ASPECTS REGARDING THE QUALITY MANAGEMENT OF INTELLECTUAL CAPITAL IN INDUSTRIAL ORGANIZATIONS

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ABSTRACT: This paper aims to present a sequence of phases that can be used to create a schematic model of quality management of intellectual capital in industrial organizations and two mathematical models for the representation of these phases by using the fuzzy formalism, functional dependencies respectively. The mathematical models are similar to the ones I created for the management of the quality of life, of the education process, of the human resources training respectively, which were presented in the books mentioned in the references. I consider that the methods and techniques of modeling and simulation that have been used so far in traditional fields, such as manufacturing, accounting, finance, engineering, marketing etc., can be easily understood, can be extended and customized as quantitative methods and techniques for other fields, such as the one approached in this paper, in the field of quality and quality management of the intellectual capital in industrial organizations respectively.

KEY WORDS: intellectual capital, quality management, mathematical model

1. INTRODUCTION

The intellectual capital (the intangible assets) was defined by Arthur Andersen as being the *"resources controlled by the company that have the following attributes: they do not have a physical nature; they are capable of producing net profit on long-term; they are legally protected"* (Andersen, 1992).

Encyclopedia Britannica defines *"intangible"* as something *"incapable of being perceived by the sense of touch"*.According to the DEX dictionary, *"intangible assets"* are *"values that do not have a physical form and that can constitute the object of a transaction"*.

According to White and Miles, in most cases, goodwill and other intangible assets arise as residuals in acquisitions by purchasing, and they represent the portion of the purchase price that cannot be allocated to the tangible assets (White and Miles, 1996). The components of intellectual capital are: human capital, structural/organizational capital, and relational capital. Human capital consists of the knowledge, abilities, and skills held by employees from an industrial organization; organizational capital consists of structured knowledge held by an industrial organization; relational capital is defined by all the relationships between the organization and its stakeholders (Tan, Plowman, Hancock, 2008). In this paper, for the quality of the intangible assets in industrial organizations I will use the following definition, adapted after the definition given to quality by Klaus J. Zink: *Quality means meeting the requirements to ensure satisfaction and the long-term sustainability of the industrial organization.* Evidently, quality management of intangible assets in industrial organizations is referring to the quality management applied for the concrete case of intellectual capital (intangible assets).

The interest for the intellectual capital, for intangible assets, has become increasingly greater in the last few decades. It was found that *the professional in knowledge* is the voice of the organization that will survive and that will have a competitive advantage in the society based on knowledge. Intangible economy is not synonymous either with information economy, or with knowledge economy (PIMS Associates, 1994; RCS Conseil, 1998).

From a social, economic, and scientific point of view, investments in intangible assets constitute important factors of competitiveness. While material resources and intellectual capital undergo descending processes, knowledge and information generate ascending processes, with clear consequences. Evidently, any progress in the way of competitiveness may influence a cascade of changes within the competitive framework.

Until now, the management of intangible assets has taken root more in Korea, Japan, China, Taiwan, Singapore, Sweden, Norway, Denmark, Finland, Canada, and the Netherlands, and somewhat in Austria, Australia, Spain, Italy, and Israel, while the rest of the world (including Romania) is still watching this process from afar (Suciu, 2008).

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The topic of intellectual capital, of intangible assets, is approached by many disciplines: accountancy, information technology, sociology, psychology, human resources management, education and development (Bontis, 1999). In the past decades there were many debates regarding the methods of evaluation and measurement of intangible assets (Andersen, 1992).

Over the years it has been tried to develop specific indicators for the economy based on knowledge (Brusoni, ş.a., 2002).

Also, on European level, the Institute of Statistics of the European Commission has proposed a classification of intangible investments, and for the measurement of intangible assets there have been set a few work methods from the works of Sveiby (1997), Bontis (2001), Bontis et.al. (1999), Luthy (1998), Petty, Guthrie (2000), Stam (2001), Roos, Goran (1997), Andriessen (2004), Schiuma, Lerro, Carlucci (2008), Sanchez (2009), etc.

2. PHASES OF THE QUALITY MANAGEMENT OF INTANGIBLE ASSETS IN INDUSTRIAL ORGANIZATIONS

In my opinion, a schematic model of the quality management of intangible assets should contain the representation of five phases: planning the quality management of intellectual capital in industrial organizations; identifying needs and setting objectives; projecting and implementing; assurance, control, evaluation; results; monitoring, reevaluating, and continuous improvement (Bucur, 2014).

