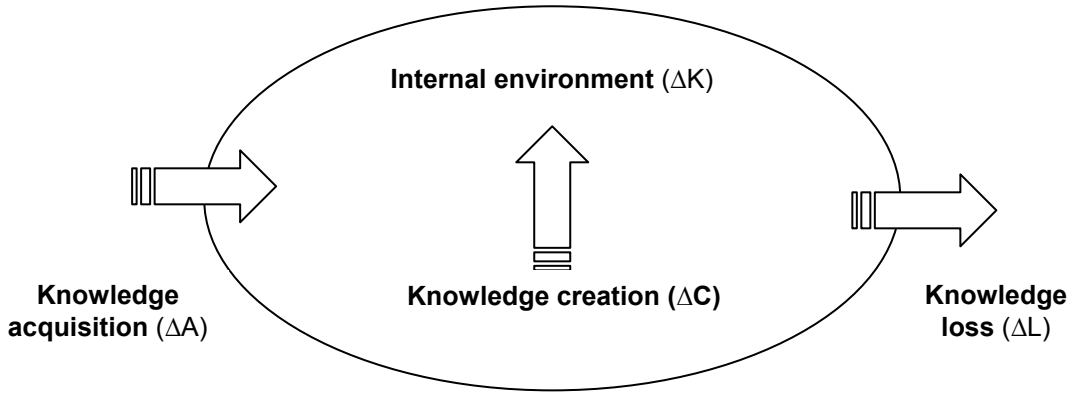

Figure 1: The dynamic equilibrium equation representation

The dynamic equilibrium equation for the level of the total organizational knowledge, developed for a time interval ΔT, is given by:

$$\Delta K = Fc(\Delta C) + Fa(\Delta A) - Fl(\Delta L) \quad (1)$$

where: ΔK is the knowledge variation in organization during ΔT time; ΔC – knowledge creation variation during ΔT time; ΔA – knowledge acquisition variation during ΔT time; ΔL – knowledge loss variation during ΔT time; Fc, Fa, Fl – weighting factors for each component of equation (1).

Thus, the level of knowledge in organization depends of how much new knowledge is creating during a given time period, how much knowledge is obtained from the external environment through different methods in the same time period, and on the knowledge loss toward the external environment through people leaving the company. People may leave the company due to their retirement age, in searching for better professional and payment opportunities, or being fired. Knowledge sharing is not contained in equation (1) because it does not contribute to the variation of maximum level of knowledge in organization. Knowledge sharing is a process by which the organizational knowledge field is homogenized. Thus, knowledge sharing contributes to the increase in the average level of organizational knowledge through its dissemination, but not to the level of total quantity of knowledge. Each factor from this above equation can be increased or decreased through different managerial processes and activities as a result of a certain knowledge strategy, as a part of the strategic thinking of the organization's top management. Strategic management is closely linked to knowledge management, since any strategy making is based on organizational knowledge and organizational intelligence. As Greiner and Cummings remark (2009, pp.38-39), " *New strategy knowledge also needs to show how strategy-making can be made more systemic by embedding strategic content into the organization's objectives, design, and culture. All of these organizational features guide and reinforce how members think and behave. By considering them together as essential elements of a strategic system, organizations can create the infrastructure and reinforcement to guide and motivate strategy-making continuously throughout the firm".*

Thus, from a managerial point of view, each factor of the equation (1) can be transformed into a strategy for increasing the total level of organizational knowledge. Each factor can be decomposed

into different well defined activities that will be implemented with different priorities. The dynamic equilibrium equation for a generic component of equation (1), called strategy (S) is given by:

$$\Delta S = W1(\Delta A1) + W2(\Delta A2) + W3(\Delta A3) + W4(\Delta A4) \quad (2)$$

where: ΔS is the generic component (i.e. knowledge creation, knowledge acquisition, and knowledge loss) variation in the time intervalΔT; ΔAi – the activity (i) variation in the time intervalΔT; Wi – the weighting factor for activity (i).

The second part of the mathematical model is based on the Saaty's AHP. This method is based on structuring the field of knowledge associated to the decision making. An illustration of this structuring process is shown in figure 2.

