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JOURNAL OF APPLIED QUANTITATIVE METHODS

Learning Organization and Team Learning. Systemic Approaching. Advantages and Challenges

Vol. 2
No. 4
Winter
2007

ISSN 1842–4562

JAQM Editorial Board

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We are happy to inform you that starting with 2007, Journal of Applied Quantitative Methods grants three annual prizes to distinguished famous scholars, senior researchers and junior researchers or valuable authors published by JAQM. We decided to delegate ***Prof. dr. Alexandru ISAIC-MANIU*** *to coordinate the nomination committee.*

The winners will be announced in JAQM Spring 2008 Issue.

STRUCTURAL IDENTIFICATION AND COMPARISON OF INTELLIGENT MOBILE LEARNING ENVIRONMENT

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Abstract: *This paper proposes a methodology using graph theory, matrix algebra and permanent function to compare different architecture (structure) design of intelligent mobile learning environment. The current work deals with the development/selection of optimum architecture (structural) model of iMLE. This can be done using the criterion as discussed in the paper.*

Key words: *intelligent mobile learning environment; system structure; graph theory; matrix approach; variable permanent function (VPF)*

1. Introduction

An ***iMLE*** system architecture is represented as a system consisting of five subsystems, which affect properties and performance of finished ***iMLE*** product. This five-subsystem ***iMLE*** is modeled as a multinomial, a permanent function **[Upadhyay and Agarwal, 2007]**. Different ***iMLE*** systems developed using different subsystems and technologies will result in structure and interaction changes. This leads to different number of terms in different groups and subgroups of their permanent.

A variable permanent system structure matrix (**VPSSM- *iMLE***) '**Vp**' of ***SSG*** of ***iMLE*** with $\mathbf{e_{ij}} = \mathbf{e_{ji}}$ in Figure 1 is written as:

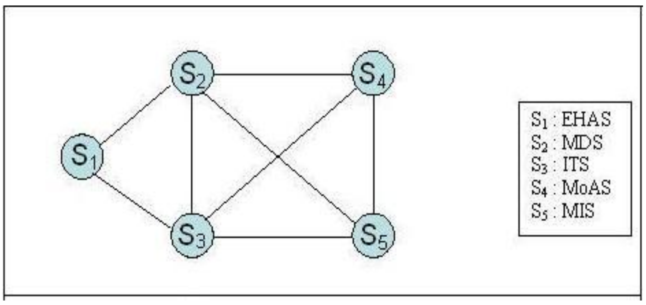

Figure 1. System Structure Graph of ***iMLE***

$$
\begin{array}{c}
\quad 1 \quad\;\; 2 \quad\;\; 3 \quad\;\; 4 \quad\;\; 5 \quad \text{Subsystems} \\
V_p = \begin{bmatrix} S_1 & e_{12} & e_{13} & 0 & 0 \\ e_{12} & S_2 & e_{23} & e_{24} & e_{25} \\ e_{13} & e_{23} & S_3 & e_{34} & e_{35} \\ 0 & e_{24} & e_{34} & S_4 & e_{45} \\ 0 & e_{25} & e_{35} & e_{45} & S_5 \end{bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix}
\end{array} \tag{1}
$$

The VPF- ***iMLE*** for matrix is written as:

Per(Vp) =

$$
\begin{aligned}
& S_1S_2S_3S_4S_5 + [e_{12}^2S_3S_4S_5 + e_{13}^2S_2S_4S_5 + e_{23}^2S_1S_4S_5 + e_{24}^2S_1S_3S_5 + e_{25}^2S_1S_3S_4 + e_{34}^2S_1S_2S_5 + e_{35}^2S_1S_2S_4 + e_{45}^2S_1S_2S_3] \\
& + [2e_{12}e_{23}e_{31}S_4S_5 + 2e_{23}e_{34}e_{42}S_1S_5 + 2e_{23}e_{35}e_{52}S_1S_4 + 2e_{24}e_{45}e_{52}S_1S_3 + 2e_{34}e_{45}e_{53}S_1S_2] \\
& + \{[2e_{23}e_{34}e_{45}e_{52}S_1 + 2e_{23}e_{35}e_{54}e_{42}S_1 + 2e_{24}e_{43}e_{35}e_{52}S_1 + 2e_{12}e_{24}e_{43}e_{31}S_5 + 2e_{12}e_{25}e_{53}e_{31}S_4] + [e_{13}^2e_{45}^2S_2 + e_{24}^2e_{35}^2S_1 \\
& + e_{25}^2e_{13}^2S_4 + e_{24}^2e_{13}^2S_5 + e_{23}^2e_{45}^2S_1 + e_{25}^2e_{34}^2S_1 + e_{12}^2e_{45}^2S_3 + e_{12}^2e_{34}^2S_5 + e_{12}^2e_{35}^2S_4]\} \\
& + \{[2e_{12}^2e_{34}e_{45}e_{53} + 2e_{45}^2e_{12}e_{23}e_{31} + 2e_{13}^2e_{24}e_{45}e_{52}] + [2e_{12}e_{24}e_{45}e_{53}e_{31} + 2e_{12}e_{25}e_{54}e_{43}e_{31}]\}
\end{aligned} \tag{2}
$$

The physical /graphical representation of permanent expression for ***iMLE*** is shown in Figure 2.

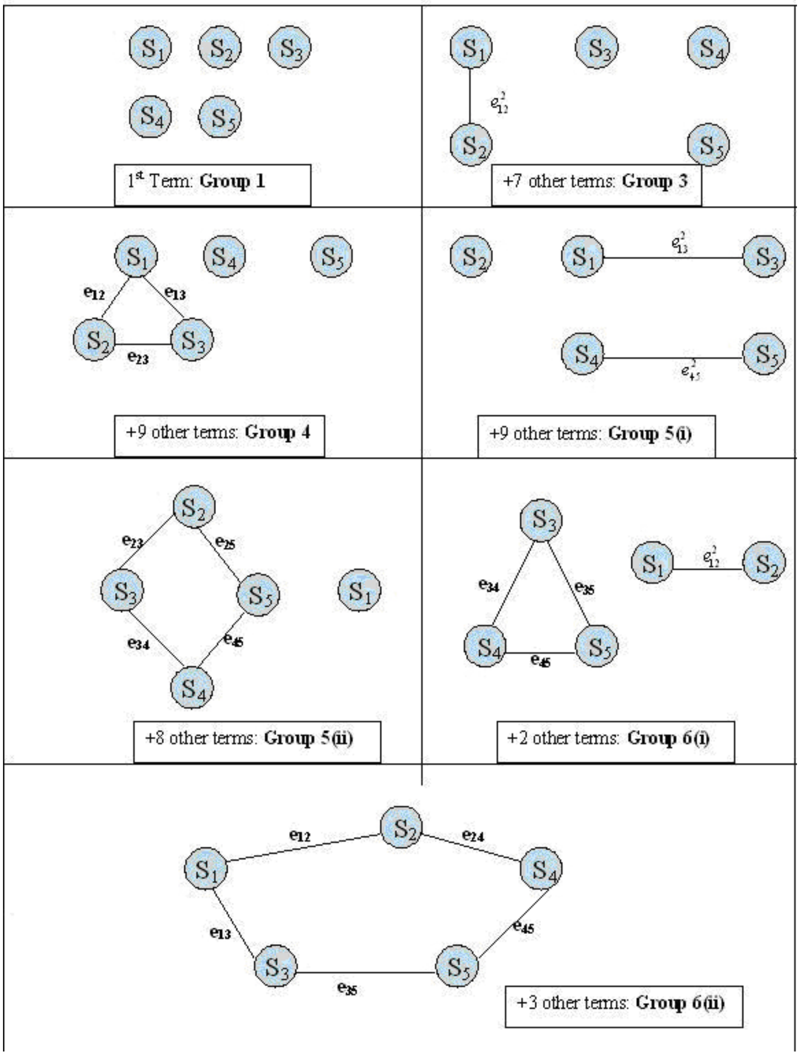

Figure 2. Graphical/Physical representation of Permanent Function Expression for ***iMLE***

2. Structural identification and comparison of systems

An ***iMLE*** system architecture is represented as a system consisting of five subsystems, which affect properties and performance of finished ***iMLE*** product. This five-subsystem ***iMLE*** is modeled as a multinomial, a permanent function. The similarity or dissimilarity in the structure between two ***iMLE*** systems is obtained by comparing their permanents. Using the proposed methodology, the identification of ***iMLE*** system architecture and its comparison with other ***iMLE*** system architecture is based on the analysis carried out with the help of **VPF- *iMLE***. Two ***iMLE*** system architectures are similar from subsystems and its interactions viewpoint only if their digraphs are isomorphic. Two ***iMLE*** system architecture digraphs are isomorphic if they have identical **VPF- *iMLE***. This means that the set of number of terms in each grouping/sub-grouping of two ***iMLE*** systems is the same. Based on this, an ***iMLE*** identification set for any product is written as:

$$\left[\left(M_1 / M_2 / M_3 / M_4 / M_{51} + M_{52} / M_{61} + M_{62} / ...\right)\right] \quad (3)$$

Where M_i represents the structural property of a system. It can be interpreted as the total number of terms in i[th] grouping, M_{ij} represents the total number of terms in the j[th] subgroup of i [th] grouping. In case there is no sub-grouping, the M_{ij} is the same as M_i ; the sub-groupings are arranged in decreasing order of size (i.e., number of elements in a loop). In general, two ***iMLE*** products may not be isomorphic from the viewpoint of architecture of subsystems and interactions among subsystems. A comparison is also carried out on the basis of the coefficient of similarity. The coefficient is derived from the structure, i.e., VPF-***iMLE*** and it compares two ***iMLE*** products or a set of ***iMLE*** products on the basis of similarity or dissimilarity. If the value of distinct terms in the j [th] sub-grouping of the i [th] grouping of **VPF- *iMLE*** of two ***iMLE*** products under consideration are denoted by M_{ij} and M'_{ij}, then two criteria are proposed as follows [**Liu et al., 2004**]: The coefficient of similarity and dissimilarity are calculated using number of terms only.

Criterion 1: The coefficient of dissimilarity C_{d-1} based on criterion 1 is proposed as:

$$C_{d-1} = \frac{1}{Y_1}\sum_i \sum_j \psi_{ij} \quad (4)$$

where $Y_1 = \max\left[\sum_i \sum_i \left|M_{ij}\right| and \sum_i \sum_i \left|M'_{ij}\right|\right]$

When sub-groupings are absent $M_{ij} = M_i \; and \quad M'_{ij} = M'_i \; and$ $\psi_{ij} = \left|M_{ij} - M'_{ij}\right|$ when the sub-groupings exists and $\psi_{ij} = \left|M_i - M'_i\right|$, when the sub-groupings are absent. Criterion 1 is based on the sum of the difference in number of terms in different subgroups and groups of **VPF- *iMLE*** of two structurally distinct iMLE architecture. There may be a case when some $\sum_i \sum_j \psi_{ij}$ is zero though two systems are structurally different. This situation may arise when some of the differences are positive while some other differences are negative such that $\sum_i \sum_j \psi_{ij}$ become zero. To improve the differentiating power, another criterion is proposed.

Criterion 2: The coefficient of dissimilarity C_{d-2} is proposed as:

$$C_{d-2} = \frac{1}{Y_2} \sum_i \sum_j \psi'_{ij} \tag{5}$$

Where $Y_2 = \max\left[\sum_i \sum_i \left(M_{ij}\right)^2 and \sum_i \sum_i \left(M'_{ij}\right)^2 \right]$

When sub-groupings are absent $M_{ij} = M_i \, and \; M'_{ij} = M'_i \; and$ $\psi'_{ij} = \left|M_{ij}^2 - M'^2_{ij}\right|$ when the sub-groupings exists and $\psi'_{ij} = \left|M_i^2 - M'^2_i\right|$, when the sub-groupings are absent.

Criterion 2 is based on the sum of the squares of the difference in number of terms in different sub-groups and groups of **VPF- *iMLE*** of two structurally distinct ***iMLE*** architecture. It shows that ψ'_{ij} (criterion 2) is much larger than ψ_{ij} (criterion 1). To increase further the differentiating power another criterion 3 is proposed.

Criterion 3: The coefficient of dissimilarity C_{d-3} based on criterion one is proposed

$$C_{d-3} = \left[\frac{1}{Y_3} \sqrt{\sum_i \sum_j \psi_{ij}} \right] \tag{6}$$

Where ψ_{ij} the same as is described in criterion 1 and

$$Y_3 = \max\left[\sqrt{\sum_i \sum_i \left|M_{ij}\right|} and \sqrt{\sum_i \sum_i \left|M'_{ij}\right|} \right]$$

When sub-groupings are absent $M_{ij} = M_i \, and \; M'_{ij} = M'_i$. Criterion 3 is derived from criterion 1.

Criterion 4: The coefficient of dissimilarity C_{d-4} based on criterion two is proposed

$$C_{d-4} = \left[\frac{1}{Y_3} \sqrt{\sum_i \sum_j \psi'^2_{ij}} \right] \tag{7}$$

Where ψ'_{ij} is the same as is described in criterion 2 and

$$Y_4 = \max\left[\sqrt{\sum_i \sum_i \left(M_{ij}\right)^2} and \sqrt{\sum_i \sum_i \left(M'_{ij}\right)^2} \right]$$

When sub-groupings are absent $M_{ij} = M_i \, and \; M'_{ij} = M'_i$. Criterion 4 is derived from criterion 2. This can further increase the differentiating power. Using above equations the coefficient of similarity is given as

$$C_{m-1} = 1 - C_{d-1}; C_{m-2} = 1 - C_{d-2}; C_{m-3} = 1 - C_{d-3}; C_{m-4} = 1 - C_{d-4} \tag{8}$$

Where C_{m-1}, C_{m-2}, C_{m-3} and C_{m-4} are the coefficient of similarity between two *iMLE* architectures under consideration based on criterion 1, criterion 2, criterion 3 and criterion 4.

Using above-mentioned criteria, comparison of two or family of ***iMLE*** system architectures is carried out. Two ***iMLE*** architectures are isomorphic or completely similar from a structural point of view, if structural identification set for the two systems are exactly the same. This means the number of terms/ items in each grouping/ sub-grouping are exactly the same. The structural identification set equation (3) for the system shown in Figure 8 is obtained by considering its structure graph and **VPF- *iMLE*** as **/1/8/(2*5)/(2*5+9)/(2*3+2*2)/.**

It may be noted that the coefficient of similarity and dissimilarity lies in the range between 0 and 1. If two ***iMLE*** architectures are isomorphic or completely similar, their coefficient of similarity is 1 and the coefficient of dissimilarity is 0. Similarly, if two ***iMLE*** architectures are completely dissimilar, their coefficient of similarity is 0 and the coefficient of dissimilarity is 1.