Phase 1. Planning the quality management of intellectual capital in industrial organizations

In this phase is chosen the approach and is planned the quality management of intangible assets in industrial organizations for the activities included in the project. Planning the quality management of intellectual capital in industrial organizations is a process through which the decision-maker chooses the policies and methods of realization of activities associated to obtaining characteristics of quality imposed by the beneficiary's objective requirements and subjective expectancies.

In the planning phase are mainly set the standards of quality and is checked if the standards are met, including also the measures imposed in case of deviation from these standards and their continuous development.

The procedures for quality management of intangible assets in industrial organizations are documented in all aspects related to the project. The phase ends with the realization of the plan for quality management of intellectual capital in industrial organizations, in which are provided policies for quality, roles and responsibilities, methodology to apply, necessary time to obtain quality, budget, and other concrete action plans for obtaining quality characteristics.

Phase 2. Identifying needs and setting objectives

It is a process of understanding and describing the combination between requirements and necessities expressed in quantitative and qualitative terms, in order to make possible the examination and realization of quality characteristics.

The methods of identifying needs are classic instruments and techniques (the process diagram; the cause and effect diagram; the Pareto diagram; the diagram of control; brainstorming; benchmarking; files and graphs for registering and representing data related to quality; etc) as well as modern ones for quality management of intangible assets in industrial organizations (the diagram of affinities; the relations diagram; the matrix diagram; the branch diagram; the arrow diagram; the diagram of control etc).

Moreover, to set the objectives for quality management of intellectual capital in industrial organizations means to turn the identified needs into targets that are achieved by accomplishing the quality management of intellectual capital in industrial organizations. The quality objectives have to be formulated clearly, they have to be realistic, and also to be able to be evaluated through appropriate methods (*management through objectives; the management of objectives; the method "goal deployment"; etc*).

Phase 3. Projecting and implementing

In order to fulfill the objectives set in the field of quality it is recommended that the organization projects and implements a *"system of quality"*, specific to the object of activity, to the processes that it realizes, taking into consideration the benefits, costs, and the risks.

This system of quality has to be understood by every person involved, and applied to obtain the set quality standards, and also, the results of the quality management of intangible assets in industrial organizations have to fulfill the real needs

and expectancies of the beneficiaries, with emphasis on preventing problems, not on solving them.

Phase 4. Assurance, control, evaluation

Quality assurance, according to the standard in the field (Standard SR EN ISO 9000 PA CT 56), involves *providing the assurance that the requirements related to quality will be met*, both in the organization, and outside of it, towards clients and the society. Quality control, however, refers to the operational methods used to meet the requirements related to quality, and evaluation means assessing the accordance of the human, structural, and relational capital with the set quality standards, determining the place and time of risks that could lead to non-quality, as well as monitoring the system of quality, reevaluating and continuous improvement of quality.

Phase 5. Results.

Quality management of intangible assets in industrial organizations should lead to obtaining products or services of quality that fulfill the necessities and the well-defined expectancies of the beneficiaries, that take into consideration the necessity of protecting the environment, if they are in accordance with the society's requirements and the legal regulations, with applicable standards and specifications.

Quality management of intangible assets in industrial organizations is a useful and necessary instrument to the integrative and cross-functional strategy of the organization, and it also takes into account the gradual and continuous improvement in the quality of products and services, in productivity and the advantage of competitiveness.

Phase 6. Monitoring, reevaluating, and continuous improvement

Quality management of intellectual capital in industrial organizations is a cyclic process that also includes the final phase of monitoring, reevaluation, and continuous improvement of quality. Monitoring is the process of observing and controlling the realization of intrinsic elements that compose the entity named "quality", and in the end it leads to fulfilling the quality requirements and the beneficiary's needs. In this case, there will be taken measures of control and observation of the process of achieving quality, of identifying and correcting deviations from the established standards of quality until the moment when the desired quality is obtained.

In fact, monitoring, together with partial reevaluations and the final evaluation are actions specific to quality management of intellectual capital in industrial organizations, in order to ensure that the changes that may occur as deviations from the objectives, requirements, and the needs established in the field of quality management of intellectual capital in industrial organizations are known on time.