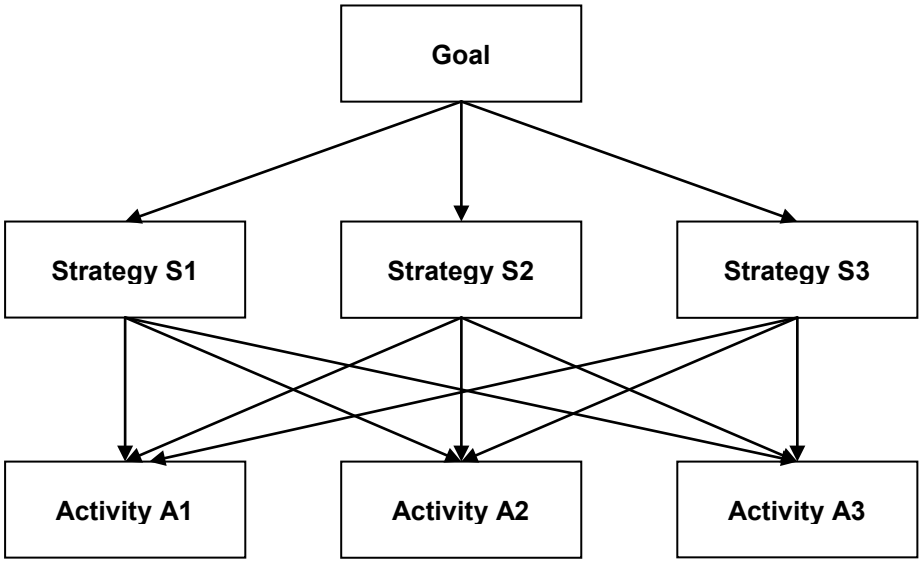

Figure 2: The AHP structuring model

We would like to emphasize the fact that this method allows us to define as many levels as we want. However, from the practical point of view three levels are the most number. The hierarchy of managerial decision making is vertical, and the alternatives for each decision are shown horizontally for each level of managerial authority. The top level contains usually the goal or the essence of the problem to be solved. The immediate downward level is for the potential strategies to be chosen in order to achieve the proposed goal. These strategies are not equally important. They have different priorities decided by the decision makers. The next downward level contains potential activities to be implemented in order to achieve the objectives of these above strategies. For each strategy there are different interests for implementing these activities, such that they will have different priorities. The AHP method is able to find out the vector of priorities for the defined possible activities and for the defined possible strategies. Based on comparative judgments, a positive matrix of choices is derived for these strategies. The ranking importance of these strategies is achieved afterwards as a vector of priorities, based on the theory of eigenvectors. The same procedure is applied for the alternatives considered with respect to every strategy. In the synthesis mode, weights beard by the strategies are applied to the considered alternatives and lastly, the corresponding totals for each alternative are calculated. The quantitative part of this method is based on a questionnaire structured according to the structured field of decision making.

4. Research methodology

We applied this OKD modelling based on the dynamic equilibrium equation and the AHP method to a large multinational company from Romania. The structure we consider for this research is composed of three levels, as shown in figure 3.

The goal considered for this research is increasing the total level of organizational knowledge. According to the dynamic equilibrium equation, this goal can be achieved through the following

strategies: (S1) – knowledge creation; (S2) – knowledge acquisition; (S3) – knowledge loss. These strategies can be implemented through different activities. We considered to be relevant the following activities: (A1) – hiring new valuable human resources; (A2) – developing training programs to enhance knowledge and understanding of employees; (A3) – developing managerial programs for efficient motivation of employees to stimulate their creation of new knowledge; (A4) – purchasing books, journals, knowledge bases and software programs. These strategies and activities can be increased, but that will lead to very large matrices and mathematical equations to be solved. Also, the questionnaires will grow in the number of questions becoming more difficult to be administered efficiently.