3. Illustrative example

Two given intelligent mobile learning environment systems can be compared using the coefficient of similarity/dissimilarity. To illustrate this, another possible permanent function is considered. This illustrative permanent function is obtained after substituting the terms containing element $\mathbf{e_{12}}$ equals to zero. This implies no connection between subsystems 1 and 2. Because, it can be considered that mobile dimension system is not dependent on environment and human aspect system. A variable permanent system structure matrix (**VPSSM- *iMLE***) '**Vp**'' of ***SSG*** of ***iMLE*** after substituting $\mathbf{e_{12}}$ to zero with $\mathbf{e_{ij}} = \mathbf{e_{ji}}$ in Figure 1 is written as:

$$V_p = \begin{array}{c} \begin{matrix} 1 & 2 & 3 & 4 & 5 & \text{Subsystems} \end{matrix} \\ \begin{bmatrix} S_1 & 0 & e_{13} & 0 & 0 \\ 0 & S_2 & e_{23} & e_{24} & e_{25} \\ e_{13} & e_{23} & S_3 & e_{34} & e_{35} \\ 0 & e_{24} & e_{34} & S_4 & e_{45} \\ 0 & e_{25} & e_{35} & e_{45} & S_5 \end{bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix} \end{array} \quad (9)$$

The VPF- ***iMLE*** for matrix is written as:

Per(Vp') =

$$\begin{aligned} & S_1S_2S_3S_4S_5 + [e_{13}^2S_2S_4S_5 + e_{23}^2S_1S_4S_5 + e_{24}^2S_1S_3S_5 + e_{25}^2S_1S_3S_4 + e_{34}^2S_1S_2S_5 + e_{35}^2S_1S_2S_4 + e_{45}^2S_1S_2S_3] \\ & +[2e_{23}e_{34}e_{42}S_1S_5 + 2e_{23}e_{35}e_{52}S_1S_4 + 2e_{24}e_{45}e_{52}S_1S_3 + 2e_{34}e_{45}e_{53}S_1S_2] \\ & +\{[2e_{23}e_{34}e_{45}e_{52}S_1 + 2e_{23}e_{35}e_{54}e_{42}S_1 + 2e_{24}e_{43}e_{35}e_{52}S_1] + [e_{13}^2e_{45}^2S_2 + e_{24}^2e_{35}^2S_1 \\ & +e_{25}^2e_{13}^2S_4 + e_{24}^2e_{13}^2S_5 + e_{23}^2e_{45}^2S_1 + e_{25}^2e_{34}^2S_1]\} \\ & +\{[2e_{13}^2e_{24}e_{45}e_{52}]\} \end{aligned} \quad (10)$$

The physical /graphical representation of permanent expression for ***iMLE*** is shown in Figure 3.

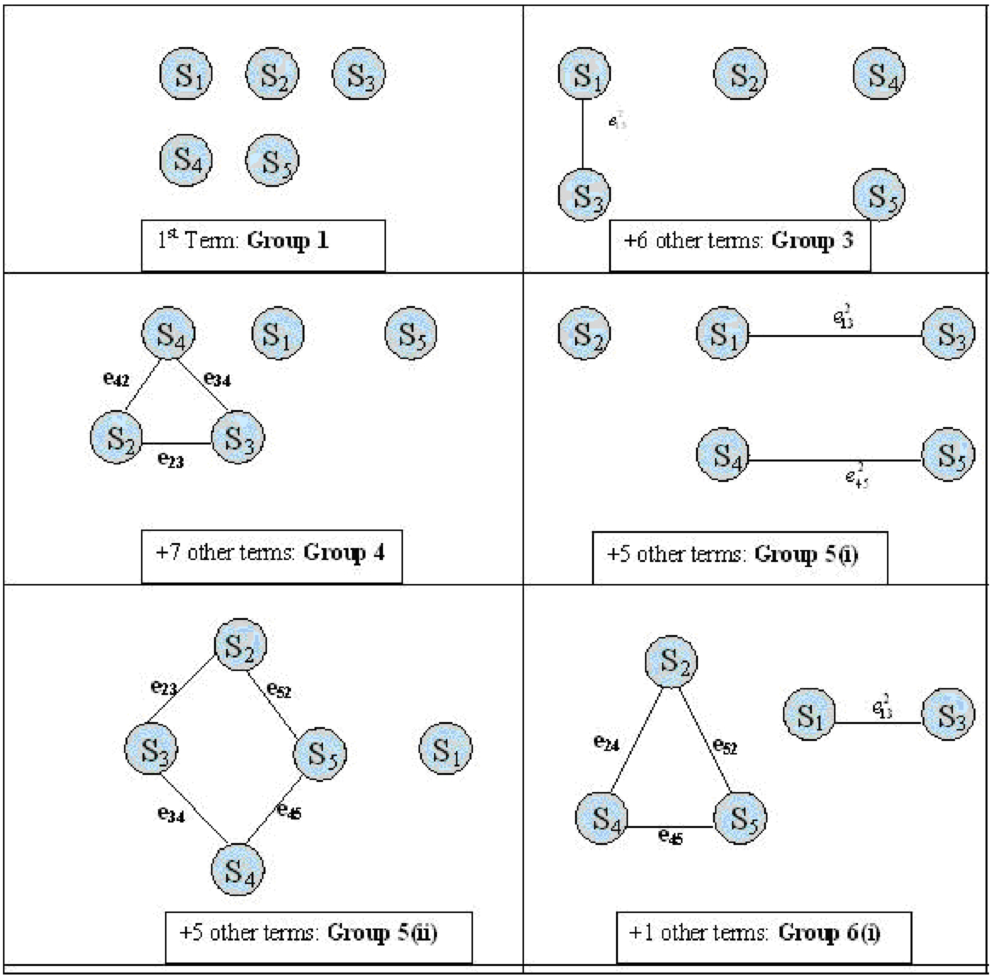

Figure 3. Graphical/ Physical representation of Permanent Function Expression for ***iMLE***

The number of terms of various grouping and sub groupings for both the system is shown below:

The coefficients of similarity/dissimilarity for these two systems are calculated by using four different criteria and are given below:

Group No.	1st ***iMLE*** Architecture	2nd ***iMLE*** Architecture
1	1	1
2	0	0
3	8	7
4	2 * 5 = 10	2 * 4 = 8
5	2 * 5 + 9 = 19	2 * 3 + 6 = 12
6	2 * 3 + 2 * 2 = 10	2 * 1 = 2
Total	48	30

The structure identification set for 2nd ***iMLE*** Architecture can be written as **/1/2/(2*4)/(2*3+6)/(2*1)/**. Similarly the matrices and graph of the new 2nd ***iMLE*** architecture can be developed.

The coefficients of similarity/dissimilarity for these two systems are calculated by using three different criteria and are given below:

Criterion 1:

$$\sum_i \sum_j |M_{ij}| = 1+0+8+10+(10+9)+(6+4) = 48$$

$$\sum_i \sum_j |M'_{ij}| = 1+0+7+8+(6+6)+2 = 30$$

$$\sum_i \sum_j \psi_{ij} = (1-1)+(0-0)+(8-7)+(10-8)+(10-6)+(9-6)+(6-2)+4 = 18$$

$$Y_1 = 48$$

$$C_{d-1} = \frac{18}{48} = 0.375$$

Criterion 2:

$$\sum_i \sum_j (M_{ij})^2 = 1^2+0^2+8^2+10^2+(10^2+9^2)+(6^2+4^2) = 398$$

$$\sum_i \sum_j (M'_{ij})^2 = 1^2+0^2+7^2+8^2+(6^2+6^2)+2^2 = 190$$

$$\sum_i \sum_j \psi'_{ij} = (1^2-1^2)+(0^2-0^2)+(8^2-7^2)+(10^2-8^2)+(10^2-6^2)+(9^2-6^2)+(6^2-2^2)+4^2 = 196$$

$$Y_2 = 398$$

$$C_{d-2} = \frac{196}{398} = 0.492$$

Criterion 3:

$$\sqrt{\sum_i \sum_j |M_{ij}|} = \sqrt{(1+0+8+10+(10+9)+(6+4))} = \sqrt{48} = 6.928$$

$$\sqrt{\sum_i \sum_j |M'_{ij}|} = \sqrt{(1+0+7+8+(6+6)+2)} = \sqrt{30} = 5.477$$

$$\sqrt{\sum_i \sum_j \psi_{ij}} = \sqrt{((1-1)+(0-0)+(8-7)+(10-8)+(10-6)+(9-6)+(6-2)+4)}$$

$$\sqrt{\sum_i \sum_j \psi_{ij}} = \sqrt{18} = 4.242$$

$$Y_3 = 6.928$$

$$C_{d-3} = \left[\frac{4.242}{6.928}\right] = 0.612$$

Criterion 4:

$$\sqrt{\sum_i \sum_j \left(M_{ij}\right)^2} = \sqrt{\left(1^2 + 0^2 + 8^2 + 10^2 + (10^2 + 9^2) + (6^2 + 4^2)\right)} = \sqrt{398} = 19.949$$

$$\sqrt{\sum_i \sum_j \left(M'_{ij}\right)^2} = \sqrt{\left(1^2 + 0^2 + 7^2 + 8^2 + (6^2 + 6^2) + 2^2\right)} = \sqrt{190} = 13.78$$

$$\sqrt{\sum_i \sum_j \psi'^{\,2}_{ij}} = \sqrt{\left((1^2 - 1^2) + (0^2 - 0^2) + (8^2 - 7^2) + (10^2 - 8^2) + (10^2 - 6^2) + (9^2 - 6^2) + (6^2 - 2^2) + 4^2\right)}$$

$$\sqrt{\sum_i \sum_j \psi'^{\,2}_{ij}} = \sqrt{196} = 14$$

$$Y_4 = 19.949$$

$$C_{d-4} = \left[\frac{14}{19.949}\right] = 0.701$$

This shows that criterion 4 has much larger value as compared to criterion 1, 2 and 3. This demonstrates larger differentiating capacity of criterion 4 over criterion 1, 2 and 3.

$$C_{m-1} = 1 - C_{d-1}$$
$$C_{m-1} = 1 - 0.375$$
$$C_{m-1} = 0.625$$
$$C_{m-2} = 1 - C_{d-2}$$
$$C_{m-2} = 1 - 0.492$$
$$C_{m-2} = 0.508$$
$$C_{m-3} = 1 - C_{d-3}$$
$$C_{m-3} = 1 - 0.612$$
$$C_{m-3} = 0.388$$
$$C_{m-4} = 1 - C_{d-4}$$
$$C_{m-4} = 1 - 0.701$$
$$C_{m-4} = 0.299$$

If we compare these two system graph, it is found that both have the same number of nodes, but the new system has only one edge less. This deleted edge causes a large change in the structural complexity, which is directly reflected in the similarity/dissimilarity coefficient as calculated.

It may be noted that the coefficient of similarity and dissimilarity lies in the range between 0 and 1. If two ***iMLE*** architectures are isomorphic or completely similar, their coefficient of similarity is 1 and the coefficient of dissimilarity is 0. Likewise, if two ***iMLE*** architectures are completely dissimilar, their coefficient of similarity is 0 and the coefficient of dissimilarity is 1.

4. Architecture and performance of *iMLE* products

It has been shown by a number of researchers that performance of any system is dependent on its architecture/structure consisting of its structural components and interactions between them. Structurally similar or closely similar architectures will likely perform nearly the same. Availability of a number of alternative architecturally similar ***iMLE*** modules provides a large amount of design flexibility in the hands of designer to develop highly efficient, effective and consumer friendly ***iMLE*** products at less cost and less time. This provides a competitive edge in the hands of different stakeholders.

5. Step-by-step procedure

The step-by-step methodology is proposed which will help in identifying various choices of available designs depending upon interaction/interdependencies or information flow between systems and their sub-systems (modules) and so on. A generalized procedure for the identification and comparison of ***iMLE*** system architecture which is extension of the procedure specified in **[Upadhyay and Agarwal, 2007]** is summarized below:

Step 1: Consider the desired ***iMLE*** product. Study the complete ***iMLE*** system and its subsystems, and also their interactions.
Step 2: Develop a block diagram of the ***iMLE*** system, considering its sub-systems and interactions along with assumptions, if any.
Step 3: Develop a systems graph of the ***iMLE*** system Figure 1 with sub-systems as nodes and edges for interconnection between the nodes.
Step 4: Develop the matrix equation (1) and multinomial representations equation (2) of ***iMLE*** system.
Step 5: Evaluate functions/values of diagonal elements from the permanent functions of distinct sub-systems of the composite and repeat Steps 2 – 4 for each sub-system.
Step 6: Identify the functions/values of off-diagonal elements/interconnections at different levels of hierarchy of the ***iMLE*** amongst systems, sub-systems, sub-sub-systems, etc.
Step 7: Calculate ***iMLE*** identification set. Carry out architectural similarity and dissimilarity with potential candidates to take appropriate decisions.
Step 8: Carry out modular design and analysis of ***iMLE*** products while purchasing off the shelf from the global market.

The visualization model for the comparison of two ***iMLE*** system/product is shown in Figure 4.

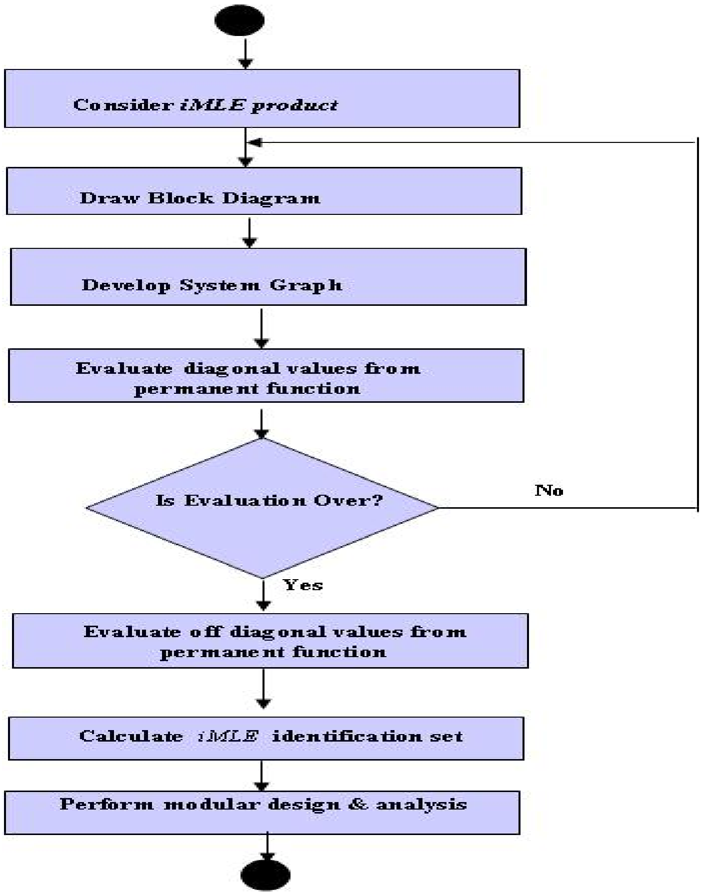

Figure 4. Visualization model

6. Usefulness of the proposed methodology

Different stakeholders in ***iMLE*** e.g. students, universities, ***iMLE*** module developers, designers and consultants are benefited by the proposed methodology as:

1. The methodology is dynamic in nature as sub-systems/components and interactions, which appear as variables in different models may be changed without any difficulty.
2. It also helps to develop a variety of ***iMLE*** systems providing optimum performance characteristics under different industrial/organizational learning applications.
3. Thus, the approach helps to express the ***iMLE*** system in quantitative terms, which has more often been expressed in qualitative terms.
4. The procedure helps to compare different ***iMLE*** systems in terms of its characteristics and rate them for particular applications.
5. It is hoped that this methodology will provide a new direction in the research attempts towards global projects of quantitative structure activity relationship (**QSAR**) and quantitative structure properties relationship (**QSPR**)[**Liu et al., 2004; Katritzky et al., 1997**].
6. The present work is an attempt towards the development of complete methodology for virtual integration [**Choi and Chan, 2004**] of ***iMLE*** components/sub-system as well as virtual design of complete iMLE system

architecture consisting of Mobile Dimension System (**MDS**), Mobile Agent System (**MoAS**), Multiagent Intelligent System (**MIS**), Intelligent Tutoring System (**ITS**), Environment and Human Aspect System (**EHAS**).

7. The proposed methodology is a powerful tool in the hands of the system analyst, designer, decision makers and developers.
8. Using this and morphological chart/tree, the system analyst, decision makers and designer can generate alternative design solutions and select the optimum one.
9. Similarly, this method can be exploited to improve quality and reduce cost and time-to-market in learning industry.
10. It is also possible to exploit the methodology to extend the useful product life in the learning industry market by making strategic changes in the ***iMLE*** systems architecture. This methodology gives a comprehensive knowledge to the user about ***iMLE*** systems architecture and helps in the selection of right systems architecture at the right time and at right cost from the global market.