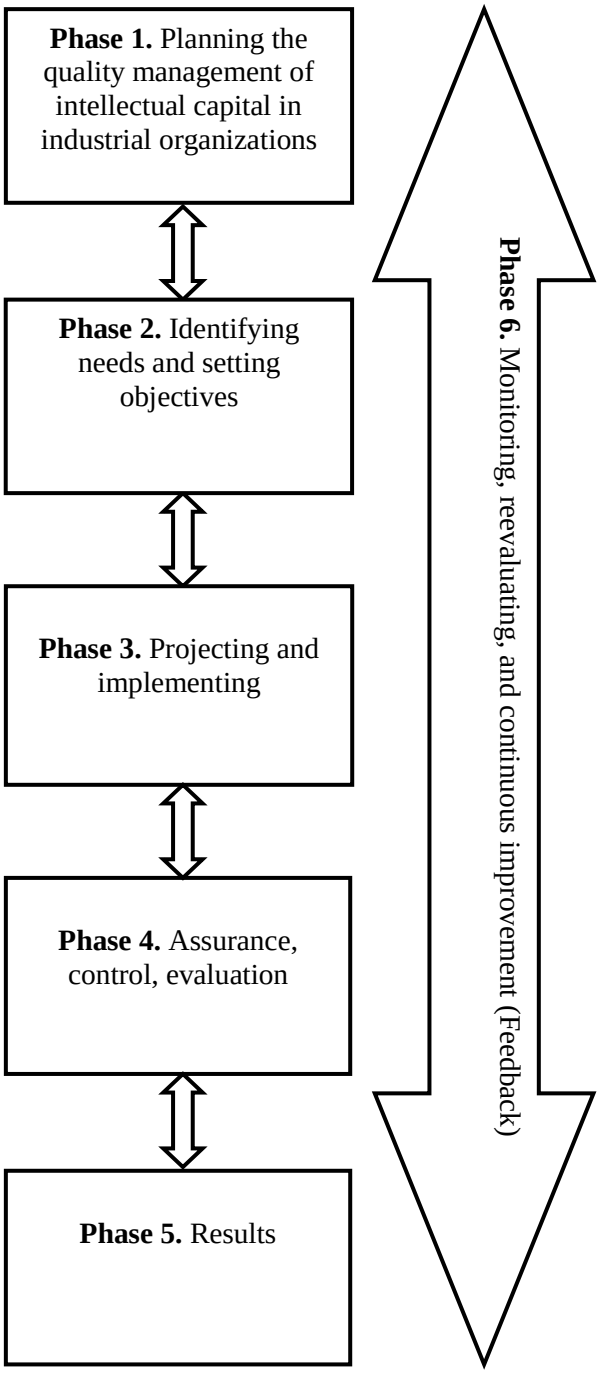

Figure 1. Schematic model of the phases of the quality management of intellectual capital in industrial organizations

3. MATHEMATICAL MODELS

Turning the schematic model into a mathematical model may require certain mathematical relations in each phase, as well as for the entire model. I will present two types of general mathematical models for quality management of intangible assets in industrial organizations, a representative one for each individual phase of the management (a), and a second one for the entire model (b).

a). Fuzzy logic, both in theory and in practice, has proven to be capable of providing the mathematical support for different problems to solve, especially for modeling uncertainty and risk (Ionescu, Cazan, Negruşa, 1999).

Quality management of intellectual capital in industrial organizations that involves the internal and external factors of any organization, many of these being uncertain elements or elements subjected to risk, is suitable to be formalized by the fuzzy method. In fact, in practice, many companies with an informatics profile offer an abundance of software products dedicated to operating with fuzzy systems.

The possibilities offered by the fuzzy formalization to translate the current language into mathematical terms by simply assigning a degree of affiliation to the linguistic variables (quality that is "superior", "poor", "better", "relatively high" etc.) lead to the possibility of adopting the fuzzy mathematics as a common language in quality management of intellectual capital in industrial organizations. The mathematical model of quality management of intellectual capital in industrial organizations may also use fuzzy formalism because the variants of decision from each phase are related to different criteria of decision. The degree to which each variant can fulfill each criterion can be evaluated through the values of a function of affiliation.

The function of affiliation μ takes values from the range *[0, 1]*, and μ_{ij} expresses the degree to which variant V_i fulfills the criterion C_j, $i=1,...,n$, $j=1,...,m$.

Thus, we obtain the matrix mathematical model from table 1. Taking into consideration the fact that each variant has to fulfill all *m* criteria, $C_1,..., C_m$ (more precisely C_1 and ... and C_m), it follows that the rows consist of a logical operation *AND,* which leads to the conclusion that for each row there have to be chosen the minimum values of the function of affiliation.