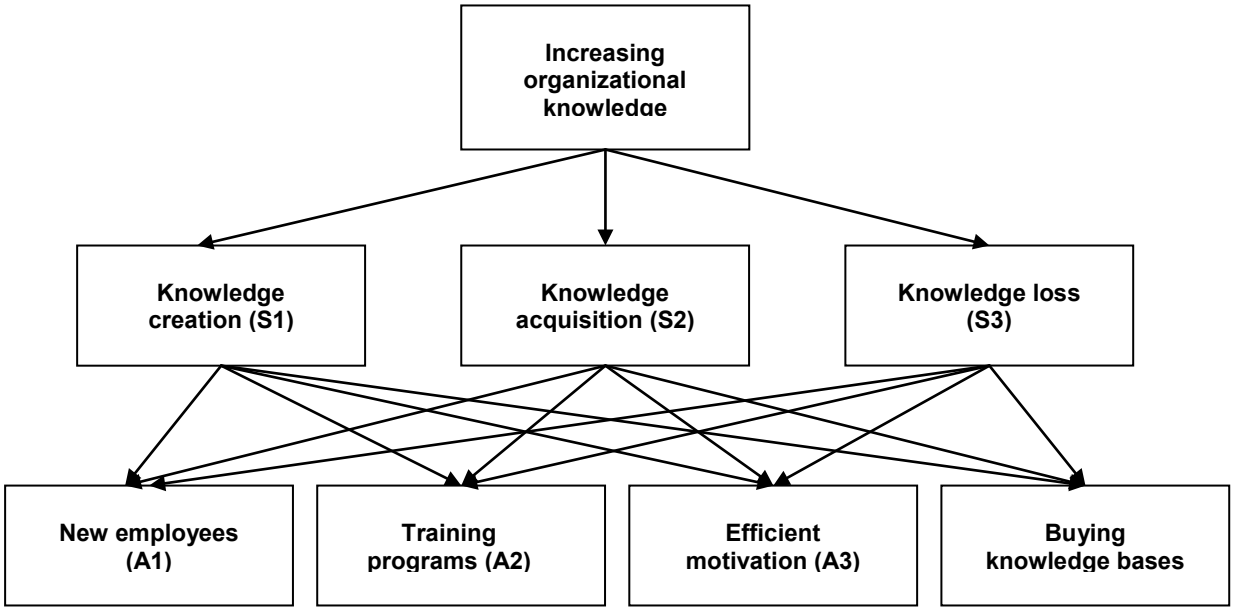

Figure 3: The knowledge dynamics structure according to AHP method

In the following it will be presented the general form of the survey considered and one example of answer will be indicated in square brackets. Also, it will be showed how the answers were processed. In the first page were asked general information about the position of the respondent in the considered company. The survey's second page was devoted to the determination of the priority vectors of the three chosen strategies in the knowledge variation in organization (*the strategy for increasing knowledge creation* (S1), *the strategy of increasing acquisitions of new knowledge* (S2) and *the strategy for reducing knowledge loss* (S3)). The goal in this research is to increase the level of organizational knowledge. The scale considered for this research is from 1 (equally important) to 9 (extremely important). Questions are formulated in comparative terms, as shown below:

1.a) Given the goal, what do you think is more important : *the strategy for increasing knowledge creation* (S1) or *the strategy of increasing acquisitions of new knowledge* (S2). [S1]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [6]

2.a) Given the goal, what do you think is more important : *the strategy for increasing knowledge creation* (S1) or *the strategy for reducing knowledge loss* (S3). [S3]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [4]

3.a) Given the goal, what do you think is more important: *the strategy of increasing acquisitions of new knowledge* (S2) or *the strategy for reducing knowledge loss* (S3). [S3]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [6]

The survey's third page was devoted to the determination of the priority vectors of the alternatives (*hiring new valuable human resources* (A1), *developing training programs* (A2), *creating a performing motivation for the employees* (A3) and *purchasing books, journals, software programs and other informative materials* (A4)) taking into consideration the strategies in the above level of hierarchy. For the first strategy or strategy for increasing knowledge creation (S1), questions were formulated as follows:

4. a) Given the strategy (S1), what do you think is more important: *hiring new valuable human resources* (A1) or *developing training programs* (A2)? [A2]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [8]