7. Conclusion

1. Proposed structural coefficients of similarity and dissimilarity and identification sets are useful models to select optimum set of subsystems up to component level to finally achieve high quality ***iMLE*** system architecture in less cost and time by comparing their structures.
2. As proposed systems model gives complete information of the existing system, **SWOT** (Strength-Weakness-Opportunities-Threats) analysis and cause and effect analysis (Fishbone diagram/Ishikawa diagram) can be carried out effectively and efficiently. This permits cutting edge over its competitors.
3. This study gives a criterion how to compare two ***iMLE*** system architectures with the help of permanent function on structure basis.
4. Research is in progress to correlate quantitatively the structure of the system with different performance parameters of ***iMLE*** e.g. quality, reliability, etc.
5. Current undergoing research deals with correlation of structural models with the desired performance parameters (quality, reliability, responsiveness, flexibility etc), design and development of new systems as an improvement of existing systems and critical analysis of failed system. The outcome will be reported in future publications.

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THE LEARNING PARADOX AND THE UNIVERSITY

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Abstract: *Universities are by their nature learning based organizations. They deliver knowledge to students through teaching processes. Students acquire knowledge through learning processes, from their professors and from other different knowledge resources. Since learning is a fundamental process within any university, people may consider universities as being learning organizations. This is a major error, especially in the former socialist countries. The purpose of this paper is to demonstrate that most universities are far away from being learning organizations, due to some organizational learning barriers.*

Key words: *knowledge generation; knowledge transfer; learning process; learning organization; universities*

1. The learning paradox

The paradox may be formulated as follows: *although a university is an organization based on learning processes, it is not necessarily a learning organization*. It can become a learning organization if and only if there is at least a strong integrator to assure the transition from individual learning to team and organizational learning. Also, it would be important to advance from adaptive learning to generative learning. Most universities are far from being learning organizations due to some mental and functional barriers. Identifying and evaluating these barriers would help in designing adequate solutions to transform these universities in successful learning organizations, able to compete on the new global market of higher education.

This paradox may be linked to the Albrecht's Law (Albrecht 2003, p.4): "Intelligent people, when assembled into an organization, will tend toward collective stupidity". This is not a compulsory phenomenon in any group of people. It is an optional one to the extent to which group members allow it to happen. However, it does happen frequently since it follows the *entropy* law. In order to aggregate individual knowledge and intelligences from all the employees of a given organization one needs specific mechanisms, capable of integrating them and generating adequate synergies. In order to explain the synergy generation in a knowledge field, Karl Albrecht introduces the concept of *syntropy*: "We can define syntropy as the coming together of people, ideas, resources, systems, and leadership in such a way as to fully capitalize on the possibilities of each" (Albrecht 2003, p.42). While entropy measures the energy degradation in a natural system through increasing disorder, syntropy would denote the upgrading of organizational energy, knowledge and intelligence through increasing alignment, or integration of all resources and capabilities an organization may have. In the organizational environment, the entropy would show the natural tendency of people toward loose interaction and increase stupidity, the syntropy would show the conscious, deliberate and intelligent effort for organizational learning.

2. The learning organization

The *organization* is a social invention. It represents a systematic arrangement of people brought together to accomplish some specific objectives (Robbins and DeCenzo 2005). These objectives would have been impossible to be realized by one single man. Organizations can be companies, public institutions, professional associations, charity foundations and any such entity having a legal status and a certain mission. Thus, we use the concept of organization as a generic concept for any kind of profit-making or non-profit legal entities. More than a century ago, the study of organizations rested on the assumption that there is, or there should be, one right organization for any conceived purpose (Drucker 2001). Experience demonstrated that the pattern of the right organization has changed more than once, as business environment changed itself. The concept of organization has no absolute meaning, since an organization is only a tool for making people productive in working together. It has a relative meaning. Actually, this is reflected in the origins of the word organization, which derives from the Greek *organon*, meaning a tool or instrument. That means that an organization is not an end in itself, but an instrument conceived to perform some kind of goal oriented processes.

In any organization all activities can be grouped together into two basic processes: the production process and the management process, as shown schematically in figure 1 (Bratianu, Vasilache and Jianu 2006). The production or technological process is designed to produce the organization end results as tangible objects or services. The process of management is necessary in order to perform the first process efficiently and effectively. Efficiency means doing tasks correctly, such that products can be obtained with minimum of resources. Effectiveness means doing the right task, searching for goal attainment. Efficiency and effectiveness are interrelated concepts. The process of management can be performed through its main functions: planning, organizing, leading and controlling. It is important to have in mind this functional perspective on the internal environment of any organization, in order to understand better the meaning of the twin concepts: organizational learning and learning organization. Both concepts reflect a conscious effort which must be done within the management process, even if knowledge can be generated within the production process and the management process. In this context, the organization management acts as an integrator, having a decisive impact on the aggregation of all employees knowledge, intelligences and values, as we will demonstrate in this paper farther on.

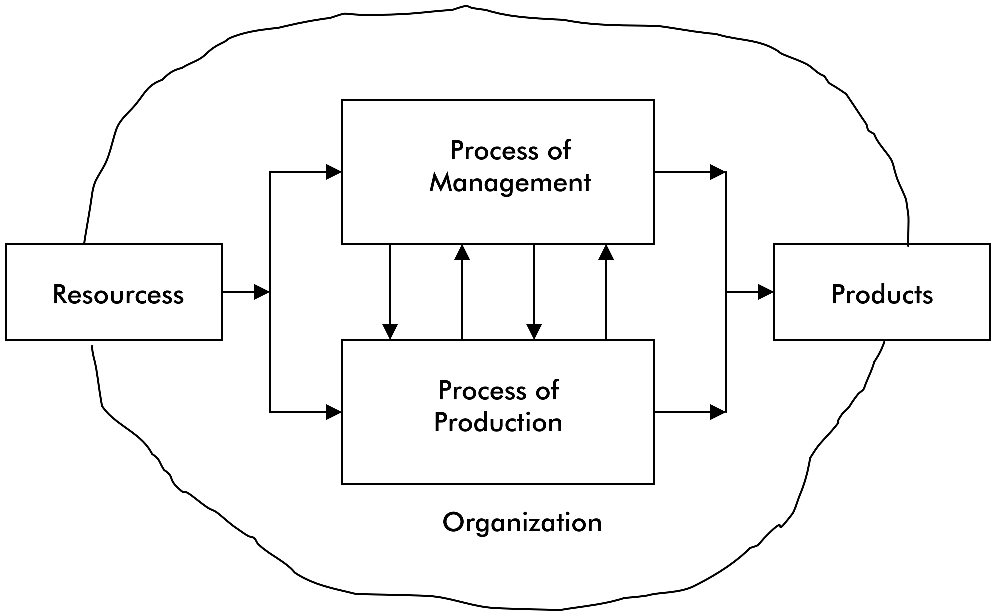

Figure 1. The organization basic functional structure

A learning organization is "an organization that is continually expanding its capacity to create its future. For such an organization, it is not enough merely to survive" (Senge 1990, p.14). In his seminal book, Peter Senge stress the fact that learning in order to adapt to the external business environment is essential for any organization, but it is not enough. Adaptive learning is a survival learning, and no organization would like to struggle all the time with surviving. *Adaptive learning* should be only the first phase of such a process, being continued with *generative learning*, the process that enhances our capacity to create. In defining the learning organization we must be able to avoid the trap of transferring human capacity of generating and processing knowledge to pure organizational structures. In essence we talk about people, structured in teams and organizations, and about their capacity of developing new and specific modalities of learning in groups. Although it looks like a natural process, in real organizational life things are different for the simple reason that management is by its own nature antientropic. Innovation and change management put forward a new perspective of a relaxed hierarchical structure, and tasks beyond the rigid job description.

Learning is one of the most powerful processes at both individual and collective levels. It is fully engaging, rewarding and enjoyable. Learning constitutes the prerequisite for knowledge generation through innovation, at both operational and managerial levels. Many researchers consider learning to become the critical issue of the twenty-first century business. The process of learning is composed of several activities, among them being more important: perception, knowledge acquiring, knowledge structuring and re-structuring through a continuous dynamics, knowledge storage, knowledge removal from the memory, and knowledge creation through a conscious effort. In all of these processes we may find both *tacit* knowledge and *explicit* knowledge. Tacit knowledge can be obtained from the direct individual experience and it is stored within the unconscious zone of the brain. Let us consider for instance a child who tries to touch a hot plate with his fingers. It hurts and it might burn the finger skin. The child cannot understand the cause of this pain, but he acquired a new knowledge which will be used in his future behavior. This is a piece of tacit knowledge. When his mother will explain to him about the risk of touching hot plates, the child receives explicit knowledge. It is a kind of rational and explained knowledge. Later on, he will be able to find this kind of knowledge in books, to get it from school or TV. Explicit knowledge can be detached from its owner and processed at the group or organizational level. At the individual level, each concept becomes clearly defined when there are both components, i.e. the tacit and the explicit knowledge.

In his research about learning organization, Bob Garratt demonstrates that "organizations can only become simultaneously effective and efficient if there is conscious and continuous learning between three distinct groups – the leaders who direct the enterprise, the staff who deliver the product or service, and the customers or consumers" (Garratt 2001, p.IX). Thus, the learning process should not be confined only with the given organization; it should be extended over the external business environment of the company. The learning organization will have in this perspective

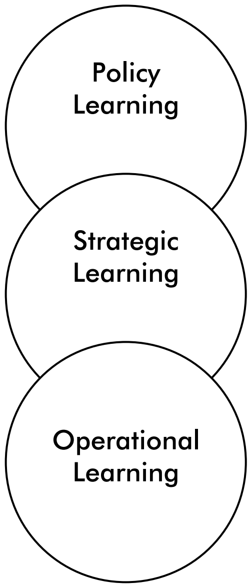

Figure 2. The Garratt learning organization model

three main cycles of learning: the operational learning cycle, the strategic learning cycle and the policy learning cycle (figure 2). Thus, organizational learning differs from the individual learning, where there is only one cycle going from practice to conceptualization and testing, through the tacit and explicit knowledge.

The *policy learning cycle* contains the organization's relationships with the external business environment. Its focus is the organization effectiveness with respect to its defined objectives and consumers satisfaction. Experience shows that the customer's or consumer's perception of organization effectiveness contributes directly to the success or failure of that organization (Garratt 2001). This perception may have two important consequences: satisfied customers will repeat their purchase from same company; satisfied customers will be convinced more easily to pay a small price premium as they believe that the product or service is good value for money. Customers who pay a premium are likely to be profitable customers for the company, and in the same time to tell to other people about the quality of the purchased products. Big companies like Coca-Cola and General Electric introduced into their mission statements the need to generate enthusiasm for their customers. The policy learning cycle is controlled from inside by top management, people in charge with establishing company's policy. They must understand the complexity of the new unpredictable and chaotic external business environment.

The *strategic learning cycle* refers to the bridging together the policy learning cycle and the operational learning cycle. Strategic learning is component of the strategic management process of the company. As Bob Garrat explains, "Strategic learning is about monitoring the changing external world, reviewing the organization's position in these changes, making risk assessments to protect and develop enterprise, broadly deploying its scarce resources to achieve its purpose, and ensuring that there are feedback procedures in place to measure the effectiveness of any strategy being implemented" (Garrat 2001, p.8). Strategic learning cycle is projected on a long time scale of 4-5 years, consistent with the strategic management time scale and objectives.

The *operational learning cycle* is a component of the operational management. It is based on the daily activities, the time scale ranging at the most up to one year. Operational management is concerned mostly with the process of production and its efficiency. Economic rationality and short term objectives are the most obvious characteristics of the operational management. The operational learning cycle produces innovation at execution line, both technological and managerial. In conclusion, Garratt's model is composed of these three learning cycles, the strategic cycle playing the role of integrating the other two.

Chris Argyris, professor at the famous Harvard Business School, is one of the leading researchers in this field of learning organizations. His theory is based on the single-loop and double-loop learning processes, which are schematically presented in figure 3 (Argyris 1999, p.68). Single-loop learning is the inner knowledge circuit when there a situation of matching the objectives. Also, it can be used when the mismatch situation can be solved working only on the production process by changing actions. Double-loop learning intervenes when the solution of the problem cannot be obtained within the inner single-loop. It is a larger and deeper loop which requires changing one or several governing variables at the organizational level. Thus, it is necessary first to change these governing variables and only then to change the actions to be performed. These variables are not cultural values or beliefs people espouse. They are variables used by managers to control the production process. That means the double- loop allows adjustments to the production process, but not to the external business environment. By comparison with the Garratt model, the Argyris model is focused only the internal business environment, working on the production process (single-loop learning), or on both the production process and management process (double-loop learning). Single-loop learning is quite suited for the adaptive or surviving learning. Generative learning needs the second loop, or much better a third loop to parallel the third learning cycle of the Garratt model. It is important to stress the fact that *organizational learning* does happen only when the chosen solution is fully implemented. As Chris Argyris demonstrates "Learning occurs when the invented solution is actually produced. This distinction is important because it implies that discovering problems and inventing solutions are necessary, but not sufficient conditions, for organizational learning. Organizations exists in order to act and to accomplish their intended consequences" (Argyris 1999, p.68).

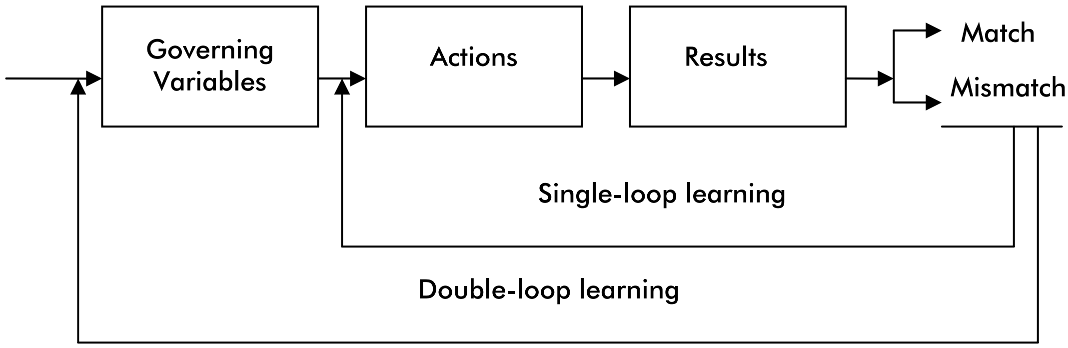

Figure 3. Single-loop and double-loop learning

3. Universities as learning organizations

For a university, figure 1 becomes very interesting since the process of production and the process of management both operates in the field of knowledge. In the industrial environment, the process of production performs in a tangible world, while the process of management performs in an intangible world. In the university internal environment, the process of production is a knowledge generation and transfer process, and the process of management deals also with knowledge. Thus, both processes perform in the world of intangibles, and the production process is actually limited by the performance capacity of the management process. In this context, the paradox may have a sense, since the production process is actually a learning process. If a certain university is going to be a *learning organization*, it is necessary that the process of management to become a learning process as well. Thus, there is a reasonable concordance with the double-loop learning shown in figure 3, and with the strategic learning cycle presented in figure 2.

A new and interesting perspective has been recently presented by Constantin Bratianu in analyzing the dynamic structure of the intellectual capital (IC), by comparison with previous static structures (Andriessen 2004; Bratianu 2007). Figure 4 shows the transformation of individual contributions of all the organization members into the organizational entities, in terms of knowledge, intelligence and values. The major role in this dynamic process is played by *integrators*. According to Constantin Bratianu,

> *"an integrator is a powerful field of forces capable of combining two or more elements into a new entity, based on interdependence and synergy. These elements may have a physical or virtual nature, and they must posses the capacity of interacting in a controlled way"* (Bratianu 2007, p.111).