Table 1. Matrix mathematical model of the values of the function of affiliation

C_1	...	C_m	
μ_{11}	...	μ_{1m}	V_1
...	...	...	...
μ_{n1}	...	μ_{nm}	V_n

From these values (*OR* first, *OR* second, ..., *OR* the *n*th) we will then choose the one that leads to the conclusion that between the *n* variants there is a logical operation *OR*, therefore we will choose the maximum from the values obtained on the rows (the maximum out of the minimum values obtained on the rows) (Bucur, Oprean, 2014).

b). Mathematical model that uses functional dependencies. Another mathematical model that can be associated to figure 1 is the functional model, because each arrow represents, in fact, a relation of functional dependence:

$$f_5(n_1,..., n_m) = f_5(f_4(f_3(f_2(f_1(n_1,..., n_m))))) \quad (1)$$

where:

f_5 – represents the function that quantifies the degree of fulfillment of results; it depends on the function f_4, which quantifies the quality degree of the output from the phase of assurance, control, and evaluation;

f_4 – represents the function that quantifies the degree of fulfillment of the objectives from the phase of assurance, control, and evaluation of the general mathematical model; it depends on the function f_3, which quantifies the quality degree of the output from the phase of projecting and implementing;

f_3 – represents the function that quantifies the degree of fulfillment of the objectives from the phase of projecting and implementing of the general mathematical model of quality; it depends on the function f_2, which quantifies the quality degree of the output from the phase of identifying the needs;

f_2 – represents the function that quantifies the degree of fulfillment of the objectives from the phase of identifying the needs of the general mathematical model of quality; it depends on the function f_1, which quantifies the quality degree of the output from the phase of planning the quality management of intellectual capital in industrial organizations;

f_1 – represents the function that quantifies the degree of fulfillment of the objectives from the phase of planning the quality management of intellectual capital in industrial organizations; it has

as variables the needs/requirements "n_1 ,..., n_m " of the quality characteristics of the human, organizational, and relational capital;

n_1 ,..., n_m – represents a number of *"m"* needs/requirements related to the quality characteristics of the human, structural, and relational capital expressed by numerical values, if they are quantitative entities, or by values associated on a Likert scale, if they are qualitative entities.

The model, through its construction and functionality, ensures the assembling of all elements that are in a functional dependence, which, according to the principle of determinism cause-effect, can lead to results that are controllable, permanently subjected to improvement and to the realization of desired characteristics, and specific to the expected quality.

4. CONCLUDING REMARKS

The mathematical knowledge in the phases of quality management of intellectual capital in industrial organizations is theoretical, dynamical, tautological, acontextual, and intrinsic to the human mind.

Nowadays, mathematics represents the logical and formal tool that provides mathematical models and clear answers in solving ensembles of diverse elements that form a phenomenon, system, process etc. from the natural or human and social environment.

Simulation of certain mathematical models with software is a modern method from the field of Informatics used in various other fields due to its efficiency, due to it being less time-consuming, requiring lower costs, and being faster in providing concrete conclusions about a certain phenomenon, process, activity, product, service etc. Throughout the years, for the simulation of models there have been used different software with specialized simulation languages, such as: DYNAMO, EZQ, GASP, GPSS, SIMSCRIPT, SIMULA, SIMULINK, SLAM, MATLAB etc.

Other software used for simulation is: WinQSB, MAPLE, and GEOGEBRA.

Mathematical modeling and the usage of informational products in the field of quality of intangible assets and its management are quantitative methods and techniques of analysis and decision that offer rigor and accuracy in making the optimal decision. The logical and mathematical tools and the simulation of mathematical models for the working hypotheses may insure that the quality of intellectual capital and its management are obtained, kept, and continuously developed.

5. ACKNOWLEDGEMENT

This work was supported by the strategic grant POSDRU/159/1.5/S/133255, Project ID 133255 (2014), co-financed by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007 – 2013.

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7. NOTATIONS

The following symbols are used in this paper:
V_i - the "j" variant;
C_j - the "i" criterion;
μ - function of affiliation;
μ_{ij} - expresses the degree to which variant V_i fulfills the criterion C_j;
f_5 , f_4, f_3, f_2 , f_1 – functions;
n_1 ,..., n_m – represents a number of *"m"* needs/requirements related to the quality characteristics of the human capital, the structural capital, and the relational capital.