5. a Given the strategy (S1), what do you think is more important: *hiring new valuable human resources* (A1) or *creating a performing motivation for the employees* (A3)? [A3]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [8]

6. a Given the strategy (S1), what do you think is more important: *hiring new valuable human resources* (A1) or *purchasing books, journals, software programs and others* (A4)? [A4]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [5]

7. a Given the strategy (S1), what do you think is more important: *developing training programs* (A2) or *creating a performing motivation for the employees* (A3) ? [A3]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [7]

8. a) Given the strategy (S1), what do you think is more important: *developing training programs* (A2) or *purchasing books, journals, software programs and other informative materials* (A4)? [A2]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one. [5]

9. a) Given the strategy (S1), what do you think is more important: *developing creating a performing motivation for the employees* (A3) or *purchasing books, journals, software programs and other informative materials* (A4)? [A3]

b) Please indicate, on a scale from 1 to 9 to what extent you consider your previous choice is more important than the other one.[8]

Similar questions as those from 4 to 9 are establishing comparisons among alternatives A1 to A4 with respect to the next two strategies, S2 and S3 , so that a total of 21 questions are used as a base for establishing decision matrices associated with one respondent .

Paired comparison judgments in the AHP are applied to pairs of homogeneous elements and summarized in a matrix of judgments. Scoring is applied to rank the three alternatives in terms of each of the three strategies considered (Agapie, 2010; Bratianu et all., 2010). Based on this survey, four matrices of judgments are built, for every respondent. First matrix, denoted with **S**, $S=(s_{ij})_{i,j=1,2,3}$,corresponds to the comparisons among the three strategies(S1, S2 and S3) and it is a positive, reciprocal one ($s_{ij}>0$, $s_{ij}=1/s_{ji}$,i,j=1,2,3 and $\neq$j) with ones on the main diagonal ($s_{ii}=1$, i=1,2,3). If strategy S1 is considered to be 6 times more important than strategy S2 then we write S1 $>^6$ S2 and we assign $s_{12}=6$. Thus, the matrix of judgments **S** is determined assuming values equal to one on the main diagonal and also reversibility of the preferences - so that if S1 is preferred to S2 at a corresponding absolute value of 6, then the S2 strategy will be preferred to S1 at an absolute value of 1/6, which is 0.166 ($s_{21}=0.166$). The next three matrices are corresponding to the choices done among the alternatives A1, A2, A3, and A4 from three points of view: *the strategy for increasing*

knowledge creation (S1), *the strategy of increasing acquisitions of new knowledge* (S2) and *the strategy for reducing knowledge loss* (S3.).These matrices are denoted **S1** and respectively **S2** , **S3.**

For all these four matrices (**S, S1, S2, S3**), the corresponding vector of priorities is calculated in an eigenvalue formulation. The solution is obtained by raising each matrix to a sufficiently large power, then summing over the rows and normalizing to obtain the priority vector. The process is stopped when the difference between components of the priority vector obtained at the k-th power and at the (k+1) power is less than some predetermined small value. The vector of priorities is the derived scale associated with the matrix of comparisons (Saaty,1994; Saaty, 2009; Saaty & Louis, 2001). After setting priorities for the strategies, pair wise comparisons are also made ratings themselves to set priorities for them under each strategy and dividing each of their priorities by the largest rated intensity to get the ideal intensity. Finally, alternatives are scored by checking off their respective ratings under each strategy and summing these ratings for all strategies. For the example considered in the section above, the first two pair wise comparison matrices are given in Tables 1 and 2.

Table 1: The pair wise comparison matrix **S**

Absolute judgments amongst strategies	S1	S2	S3
S1	1	6	0.25
S2	0.166	1	0.166
S3	4	6	1

Table 2: The pair wise comparison matrix **S1**

Absolute judgments amongst alternatives A1, A2, A3 ,A4 with respect to Strategy (S1)	A1	A2	A3	A4
A1	1	0.125	0.125	0.2
A2	8	1	0.142	5
A3	8	7	1	8
A4	5	0.2	0.125	1

The correspondent vector of priorities for the **S** matrix calculated as briefly presented above is given by any column in the above normalized matrix, as presented in Table 3.