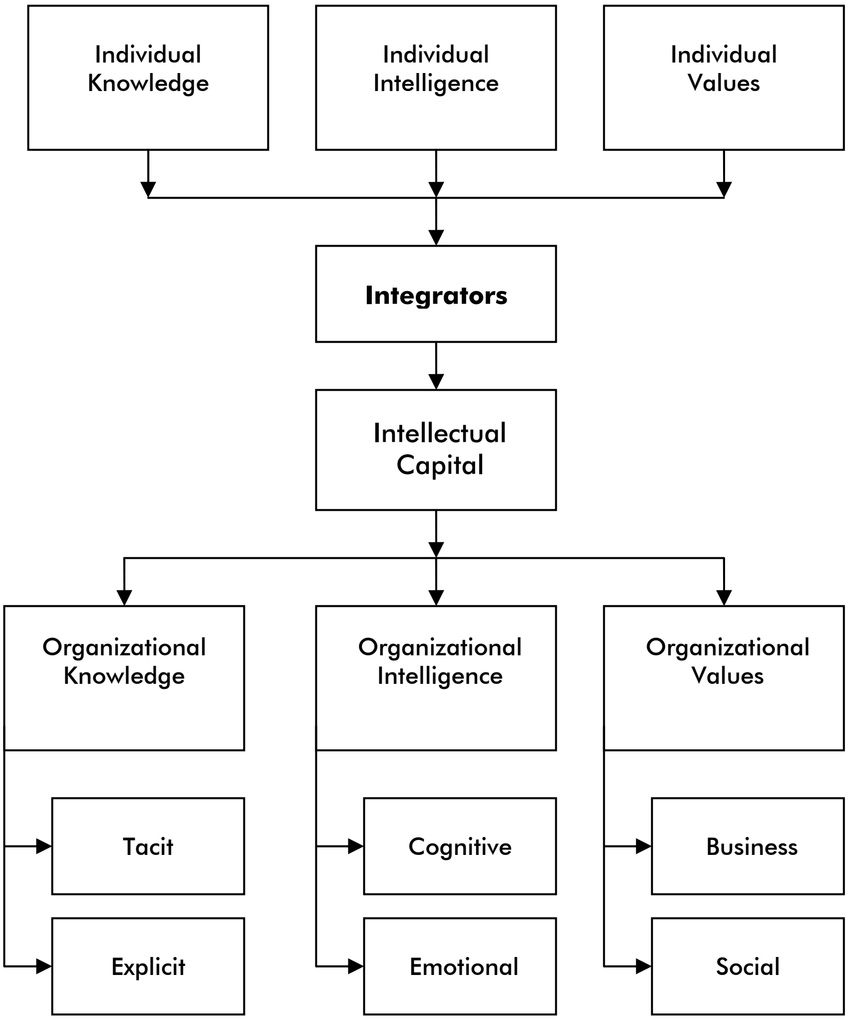

Figure 4. Integrated perspective of the organizational IC

The *interdependence* property is necessary for combining all elements into a system. The *synergy* property makes it possible to generate an extra energy or power from the working system. It makes the difference between a linear system and a nonlinear one. In the case of a linear system the output is obtained through a summation process of the individual outputs. In the case of a nonlinear system the output is larger than the sum of all individual outputs. For instance, a mechanical system made of rigid frames works in a linear regime, while a complex electrical system works in a strongly nonlinear regime. In the first case there is only interdependence and no synergy. In the second case there is both interdependence and synergy. In organizational behaviour, we can talk about linear work in groups and nonlinear work in teams. In the first case, sharing the same goal but not the same responsibility leads to interdependence and a linear behaviour. In the second case, sharing the same goal and the same responsibility leads to interdependence and synergy, which means a nonlinear behaviour. However, synergy is not a guaranteed effect. It must be obtained by an intelligent team management. We can say that this *team management* acts as an integrator at the team level. It is important to stress the fact that we adopted in this work the concept of multiple intelligence proposed by the Harvard University professor Howard Gardner (2006).

4. Integrators for learning organizations

The production process consists of a certain technology and all associated work processes. In classical industrial companies, technology and its associated processes put people to work together in different chain sequences and assembly line. These are linear systems based on interdependence and a technological flux. People can change their places or can be replaced by others without any change in the final result, as much as their contributions are according to their job requirements. Think about an assembly line for a motorcycle, where each worker is assembling usually only one piece to the whole body. Such an assembly line is not an integrator since it is a linear system. Let us consider now a modern airplanes manufacturing company, where all processes and technologies have been interconnected based on the concurrent engineering philosophy. That means to create a powerful IT system as a core framework and to allow many processes to develop simultaneously and interactively, generating this way the synergy effect. The main role is played by the IT system which is an excellent explicit knowledge integrator. In the new economy organizations where the intangible resources became much more important than the tangible ones, the synergy effect of the IT is felt stronger, and integration power increased almost exponentially.

For a university, the IT system constitutes a strong integrator if is used for creating a virtual campus and a virtual learning environment. In this new learning environment both professors and students share the same knowledge bases and intelligent platforms to process them. For those universities having highly developed IT systems, there is a strong integrator for both knowledge and intelligence. The organizational intelligence integrates in this case not only the individual intelligences but also the human intelligence and the artificial intelligence. The resultant systems might be considered some kind of hyperbeings: „Hyper-beings are not some figment of my imagination. They are organizations of unprecedented scale, spanning nations and continents, coordinating, working around the clock, honing their ability to think efficiently and act precisely. These organizations collect information on a real-time basis, assess their plans and expectations, and modify their models as required"(Hayes-Roth 2006, p.131).

Management is by its own nature an integrator, much more powerful than technology and its associated processes. However, unlike technology which is a highly specific and rather stiff integrator, management is a generic and rather flexible integrator. It acts upon the individual knowledge transforming it into organizational knowledge, and upon the individual intelligence transforming it into organizational intelligence. The technology integrator is capable to act only upon the explicit knowledge, which is codified in a certain way. The management integrator can act upon both explicit and tacit knowledge, generating explicit organizational knowledge and tacit organizational knowledge (Andriessen 2004; Davenport and Prusak 2000; Polanyi 1983).

The management process is intimately related to the production process, such that in an old type of manufacturing plant there is an old type of industrial management. In this situation, if the technology is very close to a linear system, the management will be predominantly linear and the synergy effect will be very small. Of course, workers are not machines but their activities are designed to be fuelled mostly by their energy and practical knowledge. The integrator will produce little organizational knowledge. On the other hand, in the new economy companies, where the technology integrator is highly nonlinear, the management must be also highly nonlinear in order to match the process requirements. The final output in this situation contains large synergy and the organizational knowledge contributes greater to the intellectual capital. However, we may find some anomalies as well.

A university is a highly nonlinear value system. If the academic management is based on linear thinking patterns, and linear decision making processes, the integration effect will be very small. I am considering especially universities from the former socialist countries, where the linear thinking and decision making is still very powerful and very inefficient. In these situations, the academic management is a poor integrator with very little synergy effects on the organizational intellectual capital (Bratianu 2005).

I am not going to open the debate concerning the overlapping meanings of management and leadership, or their definitions (Robbins and DeCenzo 2005). I am going to consider a continuum between management and leadership, with a driving force oriented from the left hand side toward the right hand side. Far away to the left I shall consider the linear management, and far to the right I shall consider leadership. Somewhere in the middle is situated the nonlinear management. The industrial era management is situated to the left, while the new economy management is situated in the middle. That means that leadership is a much stronger integrator than the new management since it acts especially on the individual intelligence and the individual core values of employees. While the management is emphasising the integration process of individual knowledge and individual intelligence, leadership is emphasising especially the integration process of individual intelligence and individual core values. Thus, it is a strong integrator with a powerful impact on the generation of organizational intellectual. Great companies have great leaders, capable to inspire all the employees with their force of vision and motivation (Welch 2005). Great companies run by leaders succeed in generating greater intellectual capital than companies run by mangers. In order to increase the organizational intellectual output it is necessary to move from the operational management toward the strategic management and leadership.

Unfortunately, in universities hardly we talk about leadership. University management remains predominantly a linear process, and most of the universities still have a huge bureaucracy. This is true especially for all universities from the former socialist countries. We may consider the case of the Romanian universities, where the academic management has been practically transformed into a pure administration. Leadership has been replaced by prominent scientific figures, like academicians, without any managerial skills. From this perspective, the actual university management is far from being a strong integrator for the learning process. The current legislation says that the department head is elected from within his department by vote. Thus, all members of a department participate in the election of its head. The dean of a faculty is elected by members of the faculty council, i.e. only by professors from within the faculty. The rector of the university is elected by members of the university senate, members who are professors at the university. No election can take into consideration candidates from outside the university. That means from election point of view, that a university is treated as a *closed system*. We know very well from theory and practice that closed systems cannot assure quality and performance in their management due to a natural process of increasing entropy and downgrading its life. From the practice of these transition years we learned how mediocrity spread out and dominate the whole spectrum of academic management. The only way to introduce a real and a beneficial competition is *to open up* the university for elections. That means to allow to any qualified professor, from any university in this country to be eligible for being elected to an academic management position. Thus, there is a natural increase of selection basis and of chances to get out of the internal mediocrity control. Decision should be taken by a commission composed of qualified persons and not by everybody. This situation is quite normal and traditional in many countries, especially in the U.S.A., where there is a special committee for searching the best candidates from all over the world. Starting April 1st, 2004, this new mechanism has been put forward in Japan, changing completely their traditions (Bratianu 2004). This competition will have an important impact on developing leadership in our universities, a basic prerequisite for transforming them into learning organizations.

Just continuing this above idea, moving toward learning organizations I shall put forward the vision and mission statement for any organization. Vision means a projection into the future of this organization, a projection capable of a strong motivation and inspiration for all its employees. An application of this vision in terms of products to be offered and markets to be served constitutes the organization mission. Thus, the strategic mission is externally focused. This is true also for universities. However, since all the Romanian universities before 1989 have been established by the government, not private or community initiatives, they had no vision and mission statements. Only recently, by implementing the strategic management in our universities after 1999, this important integrator became visible and a necessary instrument in developing learning organizations. Great leaders know how to use this integrator in generating valuable organizational intelligence and driving forces for elaborating and implementing successful strategies. Since emotions have a strong nonlinear nature, this integrator is capable of generating much more synergy than the previous integrators acting mostly on knowledge.

Peters and Waterman were among the most convincing authors in emphasising the great importance of corporate culture in achieving excellence. As they conclude in their research of the best-run companies,

> *"The excellent companies are marked by very strong cultures, so strong that you either buy into their norms or get out. There's no halfway house for most people in the excellent companies"*(Peters and Waterman, 1982, p.77).

A strong organizational culture is a system of core values, traditions, symbols, rituals, and informal rules that spells out how people are to behave most of the time. Companies that have developed their personality by shaping values, making heroes, spelling out rites and rituals, and acknowledging the cultural network have an edge over the others. These companies have values to pass along their life, not just products and profits.

Organizational culture is a very powerful integrator since it acts especially on the individual intelligence and individual core values, generating the spirit of excellence. However, the organizational culture can produce also adverse results if its core values are based on fear and punishment, and there is a mismatch between corporate interests and individual core values. Great leaders have always understood the importance of the corporate culture and thus they contributed first in developing a strong, and stimulating culture. As an integrator, organizational culture contributes especially in building up an intellectual capital with a great potential for innovation. Also, it can play a significant role in strategic and change management, and in crafting a successful organizational behaviour.

Organizational culture transforms actually a mechanical type organization into an organic type organization, as demonstrated by Aries de Geus in his excellent works (2002). This is true also for universities, and it is proved by the fact that world class universities developed in time powerful organizational cultures. Think about Harvard University, Massachusetts Institute of Technology, and actually all the Ivy League universities from USA, Oxford University and Cambridge University from UK, Tokyo University, Kyoto University or Osaka University from Japan, and examples can continue.

5. Conclusions

Universities are by their own nature organizations of learning, where knowledge generation and knowledge transfer constitutes the production process. However they are not necessarily learning organizations, and this is an intriguing paradox. Knowledge, intelligence and cultural values coming from all individuals who are part of the academic community is aggregated at the organizational level. This aggregation can be a linear or a nonlinear one. In the first case, the university is not a learning organization since there is no synergy and no learning within the management process. In the second case, the university generates important synergies and learning becomes an encompassing process. As a learning organization, the university can adapt continuously to the external economical and social environment, and it can generate knowledge for its future development according to its vision and mission.

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INFORMATION TECHNOLOGY AND THE COGNITIVE DOMAIN

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Abstract: *The purpose of this article is to map the context within which learning could occur, that is, the organizational learning processes and structures that can create or improve learning in a learning organization. Such an approach produces definition for learning organization and integrates the basis concepts into a model of organizational learning in the technologically environment, based on assisted instruction.*

Key words: *learning organization; organizational learning; assisted instruction*

Literature overview

Actual researches in the cognitive domain, focused on learning about learning, both as individual or as organization, imply information technology and two effects of it: diversity and globalization.

[Pedler *et al.*, 1991][2] define learning organization as a form of organization that enables the learning of its members in such a way that it creates positively valued outcomes, such as innovation, efficiency, better alignment with the environment and competitive advantage. [Finger & Brand, 1999, pp.137] conceptualize the learning organization as a strategic objective, like, increased profitability or customer satisfaction.

[Armstrong & Foley, 2003] relate that there is a little opposition to the premise that organizational learning is a competence that all organizations should develop in fast-changing and competitive environments, based on [Nonaka, 1991], [Senge, 1992], [Hamel & Prahalad, 1994]. In the same time, the authors distinguish between *organizational learning*, which concentrates on the observation and analysis of the processes involved in individual and collective learning inside organizations, and the *learning organization* literature that has an action orientation, and it is geared toward using specific diagnostic and evaluative methodological tools which can help to identify, promote and evaluate the quality of learning processes inside organizations. Their conclusion is based on the documented researches of [Esterby-Smith & Araujo, 1999].

[Phillips, 2003] outlines a ten-principle learning organization benchmarking and implementation model and describes the methodology used to establish its validity. The model is derived from the work of major thinkers and writers in the field of organizational learning and the learning organization, and attempts to outline the ideal learning organization. (1) *Will*: The organization maintains a passionate and enthusiastic commitment to continuous improvement through continuous learning. (2) *Leadership* is continually mindful that the vision is understood and shared at all levels and removes obstacles where necessary. (3) *Strategic thinking and vision*. Employees are encouraged to become system-thinkers. (4) *Communication*. (5) *Learning and development*. (6) *Innovation and decision making*. (7) *Change management*. (8) *Intellectual capital and knowledge management*. (9) *Measurement and assessment*. (10) *Reward and recognition*.

[Örtenblad, 2004] presents an integrated model of the learning organization, based on empirical research of the learning organization literature, as well as on practitioners' understandings of this concept. The model includes four aspects which cannot be treated as separate: learning at work, organizational learning, developing a learning climate, and creating learning structure. The author considers that the concept of the learning organization has been quite ambiguous, since it was first coined by [Garratt, 1987]. Örtenblad's integrated model is not a theory, but the author considers that it would increase the possibilities that the term "learning organization" can become an academically accepted concept, while it is now more practice-oriented.

[Sicilia & Lytras, 2005] are introducing the concept of a "semantic learning organization" as an extension of the concept of "learning organization" in the technological domain. The authors consider the learning organization as an ideal form of system in which learning behaviour improves and adapts, and managers are supposed to be coaches instead of directors. This vision contrasts to the old one, in which the knowledge is considered to reside in the company, mainly in the form of procedures, rules, and other means for shared representation. The article develop the idea that certain kind of technology can be considered as better drivers or facilitators for achieving the status of learning organization. The "semantic learning organization" extends the notion of learning organization in the technological dimension, so that it can be considered as a learning organization in which learning activities are mediated and enhanced through a kind of technology that provides a shared knowledge representation about the domain and context of the organization.