Table 3: Vector of priorities for the pair wise comparison matrix **S**

Strategies	Priorities
S1	0.207
S2	0.095
S3	0.696

The interpretation is that, in the view of the particular person who answered the survey, the prevalent strategy determining the increase in the level of organizational knowledge is *the strategy for reducing knowledge loss*, corresponding to S3, since it has the highest value: 0.696. Second in this line of reasoning is *the strategy for increasing knowledge creation*, corresponding to S1 with a value in the associated vector of priorities of 0.207, and the least important strategy would be to *the strategy of increasing acquisitions of new knowledge* , corresponding to S2, with a value of 0.095 in the priority vector. Similarly were determined the priority vectors corresponding to the pair wise matrices of judgments of the four alternatives with respect of the three strategies. In the Table 4 we give the corresponding vectors of priorities to matrices **S1**, **S2** and **S3**.

Table 4: Corresponding vector of priorities to matrices **S1**, **S2** and **S3**

Activities	Vector of priorities corresponding to matrix **S1**	Vector of priorities corresponding to matrix **S2**	Vector of priorities corresponding to matrix **S3**
A1	0.075	0.678	0.037
A2	0.126	0.151	0.352
A3	0.706	0.094	0.108
A4	0.091	0.075	0.500

These above matrices illustrate the way the method works, considering the arbitrary answers we given to the structured questionnaire presented above as a model. Next, we shall consider the survey we performed in a multinational company operating in Romania.

5. Data processing: Aggregation in the synthesis mode following the traditional methodology in AHP theory

The survey was electronically delivered to 500 employees from a large company and the rate of response was 37.5%. Out of the received answers, 173 were valid answers. The priority vector of the strategies considered to influence the increase in the level of organizational knowledge was calculated as an average on the individual vectors of priority, using the Gauss 9.0 program. Individual's vector of priorities for the pair wise comparison matrix (as presented in table 5) were averaged over all the respondents and yielded the values in the first row of the Table 5 (0.469, 0.270, 0.259). These can be interpreted as follows: given the goal of increasing the level of organizational knowledge, employees' perceptions regarding the three strategies S1, S2 S3 rank *the strategy for increasing knowledge creation* (S1), as being the most important, with a weight of 0.469, *the strategy of increasing acquisitions of new knowledge* (S2) on the second place, with a weight of 0.270 and *the strategy for reducing knowledge loss* (S3.) as being sensibly less important than the previous one, with a weight of 0.259.The weight of the Alternative 1 (*hiring new valuable human resources*) from the point of view of *the strategy for increasing knowledge creation* (S1), is calculated again as the average over the individual values (as shown in Table 6, first column) and the corresponding priorities vectors are also presented in Table 5.

Table 5: Synthesis in the distributive mode

Distributive Mode	S1	S2	S3
	0.469	0.270	0.259
A1	0.224	0.284	0.160
A2	0.291	0.231	0.337
A3	0.380	0.301	0.265
A4	0.103	0.181	0.236

In order to establish the composite or global priorities of the alternatives considered we lay out in a matrix the local priorities of the alternatives with respect to each strategy and multiply each column of vectors by the priority of the corresponding strategy and add across each row, which results in the composite or global priority vector of the alternatives. Corresponding results are presented in Table 6.

Table 6: Synthesis

Distributive Mode	Priorities
A1	0.224
A2	0.287
A3	0.329
A4	0.159

As a straight conclusion, from the point of view of assessing the importance of the four alternatives (hiring new valuable human resources (A1), developing training programs (A2), creating a performing motivation for the employees (A3) and purchasing books, journals, software programs and other informative materials (A4) the respondents' perception rank A1 to A4 to be sensibly equal, with A3 being the most important, followed by A2 and A1. The last one in this list of importance is A4, with a weight of 0.159.