[Curado, 2006], in a literature review, explores a new idea, presenting the possible relationship between organisational learning and organisational design. Analysing different ways of thinking organisational learning, the author highlights that the nature of the organisational learning is, implicitly or explicitly, associated to the meaning of individual learning. Related to [Cook & Yanow, 1995], the papers concludes that this way, a relation between organisational learning and the theories of cognition can be established. As a result, this perspective on organisational learning is referred to as the "cognitive perspective".

[Thomas & Allen, 2006] consider that the need to create and apply knowledge has contributed to the prescription of a learning organisation. The two researchers appreciate that what are central to the concept of a learning organisation are both organisational learning, defined as the intentional use of learning processes to continuously transform the organisation, based on [Dixon, 1999] and the related concept of knowledge, based on [Argyris & Schon, 1978], [Revans, 1982], [Schein, 1993], [Senge, 1995], [Pedler et al., 1997].

[Dymock & McCarthy, 2006] fix as a purpose of their research to explore employee perceptions of the development of a learning culture in a medium-sized manufacturing company that was aspiring to become a learning organization. This objective was based on [Senge, 1990], the Senge's concept of the learning organization, as a goal, a state that could be achieved.

Basis for a new model

Basis for a new model results from the earlier theoretical and practical researches in didactics assisted design [Zamfir, 2003], [Zamfir, 2004], [Zamfir, 2005]; theory and practice interact in the educational space, and the learning system becomes the engine of the learning society. The idea was developed first in 1971, in information technology domain, when the microprocessor was created in order to solve a more general problem, and then it was included as a computer in a personal computer. We have to use concepts from computers science to create teacher professional development models that help mentors integrate technology into the curriculum. The basic structure of a personal computer consists of hardware (physical resources), firmware (logical resources implemented in physical resources), software (logical resources) and dataware (informational resources). Each part is based on an architecture which generates different effects in different approaches: logical, technological and functional. Technological development in the areas of information storage, retrieval, and communication, can be expected to alter the logical and functional directions, and by default, the manner of teaching and learning.

When people know their level of competence, they could learn what they need to know in order to meet specific job requirements and performance standards. Notions are shaped by the paradigms we hold. In this sense 'paradigm' means the 'working model' of what we do, why and how that we exist as intellect entities. Such a working model is Bloom's Taxonomy for the cognitive domain. The cognitive domain involves, as an entry, knowledge as a process, and offer, as an output, knowledge as an object.

[Zamfir, 2007a] develops an overview of the main activities of this permanent cognitive restructuring: configuring and maintaining the infrastructure that makes technology works. From this point of view of the cognitive restructuring, three kinds of infrastructure are likely to emerge: technological infrastructure, conceptual infrastructure of the new study programmes, and the cognitive infrastructure of all the participants involved in the learning process. Technology is usually 'embedded' in a device or an approach that, potentially, changes the way an activity is carried out. A device with embedded technology may be able to be used to carry out certain functions within an activity. Thus it may be useful to think of technology more in terms of functionality rather than devices. The context generated becomes infrastructure. In relation to teaching and learning, appropriate infrastructure has potential functionality in areas such as clarifying the zone of proximal development for a learner, scaffolding learning activities, mediating learning while in progress [Robertson & all, 2003]. Considering pedagogy to be the activities that assist understanding, and teaching to be scaffolding learning activities and mediation of learning experience, technology could be used in activities for developing learning objects, or as tools, in order to contribute to the completion of tasks. Tasks are undertaken in order to achieve a result or outcome.

[Zamfir, 2007b] analyses knowledge management from the point of view of assisted instruction and highlights that the duality of the knowledge (as an object or as a process), developed as a dichotomy generated different terms to distinguish between the types of knowledge: formal and informal, explicit and tacit, know-what and know-how. According to these concepts, there is knowledge that can be or not, easily expressed, captured, stored and reused. It can be or not, transmitted as data and is found or not, in databases, books, manuals and messages. [Nonaka, 1991] consider that "the two complementary entities interact with each other in the creative activities of human being and call this interaction the knowledge conversion process". This process consists of four stages:

socialization, externalization, combination and internalization and it reflects transfer tacit between individuals, translate into procedures, spreads throughout the organization and translate into individual.

The Vygotskian-inspired, sociocultural-based, learning-centered model is so radically different from the two most dominant models of teaching and learning (teacher centered and student-centered) that most people have never consider it. [Wilhelm & all, 2000] This is because this new model is two-sided and requires mutual effort and responsibility on the part of learners and teachers, whereas the dominant models are one-sided and place nearly complete responsibility for learning with the student.

Man has always lived and worked in some type of social network. An application of this model is the communities of practice, which became communities of competence, as self-organizing systems. The roles of corporate university, an enterprise academy and a community of competence are similar. It's about a process for total developmental integration – a totally inclusive people, learning and business and process idea.

Workplace learning basically operates with the concepts of learning environment and learning processes. Learning in the workplace includes the learning environments of the workplace and the employees' learning process. Technology influences what activities are possible and what activities may achieve.

Assisted instruction paradigm

In a world of a continuous change, one of the most prevailing behaviour is that of convergence. Concepts converge to form completely new concepts; people converge into new local, global and virtual communities; professional skills converge to create new professions. Technology converges to create new technologies and products; the personal computer become tool, tutor, and tutee and now is a real context in education.

One of the most important impacts of technology to the social context was the possibility of developing and implementing standards, as well defined levels of knowledge, in the cognitive domain. First of all, there were developed hardware standards, which generated software standards and dataware standards, for data processing. In information technology, the most important impact was about standards for users. In education, the new conceptual framework that characterize teaching as a complex cognitive skill determined in part by the nature of a teacher's knowledge system to explain patterns in participants' planning, teaching and post-lessons reflections is based on assisted instruction for a personalized process.

Based on the classic structure of levels in producing education (Pre-Assistant Lecturer, Assistant Lecturer, Lecturer, Senior Lecturer and Professor), we add new specific competencies (information literacy, computer literacy, technologic literacy and education literacy), and now, the teacher processes data, structures information, systematizes knowledge, developing educational objects.

Categorization, as a central topic in cognitive psychology, in linguistics, and in philosophy, it is crucial precisely in learning. Concepts categorization enables the student to classify (or to recognize the classification of) objects or concepts that belong to a group. This characteristic accelerates the thinking process, favours the immediate selective perception and facilitates generalization and learning. This is the pyramid of concepts and represents the basis for knowledge, comprehension and application. Categorization, together with processing and analogical reasoning, has a special role in the inference of non-explicit (tacit) knowledge that the learner can infer from what he has seen or heard.

Conceptual categories are higher order concepts, and they express the specific role of concepts in their contexts, and in concepts mapping they are visual elements relevant to analysis, synthesis and evaluation. These entities have a special role in processing explicit knowledge that the learner can receive in a pedagogical dialog.

Scaffolding in assisted instruction consists in developing and using dedicated applications in order to synchronize tacit knowledge to explicit knowledge in the zone of proximal development (see Figure 1).

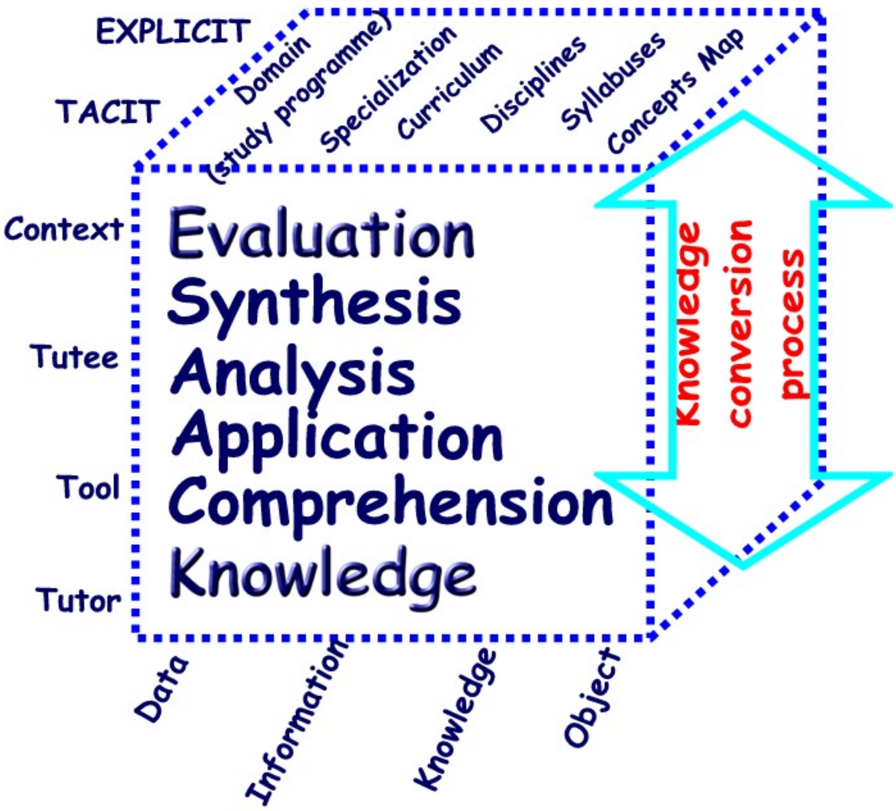

Figure 1. Knowledge and scaffolding in assisted instruction

Modelling, coaching and scaffolding are all types of support in education. Modelling can be part of a scaffolding process. Modelling provides an example of the required performance, whereby the most important steps and decisions are stressed. The goal is imitation of the performance of an expert by the learner. When the model is faded, which means that students should follow their own thoughts instead of following an example, modelling is a part of scaffolding process. Coaching can also be part of a scaffolding process. In coaching learners performs the required performance by themselves. A coach can give hints, prompts, and provides feedback to a learner. A good coach will be a scaffolder of students learning. This means that the coach will be receptive to the current level of performance of students, and will realize that the students should become self-reliant in performance of a task. Therefore this coach will fade the support that is given. So, in the case where coaching is faded, coaching is a part of the scaffolding process. But fading is not an explicitly mentioned part of the coaching process.

When the computer is used to instruct in traditional mode a subject matter area, it becomes a tutor. In assisted instruction, the teachers educated using the principle of computer literacy, become competent users; they develop, adapt, and optimize their applications, based on their observations and interactions. They can eliminate the routine, when it is necessary, by recording it in procedures, or they can activate the routine, in the other cases [Zamfir, 2004, pp. 50-55].

In a traditional approach, the term computer-assisted instruction is used to describe the tutor mode; with advanced users, the content, gradually refined (data, information, knowledge and objects) is based on a glossary, permanently enhanced: as a pyramid of concepts for knowledge, comprehension and application, and as a concepts map for analysis, synthesis and evaluation.

In the tool mode, the computer solves a practical function in getting a job done. It may become a paintbrush, a typewriter or an electronic spreadsheet. The widespread acceptance of tool applications such as database management caused schools to rethink the meaning of computer literacy. At this level, we optimize the convert process in the dichotomy tacit-explicit knowledge.

When computers are tutee, the roles are reversed: the student becomes the tutor. The student teaches the computer. In this approach, learning about computer is seen as a discipline unique unto itself: it is the beginning for training the trainers. There are three disciplines in this programme: Information and Communication Technology, Informatics Didactics and Computer Assisted Instruction., as they reflect the reference mode to the computer: tool, tutor and tutee.

When the computer becomes a context, it integrates all forms of education (formal, nonformal and informal) in a single one. The context means student desktop, teacher desktop or workplace office. The student desktop could be placed at home, in the classroom or in the office. This approach leads to the workplace learning concept; for an institution it could mean organizational learning. An educational institution is the first one which becomes learning organization.

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JOURNAL
OF
APPLIED
QUANTITATIVE
METHODS

COMPARING ORGANIZATIONAL LEARNING RATES IN PUBLIC AND NON-PROFIT SCHOOLS IN QOM PROVINCE OF IRAN

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Abstract: *Regarding the increased complexity and dynamics of environmental factors and rapid changes, traditional organizations are not longer able to match with such changes and are destroying. Hence, as a tool for survival and matching with these changes, learning organizations are highly considered by many firms and corporations. What you are reading, is a summary of theoretical basics and findings of a research about the rate of organizational learning of schools. Present research is based on reviewing the rate of organizational learning of public and non-profit high schools. To obtain the research aims, this hypothesis was considered: "there is a difference between the rate of organizational learning of public and non-profit schools."*

To collect the data and find the characteristics of learning organization (high school) library method and to review the rate of organizational learning, a structured questionnaire (after determining the reliability and validity) were utilized. Collected data were analyzed by using descriptive statistical method including frequency indices, frequency percent, mean and inferencial statistics such as Mann-Whitney test. Findings of Mann-Whitney test show that there is a meaningful difference between the rate of organizational learning of public and non-profit schools: "in all achieved characteristics, the rate of organizational learning of non-profit schools is more than public schools."

Key words: learning organization; organizational learning; public schools; non-profit schools

Introduction

Today, change that is a result of human's inventions, has involved all communities and our age is called "change age." All educational, economical, political and other kinds of organizations are under such changes. Because of such rapid changes, Benis calls organizations as "temporary systems."

As the starters of wide social changes, training systems are themselves facing with changes and their transformation in unavoidable. Heler says: "Today, the head of a pedagogic area can not neglect innovations in long term and he/she must show his/her courage to accept such innovations and do not resist them."

As the operational units of formal pedagogic system, schools have significant role and position in achieving training needs and ideals. So, the quality of human forces in schools especially the principal as an authority who designs and handles the processes and trends, allocates the resources, shapes the results, creates the learning capacity for all messages and experiences inside and outside the schools, is a fundamental factor. What matters, is the reinforcement of training principals to needed skills, techniques and knowledge for changes.

Many schools are not ready for implementing learning philosophy and others are going downhill because of their wrong management. In such schools, reviving issue is too important. Establishing learning schools needs a valued and visionary shift in educational system especially in all principals.

Problem expression

Today, organizations are in a changing and unstable atmosphere and huge changes have faced them with many problems. Facing with continuous change waves is obvious in the frame of new technologies in social relations of the organizations. In this age, one should endeavor to use innovations and technical/scientific achievements in order to run the organizations and to pave the way for innovations and proper plans in such organizations. When environmental uncertainty is high, organizations need more knowledge and awareness of using environmental factors in order to adapt themselves with environmental changes and transformations. In such conditions, the only way for future organizations is converting themselves to a permanent learning system to determine their environmental needs, to provide necessary tools to adapt themselves with the environment and to continue their life. Learning organization is a response to a changing, dynamic and unpredictable workplace. In fact, the nature of learning organization is using the extraordinary mental capability of organization's staff in order to achieve performances that improve organization's conditions (Dickson, 1990).

Therefore, regarding continuous of a skilful and high quality human force and the necessity of continuous answers to innovations, we need a learning organization that should learn, grow and break the organizational structures which prevent schools' internal growth. Utilizing the principles of learning organization can cause transformation, motion and new changes in training units. It is a step in establishing learning school.

Research objective

The aim of the research is to prepare functional guidelines by which principals can use them to develop learning organizations. Meanwhile, another aim is to answer some questions about the concept of learning school, such as:

1. What is a learning organization?
2. What are the characteristics of a learning school?
3. What shall be done to encourage and reinforce learning organization?

Research literature

Learning organization means the skills and capabilities of the organization to create, achieve and transfer the knowledge and reforming individuals behavior to reflect a new knowledge and vision (Garvedin, 1993).

Organizational learning: a process in which organization members find mistakes and attempt to revise them (Argyris and Schon, 1978).

Public schools: according to law, these are schools run by the government.

Non-profit schools: these are schools founded and established by people's participation based on aims, rules, plans and general recipes of Education Ministry and are monitored by this Ministry.

Although one can identify a long history for "organizational training", the formal emphasis on training backs to mid-1940s. At those years, experts believe that "in-service training" should be designed and implemented in a way to be effective for overall organization's improvement. To achieve this aim, training should be effective either in identifying organizational deficiencies or in resolving the problems (Soltani, 2001, p. 200).

In next years, planning and implementation of organizational training courses were increased broadly. "The formation of training courses started form UK and USA and then distributed gradually from two academic routes and great/multinational firms to other countries" (Mehrdad, 2001, p. 8). However, by starting "organizational development" activities, training was considered as a principal element in all HR management programs and the amount of emphasis on training was considered as one of the important scales in organizational efficiency. In this period, organizational improvement experts analyzed concepts such as "organizational training", "individual learning", and "collective learning" in various aspects.

Above discussion resulted to the emergence of "learning organization" concept. In 1962, it was March who gave a definition for this concept for the first time. This concept was discussed and analyzed by management connoisseurs until the early 1990s when Wick and Roberts granted a new definition. According to Wick and Roberts (1993), learning organization shapes via the informed interactions of individuals that result to "collective intellectual".

The fundamental reason of emphasis on learning organization is the growing speed of changes. Among researches on learning organization inside and outside the country, there was not a research that studied learning organization in training units. Hence, it is attempted in this research to use the generic frameworks of "learning organization" to devise a new paradigm for the principles and characteristics of learning organization that are appropriate with schools' conditions and requirements. Following discussion addresses to this question that how training organizations can convert to a learning organization.

The characteristics of a learning school

The issue of learning in organization should not be considered only as a cognitive issue. We should look for characteristics by which organizations can achieve a clear and complete understanding for obtaining the skills of organizational learning. These characteristics should be identified and taught to principals in order that they use them to improve learning organization. In this research, a library method is applied to find the characteristics of learning organization and to review the research background. By using computerized searching, domestic and foreign researches were studied and finally four following characteristics that could be applicable in schools were chosen from various characteristics:

1. Change-maker leader

Change-maker leaders are those who facilitate changes, innovation, creativity and entrepreneurship; believe in organizational transformation; and prefer organizational reviving (Slitzer, 1990, p. 699).

In a learning organization, leaders are also designers, observers and teachers. Their responsibility is to make organizations where people can increase their common mental models and their capabilities. It means that leaders are in charge of employees' learning. Their vital role as the designers of learning organizations is to integrate the views, purposes and systemic thinking. The first step in planning organizational structure is to design the ideas and viewpoints, ideals and fundamental values that people believe and live with them. Stata says: "As a whole, organizational planning is to understand untouchable values that link the elements to each other."

The best way to realize "leader's role as an observer" in the framework of a learning organization is to study that how all people are committed to works which are an interpretation of their visions and ideas. As teacher, leader is not going to teach others how to observe. He/she is going to cultivate learning inside them. Inside the organizations, such leaders help the people to broad their views and systematic understanding (Senge, 1990). Therefore, more than any other activity, conducting organizational changing programs is based on effective leadership patterns.

2. Creative and constructive staff

In today pedagogic view, the rate of responsibility, freedom and independence of school staff (Robins, 1995, p. 967), have caused that the schools being considered as the origins of social changes and innovations and they are so-called "changeable" entities. In this line, pedagogy and society have mutual effects and pedagogy transforms not only the individuals but also other entities. Therefore, it is a context for transformation. This vision has achieved an important position in today vision. Such changes will cause innovation in training and education.

Nowadays, some thinking schools believe that creativity, is teachable and learnable (Kwartko and Hagets, 1989, p. 70). According to "changeable view" and definition of creativity, a learning school is an entity which is skilful in achieving creativity, transforming the knowledge and changing the behaviors to reflect new knowledge and insights. Creativity and innovation will be encouraged and a system is designed in which the role and share of each person is determined and creative/innovative ideas and plans are grown and executed in an interactive and collective process. It is obvious that such conditions needs creation and promotion of reliance, respect and mutual cooperation in order to provide necessary grounds for free expression of opinions and new plans. The schools must commit themselves to improve their staff in order to be benefited from learning and creative staff. So, an important and effective endeavor in line with learning organization is planning for growth and development of staff and breeding learning and creative individuals.

3. Collective learning (team working)

Collective learning is a process in which the capabilities of group members are developed and are coordinated in a way that resulted to a conclusion that all people are looking for (Senge, 1990).

In the organizations, collective learning has three basic aspects: (1) needing to deep thinking about complex concepts (2) needing to a new and coordinated act (3) the role of team members in other teams. Collective learning is based on to dialogue and discussion. "Dialogue" means to express basic and complex problems creatively and freely and to listen to other's viewpoints deeply. On the other hand, "discussion" means to find the best point to support the decisions made over time. Potentially, dialogue and discussion complete each other. Most groups, however, fail to distinguish them. Meanwhile, collective learning should be able to fight against powerful barriers on constructive discussion and dialogue. Chris Argyris calls these barriers as "defensive ways."

4. Common ideal

Common ideal is a force that behaves inside people's hearts as a huge power and gets them to act (Senge, 1990). However, the common ideal is maybe inspired by a good belief, but it never stays in one believing level. Particularly, the common ideal will be so effective that many human acts will be driven by its power, if it is supported by more than one individual. What is common ideal that creates such a power? In the simplest level of common ideal, the answer is "what we are going to create." The personal potential and actual capability will guide human to a certain direction and common ideal performs such act in organizational level. In this line, it creates a huge power. Exactly, one of the reasons that people are looking for common ideal is to link their imaginations about their own ideals by which to create a common support in order to be protected by it. Common ideal is a vital factor in establishing a learning school because that it supplies necessary energy for learning. Today, "ideal" is a known and familiar concept in organizational leadership. Have consider its growth in detailed, we can understand the practically, the ideals of one person or a small group of men are dominated over the organization. At the best conditions, others do not oppose these ideals but do not feel commitment to them. However, a common ideal is one that most members of a society or an organization or a school feel belonging to it because that they consider it as their own personal ideal. An ideal can act as a live and dynamic force that the people believe that they can construct their future and walk in this route actively. Therefore, there is a simple and obvious truth that many managers do not perceive it. Managers never see their own share in creating current conditions and problem. Basically, they do not accept their responsibility, face the truth proactively and believe that all problems are due to system or environmental pressures. Teaching managers and principals can create an environment in which individuals can find and develop their personal ideals.

5. Motivational incentive

Everything will be repeated if it is reinforced. In fact, suitable rewards should be determined for certain behaviors in order to be repeated (Levebof, 1993, p. 85). By motivational incentives we mean the allocated rewards that are paid to employees based on their performance indices not their service background, relations, etc (Robins, 1995, p. 968).

Built-in rewards are among the fundamental pillars of rewarding and incentive system in entrepreneurial and learning organizations. Such incentives meet individuals' mental needs including the feeling of meritocracy in work, respect, belonging to a group, freedom, dependence, authority and progress. People like to feel honor and proud for what they do. They need that their works are driven by their motivations. Learning organizations consider followings in their incentive and rewarding system carefully:

- Types of incentives
- Employees' merits
- Regulating rational executive aims
- Performance-based incentive and rewards
- Predicting (estimating) the amount of chances that people could have for being rewarded.

Therefore, considering the limitations for paying material and extroverted incentives, schools' principals should do their best to develop their employees' learning capacity by introverted rewards (Samad Aghaeei, 1999, p. 156).

6. Organizational Culture

A powerful learning culture emphasizes on high learning capacity of schools' employees as well as the organizational values and norms in an individual or collective process (Finger, 1999).

There are various definitions for organizational culture. For example, organizational culture is described as the superior values by which organization is supported, or a philosophy that guides organization's policy toward staff and customers, or values by which daily works are performed in the organization (Robins, translated by Alvani and Danayi Far, 1997, p. 1381).

Many texts are written about dominated atmosphere and culture in schools. However, school culture should be humanity and has a comfortable and peaceful space mentally. Individuals should be relate each other warmly. Schools should be supportive, namely, they should spaces where the people can access needed training tools and cooperate with and learn from each other (Ron Brandt, 2003).

7. Experience and knowledge application

It means that schools endure many tests and failures. Of course, a test and experiment is acceptable that is based on planned thought and is defensible. We do not mean test-and-error. Leaning organizations believe in failure-success theory. It means that failures and successes are happened simultaneously. In fact, this theory divides the organizations into four categories:

- Shooting star organizations: these are organizations that have both many successes and many failures and have a short life like shooting stars. They accept irrational risks.
- Sentenced to death organizations: these are organizations that have irrational risks.
- Fire-brand organizations: these are organizations with small successes and failures. They are like half-burnt wood and can survive for longer term but with not a considerable profit.
- Outstanding organizations: these are organizations with small failures and high successes.

Entrepreneurial and learning organizations are in outstanding organizations category. Of course, it does not mean that they never fail, but with encouraging fruitful failures (encouraging those who promote the vision and learning of other people by expressing their own mistakes and reasons of their failures) and denying irrational risks, they go from shooting star category to outstanding category. On this basis, incentives in learning organizations have no relationship with the results of activities or events. Besides, the incentive system is designed so that they have the highest effect on individuals' vision and thought in order to find and utilize new opportunities. In other words, learning organizations believe that rewarding the successes is simple but rewarding smart failures is more important and harder because that the efforts are based on the efforts not the achieved results.

8. Accepting the suggestions

Contributive management facilitates the involvement of employees at various levels in problem identification process, analysis the situation and achieving proper resolutions (Management Association, 1992, p. 17). Contributive decision-making is a way to curb bureaucracy and to create motivation and find oneself situation (Bull Ve Ball, 1989). The fundamental hypothesis of employees' contribution is that employees' contribution leads to more productivity. This positive relationship between employees' contribution and productivity is resulted from the belief that interacting with staff in work decisions will cause that they feel more satisfactory feeling in their work. Accepting system and reviewing the suggestions can lead to increase the employees' desire in order to think about schools' improvement if such system is paid attention in schools and a program is planed for it. To systemize this method a secretariat should be established to collect the suggestions, a council and ad hoc committees should be formed to investigate these suggestions and such activities should be promoted under the school principal's supports.

9. Information Exchange

Principals must start their work by asking themselves two questions in order to produce useful data:

- What information my colleagues will receive from me? How? When?
- What information do I need? From whom and how? In what schedule?

The first question shows the importance of work nature. Our first question should be about others' needs and then to achieve the second question.

Those principals who ask themselves such questions will realize very soon that only a small part of their needed information is inside the organization and major part of these information is outside the organization. Such information should be organized separately and independently. "What information do I owe to others?" and "What information do I need from others?" seem simple; but in practice, answering them is difficult and needs high thinking, experience, experiment and endeavor. On the other hand, one should not assume that the answers are always stable and permanent. Particularly, when remarkable changes are happened in various times, organizational structure, work and mission should be reviewed.

People will understand mentioned questions and will find proper answers for both questions if they consider these questions carefully and seriously (Blanchard, translated by Amini, 2000). Awareness and information exchange (regular, exact and flexible) are performed in inter-school, intra-school and cross-school conditions. For example, information about doing the works on time, standard deviation, the rate of people's absence, complaints, students and their parents appreciations, the rate of relations with students/parents, pursuant, job units-related data (training – research data), contribution rate, employees' satisfaction and any other information that a leader needs to understand successful management, are also needed by staff for a correct decision. Schools' principals should have the courage to start informative contribution work because that its risks are not less than information monopolization.

10. Using environmental opportunities

This means that the population of each age group should be able to access training resources and facilities. Therefore, training facilities such as school, class and competent teachers should be provided for attracting the students and those who must be taught. By allocating school space in informal hours, providing special possibilities like equipments, laboratory, computer, extra program classes, students' team-making and shaping learning groups, schools' principals and staff can provide better learning opportunities for students.

11. Customer-oriented

It means that the main focus is on customer satisfaction via continuous progress in efficiency and quality of services. Nowadays, servicing or producing organizations consider customer satisfaction as an important scale in measuring the quality of their works. This trend is keeping on. A successful organization is one that while supplying customers with qualitative and acceptable goods and services, meets their needs and even provides them with services that are higher than their expectations. Achieving such level of customer satisfaction is impossible unless one assures that by continuous experiments and investigations of a quality system, organization has always a good possibility to visit customers' needs/expectations. In fact, the firs objective of an organization must be customer satisfaction in highest level. Customer-oriented organizations provide a proper ground on which customers can inform the authorities of their suggestions and complaints. In learning and responsible schools, principals measure the satisfaction level of students, parents and staff directly by their researches such as questionnaire distribution, shaping student councils, associations, studying the problems via training and research units; teachers council, correspondence boxes, etc.

12. Matching with ongoing changes

School's organizational structure is organic (dynamic and human nature) and school members are allowed to participate in decision making processes and represent their new ideas, opinions and resolutions. It will encourage them to contribute in change and transformation process as an element of pedagogy system. Current viewpoints regarding learning organizations rely upon adaptability capability. With regard to rapid steps of shifts, a research in Fortune magazine reads: "The most successful corporations in 1990 were those that were called learning organizations and had the highest adaptability capability." Therefore, against traditional schools with bureaucratic structure, learning schools have organic structure and their members are allowed to participate in decision making processes and represent their new ideas, opinions and resolutions. It will encourage them to contribute in change and transformation process as an element of pedagogy system.

13. Performance assessment

Performance assessment means to improve employees' performance and information exchange in relation with their activities and also to establish a basis for promotion, incentives, advisory and other aims that relate with employees' future work. We must consider performance assessment as a positive method in staff's participation. Many supervisors consider performance assessment as undesired task. Conversely, if as a part of hiring process, the employees are interviewed sufficiently, are training correctly, are helped when needed and are advised carefully, then their performance will reflect the acurateness rate of such tasks. Performance assessment reveals that how much an employee has been effective in organization's success. Culture, ethics, training levels and pre-determined beliefs influence over evaluations. It is really unfair to have a weak ranking based on bias or something except than what is important in assessment. Therefore, an unfair assessment can cost the organization to miss one of its valuable employees. So, in evaluations and running the organization, a unified and steady leadership is not helpful longer. Since the combination of training and education human force is a mixture of various cultures, principals should be able to penetrate into them despite of individuals' different cultures.

14. Systemic thinking

Systemic thinking means that principal and staffs consider all elements of the school and believe that there is a mutual and dynamic relationship between their school and environmental conditions. Systemic theory in management is a thinking method about organizations that provide managers with a framework by which they can have an integrated vision about inside/outside factors. In this theory, it is emphasized on dynamic relationship among organization's shaping factors as well as the dynamic relationship between organization and other organizations. On this basis, the manager has a holistic and generic vision (Zarei Matin, 2001, p. 101). The main part of systemic thinking is changing the visions. Therefore, by using a new pattern of thinking, training management can evaluate these elements by relying upon its concept and spatial situation, evaluate their effects in relations between adjacent and non-adjacent factor, and understand its position in shaping total concept of the organization to achieve the aims. A school is learning if its principals start thinking to identify systemic paradigms, apply this method as an effective tool in their daily behaviors and decisions and discover hidden secrets of problems and difficulties.

Research methodology

Topics	Descriptions
Research type	Descriptive-survey
Statistical population	All public and non-profit high schools in Qom City 2002-2003
Sample size*	$n = \left[\frac{z_{1-\alpha} + z_{1-\beta}}{d} \right]^2$, $d = \frac{\mu_2 - \mu_1}{\sigma}$
Sampling method	Stratified random (34 public schools – 34 non-profit schools)
Measuring tool	40-inquiry questionnaire
The method of reliability	Alpha Chronbach = 0.95
Data analysis method	Mann-Whitney test

* In sample size formula for hypothesis testing, α = 0.005 is type I error, β = 0.05 is type II error and d **=0.8** is the precision

Research hypotheses

Main hypothesis: there is a difference between organizational learning in public and non-profit schools.