6. Discussion and conclusions

The purpose of this paper is to present a new model for organizational knowledge dynamics (OKD) by using the philosophy and mathematical processing of AHP. The proposed model is based on the

equilibrium equation for the level of total organizational knowledge, and contains the following contributions: (a) knowledge creation; (b) knowledge acquisition, and (c) knowledge loss. In order to obtain the relative importance of these contributions (Fc, Fa, and Fl) we used the AHP model. According to this model we considered as that the level of total organizational knowledge depends on three strategies or strategies which represents the above equation contributions: (S1) increasing knowledge creation; (S2) increasing knowledge acquisition, and (S3) decreasing knowledge loss. The next level of structuring contains activities thought to implement these strategies: (A1) hiring valuable human resources; (A2) organizing training programs; (A3) developing an efficient motivation, and (A4) buying books, journals, databases, and software programs. Using AHP mathematical processing we can obtain out of these structured scheme the vector of priorities for the defined strategies, and the vectors of priorities for activities for each individual strategy, and then on the whole organization. The values of these priorities constitute the weighting factors for equations (1) and (2) defining the dynamics of organizational knowledge. Thus, the new equations are the followings:

$$\Delta K = (0.469)(\Delta C) + (0.271)(\Delta A) – (0.259)(\Delta L) \quad (1)$$

$$\Delta S = (0.225)(\Delta A1) + (0.291)(\Delta A2) + (0.380)(\Delta A3) + (0.103)(\Delta A4) \quad (2)$$

Now, the practical problem is how we can measure the level of knowledge in a given organization. The model is generic and does not impose any metric. Thus, in each organization should be design a certain metric for measuring or evaluating the knowledge at the individual and organizational levels (Andriessen, 2004; Roos, Pike & Fernstrom, 2005; Vallejo-Alonso, Rodrigues-Castellanos & Arregui-Ayastuy, 2011), and then apply these equations to determine the dynamics of knowledge variation. Measuring the knowledge level or the intellectual capital of a given company is a very complex problem that has not received a well defined answer. However, "*the controversial picture of measuring methods has not discouraged companies from attempting to measure knowledge management performances, as testified by the experiences mentioned in the literature. Consequently, the analysis of the current practice can help us to identify and discuss the main issues that companies face for choosing and using appropriate measurement approach*" (Scarso, Bolisani & Padova, 2011).

The empirical research has been done in a large company, by distributing questionnaires to a number of 500 employees. We received 173 valid answers, and processed them using the program Gauss 9.0. The obtained results demonstrate the usefulness of this new model for organizational knowledge dynamics. However, the conceptual model is generic and it can be applied to any organization. If necessary, it can be enlarged in order to contain more components and to reflect in a better way the variation of the organizational knowledge dynamics. The practical importance of this model consists in determining the vector of priorities for a defined structure of knowledge strategies. Knowing these priorities, the top management is able to emphasize and to invest in the strategy with the highest priority. Also, it is useful to learn and understand the relative importance of each strategy, and each activity within a given strategy, in order to make adequate managerial decisions. This new model is an useful qualitative and quantitative tool for managerial decisions making. The qualitative dimension comes from the structuring the main organizational strategies and activities, and the quantitative dimension comes from the computing vectors of priorities for these strategies and activities. Unlike the statistical processing using SPSS where the number of questionnaires is related to the sampling of the statistical set, in AHP the number of questionnaires is irrelevant. In applying this method the managerial position of the respondents and the authority power they have become important success factors. The modelling of OKD using AHP can be integrated in a more general perspective of strategic thinking of the organization, and from this point of view it can help in getting the adequate priorities for different potential strategies. Answering to the questionnaire means to judge the relative importance of each possible strategy, and to evaluate this relativity by a number. In the same way, for each given strategy, the managers will evaluate the relative importance of each activity designed for strategy implementation, and they will give numbers for this relativity. All of these numbers become elements of judgment matrices which will form eigenvalue equations. Solving these equations we get finally the vectors of priorities for the strategies, and then for activities.