To evaluate organizational learning, 14 characteristics were identified and 14 sub-hypotheses were designed as follows:

1. There is a difference between employees' creativity rate in public and non-profit schools.
2. There is a difference between utilizing systematic thinking in public and non-profit schools.
3. There is a difference between utilizing science and experience in public and non-profit schools.
4. There is a difference between change-making leadership in public and non-profit schools.
5. There is a difference between motivational rewards in public and non-profit schools.
6. There is a difference between team working in public and non-profit schools.
7. There is a difference between organizational culture in public and non-profit schools.
8. There is a difference between accepting the suggestions in public and non-profit schools.
9. There is a difference between common ideals in public and non-profit schools.
10. There is a difference between using environmental opportunities in public and non-profit schools.
11. There is a difference between customer-orientation in public and non-profit schools.
12. There is a difference between matching with time changes in public and non-profit schools.
13. There is a difference between information exchange in public and non-profit schools.
14. There is a difference between performance assessment in public and non-profit schools.

Research findings

At present research, organizational learning had one hypothesis with 14 indices. They were evaluated by using Mann-Whitney test. The results are listed as follows:

A: the average rate of organizational learning characteristics at two types of schools in Qom City

Organizational learning characteristics	Non-profit Schools	Public Schools	Z	P.Value
Employee's creativity	221.00	140.89	-7.345	0.0001
Systemic thinking	202.42	157.24	-4.253	0.0001
Change-making leadership	166.85	119.49	-4.898	0.0001
Science and experience application	218.62	138.06	-7.512	0.0001
Motivation reward	203.69	154.14	-4.608	0.0001
Team working	205.97	150.81	-5.113	0.0001
Organizational culture	209.93	146.15	-5.888	0.0001
Accepting the suggestions	202.31	156.08	-4.303	0.0001
Common Ideal	210.31	146.94	-5.856	0.0001
Using environmental opportunities	217.59	141.13	-7.167	0.0001
Customer-orientation	211.62	143.35	-6.373	0.0001
Matching with time changes	214.48	140.15	-6.869	0.0001
Information exchange	195.72	160.57	-3.298	0.0001
Performance assessment	202.62	145.54	-5.402	0.0001

By using Mann-Whitney test and comparing each index-related averages, it was identified that non-profit organizations in all characteristics (14 sub-hypotheses) have better conditions than public schools.

B: the average rate of organizational learning characteristics at two types of schools in Qom City

Average	Numbers	School type
208.64	169	Non-profit
127.88	167	public

Main hypothesis: there is a difference between organizational learning in public and non-profit schools.

H_0: $\mu_1 = \mu_2$

H_1: $\mu_1 > \mu_2$

By using Mann-Whitney test, Z= -7.621 and by P<0.0001, H_0 is not supported. It means that organizational learning in non-profit schools is more than public schools. So, main hypothesis is supported.

Research limits

1. Careless and reluctance of samples in answering to questionnaire who thought that the aim of questionnaire is to evaluate training centers (schools). So, it is suggested that culture-making organs, Ministries, managers and experts emphasize on completing the questionnaires and attempt as a bridge between training centers and research centers.
2. Limitations emerged from human complex behavior and uncontrolled variables that made it difficult to identify and control them despite of researcher's efforts.
3. Unavailability of a standard questionnaire. Although the researcher did his best and the questionnaire had a high validity after making necessary modifications, it is not a standard questionnaire.
4. Lack of research information and resources regarding the concept of learning organization in training organizations. It is hoped to have richer resources through future researches.

Suggestions

1. Reviewing the concept of learning organization, aspects, conditions, requirements, the benefits of a learning school, the role and position of learning in efficiency of school and organization in all levels/elements of pedagogy organization and designing a clear/practical administrative plan for establishing a learning school.
2. To restructure schools in a learning organization, administrative principles and trends of a learning organization must be implemented in all levels of the organization. The logic and rationale of the structure of a learning organization must shape the organizational culture. It means that these principles should be executed for both employees and managers.
3. Accepting the philosophy of a learning organization in different managerial pedagogy levels especially in restructuring of schools and their tasks and activities.
4. Equipping the schools especially their principals and pedagogy divisions to facilitate learning in themselves and others.
5. To establish learning schools, it is necessary to decrease the bureaucracy and principals being enjoyed more authority and freedom.
6. Utilizing 14 identified characteristics in researching schools' organizational structure practically.

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JOURNAL
OF
APPLIED
QUANTITATIVE
METHODS

ASSESSMENT OF ORGANIZATIONAL LEARNING WITHIN TEAMS

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Abstract: *Two representative approaches to measuring and assessing organizational learning are compared. Based on the benefits and drawbacks of each, an alternative framework is proposed for an assessment based on action science, from pragmatic point of view of members of a team within an organization which has declared an intention to improve learning processes.*

Key words: *organizational learning; the learning organization; assessment; measurement; action science*

1. Introduction

The organizational learning literature is quite sparse on methods for evaluating and measuring learning organizations. For the purposes of this article, we have selected two representative approaches: Moilanen (2005) who proposes a theoretically eclectic and highly quantitative evaluation method; and Smith & Tosey (1999), who propose an essentially qualitative assessment grounded in new science. We will compare them, observe the benefits and drawbacks of each from the strictly pragmatic point of view of members of an organization which has declared an intention to improve learning processes, and will provide an alternative assessment methodology.

2. Quantitative approaches and Moilanen's holistic measurement tool

Moilanen (2005) provides an inventory of the measurement instruments available for learning organizations. These are summarized in the table below:

Table 1. Questionnaire-based measurement instruments for the learning organization

Researcher	Year	Description
Pedler et. al	1989	Emphasis on the whole and on the individual's role within the whole; covers strategy, looking in, structures, looking out and learning opportunities
Mayo & Lank	1994	Emphasis on the actions needed to impact the learning process; Very broad; 9 dimensions, 187 questions
Tannenbaum	1997	Emphasis on: processes, training, and support. Carefully examines the learning environment
Pearn et al.	1995	Emphasis on ways for managers and organizational structures to encourage learning. Over-focused on leading and encouraging.
Sarala & Sarala	1996	Emphasis on validating an organization as 'learning' or not. Covers philosophy and values, structure and processes, leading and making decisions, organizing the work, training and development, and the internal and external interaction of the organization.
Otala	1996	Very general, not well rooted in a theory. Very brief - only 20 questions; self-assessment utility.
Redding and Catalanello	1997	Emphasis on the capability for learning, placing organizations within the archetypes of "traditional", "continuously improving" and "learning organizations". Simple to utilize.
Watkins and Marsick	1998	Emphasis on the aspect of learning from the individual, team, organizational and global perspective. Covers continuous learning, dialogue and inquiry, team learning, embedded system, system connection, empowerment, leadership, financial performance, and knowledge performance.

Moilanen then goes on to create and propose a comprehensive measurement instrument. His approach is not grounded in any single theoretical approach; on the contrary, there significant effort is put into listing, grouping, and an attempt to reconcile the main elements of organizational learning found in the works of Mike Pedler, Tom Boydell and John Burgoyne, Chris Argyris and Donald Schon, and Peter Senge. On this basis, a set of five areas of focus are selected: managing and leading as driving forces, finding purpose, questioning, empowering, and evaluating learning and learning organization. The author seems to consider that, by grounding his measurement instrument on an eclectic approach to organizational learning - essentially re-classifying these views to create an all-inclusive theory - a more holistic view of an organization can be achieved, and "a holistic view of learning organizations was chosen as the main criterion" (Moilanen, 2005). We shall later consider the impact of the choice of criterion and method of reaching this objective on the usefulness of the instrument for growth toward learning organizations.

On this eclectic theoretical basis, Moilanen constructs an instrument to evaluate the present state of a learning organization. The instrument is relatively straightforward to use - only 40 statements are used (though the researcher contends that "for practical purposes, the number of statements is perhaps too high", *idem*), half of them focusing on the individual level and half on the organizational level. At both levels, the statements operationalize the five areas of focus that constitute the holistic framework, and for processing are clustered by these areas of focus. Sample statements include: "Building a learning organization is a priority and has many resources in our organization" (a statement situated at the organizational level and focusing on "managing and leading as driving forces"), and "I am able to assess the outcomes and methods of the work of our team" (a statement situated at the individual level, focusing on "evaluating learning and learning organization").

The statements are then visualized by means of a diamond, which has the advantage of showing the five elements at both the individual and organizational levels in their interdependencies. This diamond is presented in the individual and organizational version, and the size and balance of the sides of the diamond are a clear and compelling visual indicator of the readiness for learning within organizations. The instrument was applied to 27 of Finnish companies, and the results of the study are presented by Moilanen in considerable detail, with an analysis of the difference between the individual level and organizational level of learning (the diamond is consistently larger at the individual level than at the organizational level) and of the difference in organizational diamonds across industries.

3. Limitations of Moilanen's approach

The rigorousness and comprehensiveness of Moilanen's method make it a good coalescing point by which to assess the quantitative, questionnaire-based approach to learning organization evaluation and measurement. These methods utilize a questionnaire delivered at the individual level, where participants are asked to individually provide their own assessment of their personal learning and the organizational learning, with varying degrees of prior familiarity with learning organization concepts. This approach is defended by statements such as "Taking a holistic perspective of a learning organization has its advantages but considering the individual before viewing the entire organization may be more informative" (Small & Irvine, 2006). However, the cumulative result of individual assessments of a group phenomenon will be vastly different from a group assessment obtained via a dialectical, political and collaborative process; and measurement systems that focus solely on the individual representation of social realities cannot but fail miserably at creating constructs that are meaningful and useful at the social level.

The evaluation provided by these methods is discrete and regards the state of the organization at a particular moment in time. In Moilanen's case, this state is captured graphically via a diamond shape as an archetype. Taking a discrete view of the continuous process of organizational learning and of growth towards a learning organization, without careful consideration of the path between one iteration and the next, is a severely limiting form of assessment.

Moilanen goes to great pains to create a holistic measurement framework, and admits that "the framework is rather general, because organizations are different; their backgrounds, histories, cultures, processes and businesses vary enormously." (Moilanen, 2005) There a very real danger that a model that is inclusive, general and eclectic enough to fit all organizations might be all but useless for any particular organization, unless it is used only as a starting point to collaboratively create a customized tool for the particular organization that intends to use it as a benchmark for growth. An eclectic approach such as Moilanen's raises serious questions about the meaningfulness of the instrument proposed. If the nature of the phenomenon should be understood in a meaningful way before any attempt at an objective or even useful measurement instrument is made; if the instrument is not grounded in a theory that provides an understanding of reality, but rather draws on multiple theories without providing and proving a coherent integration, such a measurement tool will only confuse and misrepresent.

4. New science and Smith & Tosey's simple discriminant techniques

Smith & Tosey (1999) highlight further difficulties in the evaluation and measurement of learning organizations. They approach the issue of assessment of learning organization from a more qualitative point of view that is based on new science - a "different perspective" that aims to provide "simple discriminant techniques for learning organization assessment".

Their analysis of the limitations and difficulties in assessing learning itself is helpful and illuminating. While recognizing that a simple measurement of the extent and type of learning appears to be the best type of assessment available, Smith & Tosey highlight the following key difficulties with such an approach: what is measurable is not necessarily a good representation of the process that is being studied, so that an approach that reduces the phenomenon to what can be measured about it will necessarily distort its meaning; the meaning we attribute to learning is a construct that is dependent on the meaningfulness of our theory about learning, and is therefore elusive - it is not possible to directly observer learning, all of our statements about it are obtained by inference; and the indicators that are available to human observation to support this inference might often not be an indication of the most meaningful type of learning, as "the most measurable learning may not be critical in terms of change leverage and performance" (Smith & Tosey, 1999).

Based on the analysis of these limitations, Smith & Tosey posit that assessing learning organization is primarily political in its nature, not technical or scientific.

"The activity of assessing learning and of making progress towards the learning organization ideal is, we argue, essentially a social process" (Smith & Tosey, 1999).

Assessing is social and political because on the one hand, the very process of growing towards the state of a learning organization is a social process, and on the other hand, learning itself is a different construct for different actors and groups within the organization.

Under these limitations, three main solutions have been adopted for the evaluation and measurement of the learning organization. By circumscribing the organizational learning process tightly within the existing power structures of the enterprise, those indicators would be selected that the management team considers to be the most desired outcome; it is to be observed how this approach to evaluating organizational learning contradicts the very theory of organizational learning (for ex., a top-down results-based assessment will be very liable to the perverse effects of feedback within systems; and it is difficult to avoid the accusation of incongruence between such an approach and Senge's "shared vision"). A second approach is to avoid the results trap and focus on the learning process itself, and measure the elements of this process that are the most measurable; this approach, however, ignores qualitative growth in learning strategies, that would make it impossible to accurately infer the level of learning by focusing on only some elements of that learning process; the approach will also lead to organizations reducing their organizational learning activities to the formal training, which is measurable, but very far from the leading thinking on organizational learning. The third approach is essentially the one taken by Moilanen, where indicators are selected based on the work of researchers in the field; as indicated, this approach requires the use of experts in both administering and interpreting the results, but a more serious drawback is that, to the extent that the theory is tightly knit, indicators will confirm its positions rather than provide any helpful link to organizational effectiveness.

These three approaches are then proposed as not mutually exclusive, but rather as providing valid methods as "heuristics" that, by organizing the culture and structure of an organization that wants to grow towards the learning organization ideal, provide a useful guide to action. This position is inspired by Weick's insistence that not accuracy is the main issue in representation, but rather the capacity to "galvanize action". However, giving up on accuracy to obtain a highly galvanizing evaluation has ungauged consequences for the capacity to maintain long-term energy and coherence around an organizational learning endeavor.

Smith & Tosey propose two approaches from their own research and consulting experience. These approaches are heavily rooted in the mindsets and metaphors of "new science". The first one is a three 'field' system consisting of focus, will and capability (with performance added to provide an objective measure of desired results). This approach is operationalized via a simple questionnaire, administered individually, where items are then grouped and processed along these axis. Thus, we find that, essentially, this approach is not different from any of the quantitative approaches that Moilanen considers or his own eclectic instrument; the only difference being that the statements are organized into a different set of areas of focus. The second approach proposes a model of organizations as energies of consciousness, and indicates seven types of energies that are present and move action at different stages in the life of an organization, ranging from very primary to more socially-organized forms of energy. This is a diagnostic tool to facilitate understanding and identify blocks to energy.