Acknowledgements

This work was co-financed from the European Social Fund through Sectorial Operational Program Human Resources development 2007-2013, project number POSDRU/89/1.5/S/56287 "*Postdoctoral*

research programs at the forefront of excellence in Information Society technologies and developing products and innovative processes", partner Bucharest Academy of Economic Studies-Research Center for "Analysis and Regional Policies". We would like also to acknowledge the support received from UEFISCSU Romania through PNII research project ID_1812/2008.

This work is based on the paper "Knowledge dynamics modelling using Analytic Hierarchy Process (AHP)" we presented at the 3rd European Conference on Intellectual Capital, held at the University of Nicosia, Cyprus, 18-18 April 2011.

References

Agapie, A. (2010) Numerical scales for decision makers preference judgments in the analytic hierarchy process, in: Bratianu, C., Lixandroiu, D., Pop, N. (eds.) *Business excellence*, Vol.1, pp.1-5. Brasov: Infomarket.

Andriessen, D. (2004) *Making sense of intellectual capital. Designing a method for the valuation of intangibles*. Amsterdam: Elsevier.

Andriessen, D. (2006) On the metaphorical nature of intellectual capital: a textual analysis, *Journal of Intellectual Capital*, Vol.7, no.1, pp.93-110.

Andriessen, D. (2008) Knowledge as love. How metaphors direct our efforts to manage knowledge organizations, *Knowledge Management Research & Practice*, Vol.6, pp.5-12.

Bratianu, C. (2008a) Knowledge dynamics, *Review of Management and Economical Engineering*, Vol.7, Special issue, pp.105-107.

Bratianu, C. (2008b) A dynamic structure of the organizational intellectual capital, in: Naaranoja, M. (ed.) *Knowledge management in organizations*, pp.233-243. Vaasa: Vaasan Yliopisto.

Bratianu, C. (2010) A critical analysis of Nonaka's model of knowledge dynamics, *Electronic Journal of Knowledge Management*, Vol.8, Issue 2, pp.193-200.

Bratianu, C. (2011a) Changing paradigm for knowledge metaphors from dynamics to thermodynamics, *Systems Research and Behavioral Sciences*, Vol.28, pp.160-169.

Bratianu, C. (2011b) A new perspective of the intellectual capital dynamics in organizations, in: Vallejo-Alonso, B., Rodrigues-Castellanos, A., Arreguy-Ayastuy, G. (eds.) *Identifying, measuring, and valuing knowledge-based intangible assets. New perspectives*, pp.1-21. New York: IGI Global.

Bratianu, C., Andriessen, D. (2008) Knowledge as energy: a metaphorical analysis, in: *Proceedings of the 9th European Conference on Knowledge Management*, Southampton Solent University, 4-5 September 2008, pp.75-82. Reading: Academic Publishing.

Bratianu, C., Agapie, A., Orzea, I., Agoston, S. (2010) Inter-generational learning dynamics in universities, in: *Proceedings of the 11th European Conference on Knowledge Management*, pp.146-155, Universidade Lusiada de Villa Nova de Famalicao, Portugal, 2-3 september, 2010.

Bratianu, C., Orzea, I. (2010) Organizational knowledge creation, *Management & Marketing*, Vol.5, no.3, pp.41-62.

Castro, G.M., Saez, P.L., Lopez, J.E.N., Dorado, R.G. (2007) *Knowledge creation process, theory and empirical evidence from knowledge-intensive firms*. London: Palgrave Macmillan.

DeLong, D.W. (2004) *Lost knowledge. Confronting the threat of an aging workforce*. Oxford: Oxford University Press.

Garvin, D.A. (2000) *Learning in action. A guide to putting the learning organization to work*. Boston: Harvard Business School Press.

Geisler, E., Wickramasinghe, N. (2009) *Principles of knowledge management. Theory, practice, and cases*. New York: M.E.Sharpe.

Gourlay, S. (2006) Conceptualizing knowledge creation: a critique of Nonaka's theory, *Journal of Management Studies*, Vol.43, No.7, pp.1415-1436.

Greiner, L.E., Cummings, T.G. (2009) *Dynamic strategy-making. A real-time approach for the 21st century leader*. San Francisco: Jossey-Bass.

Hammer, M. (1996) *Beyond reengineering. How the process-centered organization is changing our work and our lives.* London: HarperCollinsBusiness.

Hammer, M., Champy, J. (1995) *Reengineering the corporation. A manifesto for business revolution.* London: Nicholas Brealey.

Hawryszkiewicz, I. (2010) *Knowledge management. Organizing knowledge based enterprises*. New York: Palgrave Macmillan.

Lakoff, G., Johnson, M. (1999) *Philosophy in the flesh. The embodied mind and its challenge to western thought*. New York: Basic Books.

Nissen, M.E. (2006) *Harnessing knowledge dynamics. Principled organizational knowing & learning*. London: IRM Press.

Nonaka, I. (1994) A dynamic theory of organizational knowledge creation, *Organization Science*, Vol.5, No.1, pp.14-37.

Nonaka, I. (1998) The concept of 'Ba': building foundation for knowledge creation, *California Management Review,* Vol.40, No.3, Spring, pp.40-54.

Nonaka, I., Konno, N., Toyama, R. (1998) Leading knowledge creation: a new framework for dynamic knowledge management. In, *Proceedings of the 2nd Annual Knowledge Management Conference*, Haas School of Business, University of California Berkely, 22-24 September 1998.

Nonaka, I., Takeuchi, H. (1995) *The knowledge creating company. How Japanese companies create the dynamics of innovation*. Oxford: Oxford University Press.
Nonaka, I., Toyama, R. (2007) Why do firms differ? The theory of the knowledge-creating firm, in: Ichijo, K., Nonaka, I. (eds.) *Knowledge creation and management. New challenges for managers*, pp.13-31. Oxford: Oxford University Press.
Nonaka, I., Toyama, R., Byosiere, Ph. (2001) A theory of organizational knowledge creation: understanding the dynamic process of creating knowledge, in: Dierkes, M., Berthoin Antal, A., Child, J., Nonaka, I. (eds.) *Handbook of Organizational learning & knowledge,* pp.491-517. Oxford: Oxford University Press.
Nonaka, I., Ryoko, T., Hirata, T. (2008) *Managing flow. A process theory of the knowledge-based firm*. New York: Palgrave Macmillan.
Ortenblad, A. (2001) On differences between organizational learning and learning organization, *The Learning Organization*, Vol.8, No.3, pp.125-133.
Pinker, S. (2007) *The stuff of thought. Language as a window into human nature.* New York: Penguin Books.
Roos, G., Pike, S., Fernstrom, L. (2005) *Managing intellectual capital in practice*. Amsterdam: Elsevier.
Saaty, T.L. (1994) Highlights and critical points in the theory and application of the Analytical hierarchy Process, *European Journal of Operational Research*, Vol.74, pp.426-447.
Saaty, T.L. (2009) *Theory and applications of the analytic network process. Decision making with benefits, opportunities, costs and risks*. Pittsburgh: RWS Publications
Saaty, T.L., Luis, G.V. (2001) *Models, methods, concepts & applications of the analytic hierarchy process*. Boston: Kluwer Academic Publishers.
Senge, P. (1992) *The fifth discipline.* Sydney: Random House.
Scarso, E., Bolisani, E., Padova, A. (2011) The complex issue of measuring KM performance: lessons learned from the practice, in: Vallejo-Alonso, B., Rodrigues-Castellanos, A., Arregui-Ayastuy, G. (eds.) *Identifying, measuring, and valuing knowledge-based intangible assets*. *New perspectives.* pp.208-231. New York: IGI Global.
Szulansky, G. (1996) Exploring internal stickiness: impediments to transfer of best practice within the firm, *Strategic Management Journal*, Vol.17, Winter special issue, pp.27-43.
Szulansky, G., Jensen, R,J. (2004) Overcoming stickiness: an empirical investigation of the role of the template in the replication of organizational routines, *Managerial and Decision Economics*, Vol.25, pp.347-363.
Vallejo-Alonso, B., Rodrigues-Castellanos, A., Arregui-Ayastuy, G. (2011) *Identifying, measuring, and valuing knowledge-based intangible assets. New perspectives.* New York: IGI Global.