5. Limitations of Smith & Tosey's approach

While Smith and Tosey offer a very pertinent and helpful analysis of the difficulties of assessing learning organizations and the fallacies of traditional assessment methods, their proposed methods are insufficiently helpful in providing ways to move beyond these limitations. Their approach is highly speculative - a fact that they recognize themselves. This would severely undermine the capacity to transfer the methods into organizations with a culture that insists on rigor, especially once this introduction is no longer accompanied by the personal charisma of the authors. Both methods are heavily grounded in new science concepts and metaphors. This conceptual framework and the associated language is only familiar to a limited number of people, and it is likely that only a very small percentage of members of any given team or organization would have had previous exposure or interest in these matters. The time and effort necessary to introduce these concepts are considerable, with results quite mixed, as some people would readily understand and embrace the concepts based on a personal affinity with more 'loose' ways of thinking, while others would react with cognitive defense mechanisms. Among those who do embrace the concepts, these remain quite ambivalent and undefined, and when requiring members to use them as metaphors (with a high level of emotional content) for organizational processes, a radically different understanding would be adopted by each member. Thus, even training on new science concepts would not efficiently provide a common language. In fact, the researchers recognize these problems: "To date the framework appears successful as a facilitative method of assessment, but with the limitation that it is mainly those already conversant and comfortable with its language who are able to use it to advantage. For others, the 'learning curve' in beginning to think this way appears very steep" (Smith & Tosey, 1999) While the stated intention is to identify an assessment process that makes unnecessary the intrusion of so-called experts into the organization not only in applying the evaluation instrument but also in analysing and intepreting the results, the methods proposed actually retain some need for experts but introduce the need for a truly initatic process in the mysteries of new science. Even if the model is explained, understood and adopted exemplarily, it is still so disruptive to people's understanding of physics and the world, as well as thinking processes, that the level of cognitive discomfort will prevent it from being a useful and practical approach. While new science concepts do provide very helpful frameworks for organizational learning (such as considering that the concept of a learning organization itself is very much a "strange attractor" rather than an objective state to be achieved and measured), the difficulties in making these explicitly part of the functioning language within the culture of the enterprise argue for embracing the concepts at the level of tool and mindsets proposed to members for growing towards a learning organization state. To the extent that new science as applied to orgnaizations is actually a more valid representation of the existing phenomena and forces, it should not be necessary for members to be conversant with the concepts for the benefits to be obtained.

6. Framework for an alternative assessment methodology

This analysis of two different approaches to evaluation of learning organizations provides a promising framework from which to propose an alternative assessment methodology. This will be based on the view that organizational learning cannot be meaningfully evaluated at the individual level and in a discrete manner; for an assessment to be useful, it has to take into account the flux, the process, and be produced through and refer to social interaction. The difficulties of such an endeavor have already been highlighted; an approach that might provide a working solution will be proposed. Moilanen's ideal of holism can be retained, though it is necessary to consider the cautionary tale of summative evaluations in education that operationalize learning to a set of dimensions (much like Moilanen's areas of focus); this type of evaluation has been very much discredited by formative evaluation that re-discovers the learner as a whole irreducible to a single dimension. Taking this into account, it might be worth considering that a useful holistic approach would rather look at the interactions and interplay between different dimensions / areas of focus, rather than analyze each of them independently. In any case, reducing learning to a list of factors that are measured and mapped out can only lead to a mecanicist type of learning; and most assessment methods are, in fact, rooted in such a view of learning that is in stark opposition to the archaic and metaphoric view introduced by proponents of organizational learning. Smith & Tosey introduce the idea of assessment as a political process; and indeed, research in educational evaluation shows that attempts to eliminate subjectivity lead to gross distortions in evaluation: "Formative evaluation also fell into the trap of impartiality and correctness in which summative evaluation had fallen before, thus carrying the seeds of all disappointment." (Meyer, 1995, p. 23). Furthermore, insofar as learning itself is a construct and its assessment is a social and political process, it becomes necessary to at least provide a framework for a shared understanding of the concepts to all members who will be participating in an evaluation before requiring them to answer questionnaire questions or participate in the process. This is, indeed, time-consuming, but mitigating solutions will be proposed.

An additional key issue is the influence of measurement and assessment on further learning and growth. If we accept that what gets measured gets learned, and also that what gets measured gets valued, then the manner in which organizational learning is evaluated heavily influences the way in which learning is approached. It then becomes vitally important to avoid distortions and incongruencies between espoused values and the values that are measured; any departure from integrity within an organization with a commitment to becoming a learning organization threatens the very core of organizational learning. Thus, a necessity emerges for members of teams and organizations to take an active role in designing, negotiating, administering, processing and adjusting assessment methods, so that they become responsible for continually creating the most congruent instrument that fits their values and commitments.

The alternative method proposed below is based on collaborative research in a consulting environment applying various methodologies, as well as observations from the experiential education methodologies of Outward Bound settings. The background is firmly set in the action research and appreciative inquiry framework.

Smith & Tosey explain that "a drawback with the performance model approach has been it inability to show the degree of assessment detail that is often of interest either from the point of view of discriminating progress or better informing remedial learning. This has entailed formation of post-instrument collaborative exploratory groups from within the communities under study to jointly explore and articulate personal details - a time and resource consuming effort, often demanding consultant intervention" (Smith & Tosey, 1999). Based on this and the necessity for social construction and processing of evaluation tools, we propose that the method below be used by teams, whether in small organizations where all members would participate, or by focusing on core teams within large organizations. This also fills an important gap, where existing instrument proposed have provided questionnaires for the individual and the organizational level, but not the team level. The heuristic, pandoxist view of Smith & Tosey has obvious advantages: "At best, treating assessment as a heuristic process allows for both pragmatism and criticality." If each member of the team becomes familiar with one general theory, the assessment process can allow the interplay of the points of view provided by different theories, thus offering a more in-depth understanding of the issues facing the team and their causality. This approach does, however, leave "the issue of choice over what type of assumptions and maps to adopt in the first place." Thus the need for a set of mutually agreed-upon criteria to guide the choice. A few criteria that could seed the discussion include: ability of the model to assess learning conditions, to enable participants, to provide a focus for inquiry, flexibility to be adapted to the specific conditions, culture and lifestage of the team and organization, and meaningfulness of the language for the team as a whole. Once a set of criteria is agreed upon, and members present the main theoretical models taken into consideration, the team will undergo a negotiation process that is fully social and political to select the model that most closely meets their criteria, and to then adapt and operationalize it into a meaningful model at the team level. There is a very real danger that team members will create their own eclectic approach, integrating all theories rather than being selective and adapting. To counter this risk, a much-simplified adaptation of the diamond model can be used as a powerful visual representation where only 3 or 4 areas of focus are available to be filled in, and only a projection at the team level is used. The level to which these factors are developed is subject to negotiation within the team, and it is this very process that forces team members to consider the interplay and interdependencies at work, bringing to bear a group, collaborative form of metacognition. The process is repeated at regular intervals decided upon by team members, and at each iteration discussions focus on re-negotiating the model and evaluating progress and the processes by which progress has been obtained. There is a strong potential of scaling this approach to the organizational level via the World Cafe method.

7. Conclusions

Research performed in a consulting setting shows that this type of approach is sensitive to the team's capacity for self-deception and groupthink. This risk can be mitigated by applying these methods, in a manner based on Argyris's research into Action Science, to any team-building activities that place members in embarrassing or threatening circumstances. By contrasting the self-evaluation by the group with the more objective, outsider evaluation by another group, group biases can begin to be corrected. The question remains as to whether results obtained by this method are comparable across teams and organizations in any scientifically valid way. To the extent that learning processes are universal and transferable from one organization to another, this political and collaborative process provides more accurate representations of these processes, that can then be studied to determine manners to reconcile and compare team assessments across organizations. However, for the purposes of growth towards a learning organization "strange attractor", internal congruence is far more valuable than scientific comparisons and external benchmarking.

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JOURNAL
OF
APPLIED
QUANTITATIVE
METHODS

MODELS AND SYSTEMS FOR STRUCTURIZATION OF KNOWLEDGE IN TRAINING

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Abstract: *In this work the problems of the automated structurization and activation of the knowledge, saved and used by mankind, during the organization and training, and also that knowledge which are generated by experts (including teachers) in the current activity, are analyzed. The purpose - the further perfection of methods and systems of the automated structurization of knowledge and their applications for creation: the automated workplace of the lecturer (environment for the automated structurization of a lecture material), the virtual lecturer assistant (system for the automated dialogue with students), environments for preparation by students of reports, explanatory notes to course and degree works, the virtual adviser and knowledge tester for students testing during training, for other applications. Developed by authors "the matrix of elements of knowledge" - became acting system of the automated structurization of knowledge in training, it present interest for its use in other spheres.*

Key words: *knowledge; presentation; structure; element; matrix*

1. Problem status

The analysis of a problem status was already marked by us in [1][1]. There it was marked, that the human knowledge which has been accumulated up in many millenniums, are brought up to now on such physical carriers as the papyrus, paper and others. The most widespread form of representation of this knowledge is the text. On modern representations, the access to the necessary text, labour-consuming and rather long procedure. In the computer century there is a necessity of the decision of knowledge formalization problem already saved up by mankind and, formalizations of again appearing knowledge, on the one hand, a kind convenient for their direct use and, on the other hand, in the form of electronic knowledge bases. This problem is evidently showed on the block diagram presented below (fig.1).

Importance of a problem of knowledge formalization and their representations in the form of base is conclusive. However complexity of adequate display of knowledge in the knowledge bases, expected cost and time expenses compel to search for a new ways of full or, at least, partial formalization.

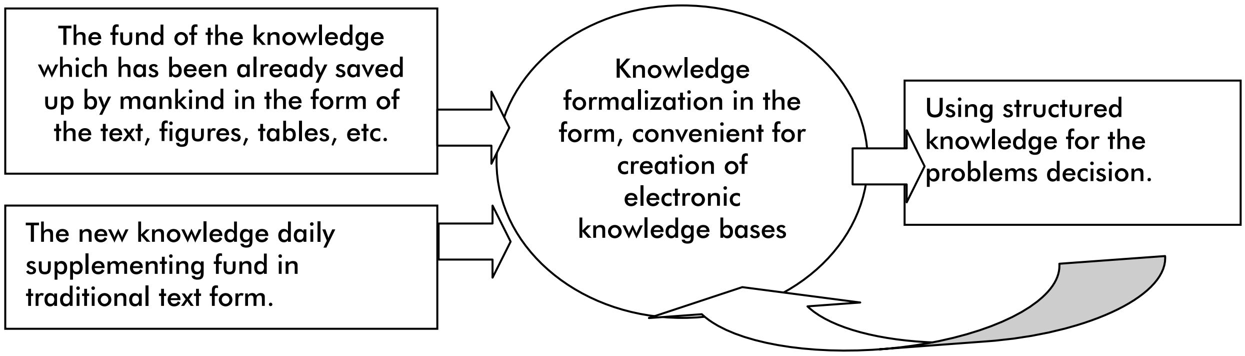

Figure1. Knowledge formalization and their using for problem solving

The following decision could be effective: if during human activity, at each compelled reference to world funds of knowledge, the mechanism of their transformation and in the form of electronic knowledge bases was simultaneously realized. The more often references to funds of human knowledge, lead to the more effectively process of transformation of knowledge in knowledge bases.

Spheres of human activity where there is the most frequent references of the person to knowledge it, first of all, manufacture, science, education. We [1,2,3,4,5] investigated the questions of knowledge structurization in some subject domains. In the present work we shall analyze within the limits of education, only training, as a process of transfer and studying of knowledge, skills, skills of activity, the basic means for preparation of the person for a life and work. While training there is the most intensive reference to the saved up and accumulated knowledge. The society purposefully invests in this process huge means, thus all the saved up human knowledge repeatedly, again and again are displayed and fixed in memory of millions people, closely and carefully structured and restructured by teachers of educational institutions for their more evident representation to the pupil. The cycle of repeated viewing and ordering of knowledge by the teacher of an educational institution seldom exceeds duration in one year.

Intuitively, educational process in which one of leading roles is played by the teacher could be one of a source of the structured knowledge which has been saved up and stored by mankind in a passive kind. We shall consider this process in more details.

Training - the bilateral process including activity of training (teacher) and trained (pupils). Training is characterized by interaction of the purposes and maintenances of training, teaching and the doctrine, i.e. activity of the pupil on mastering by knowledge. We believe at formalization of knowledge during training the questions connected with formation of the purposes and maintenances of training will not undergo essential changes.

If it would be possible "to build in" a knowledge former (structurer) in a contour of process of knowledge transfer and familiarization for their subsequent representation and in the form of electronic knowledge bases, then the problem of structurization of the knowledge, main in the present work, could be solved. We shall consider possible models of systems which could be used for structurization of knowledge of the various nature.

2. Models of systems for knowledge structurization

In Fig. 2 we shell schematic present the process of knowledge retransformation from passive form in active [6], listing the main actions which will be necessary in executing the process of automated knowledge structure in knowledge bases for their using in contemporary education.

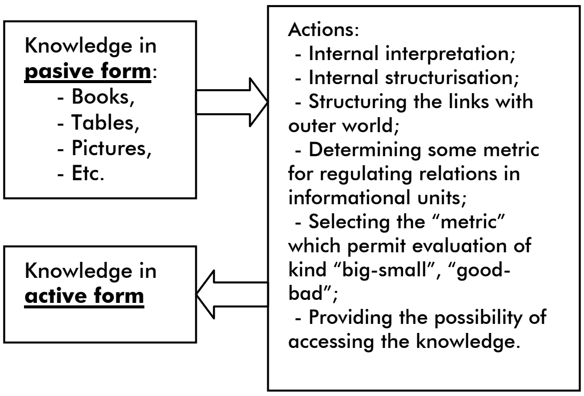

Figure 2. The process of knowledge transformation from passive to active

Active knowledge is that which we can memorize (for example, in computer) and will have access to "make" possible a conversation (for example, as it is made in "ELIZA").

A good part of actions provides from the problem of knowledge structurization. From existent methods of knowledge presentation (structurization), the most popular are logic based presentation, semantic networks and frames. For example, in logic presentation, as indivisible element for interpretation is the elementary clause. More complicated clause, such as phrases, texts are presented by using mote times inductive steps. Schematic this process is presented in Fig. 3.

Unconditionally, logic presentation permit adequate transfer of reality, but need more time and more expenses, high qualification of specialists and reliable methods of control of process of formalization. For resolving problems of mankind knowledge structurization using logic based presentation, we'll need ages, the facts which make us to search other solutions.

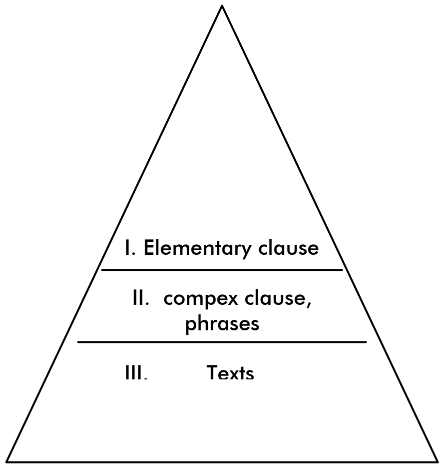

Figure 3. The process of knowledge structurization

Retransformation of existing knowledge and those which are newly created in structured knowledge, in our vision, can be realized through three separate models (Fig. 4 a,b,c).

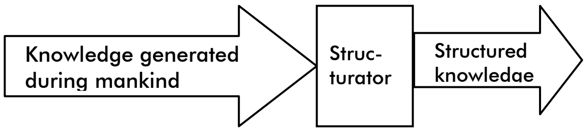

Figure 4a. Model for knowledge structurization generated actually

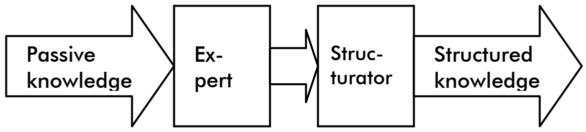

Figure 4b. Model I for knowledge structuration from books, tables, etc., accumulated in previous period

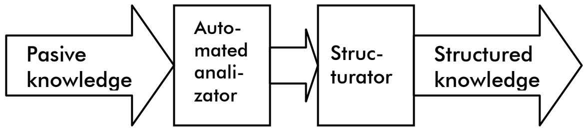

Figure 4c. Model II for knowledge structuration from books, tables, etc., accumulated in previous period

Knowledge structurization in the base of model presented on Pic.4. in the near future it is improbable. The ways of problem solution in the base of this model, are not discussed in this article.

The model presented on pic.4a represents the big interest because of its urgency. Annually the volume of the information accumulated by mankind practically is doubled. But also now, a significant part of the knowledge, again registered a symbolical kind, have no precise structure, that already by definition classify them as passive knowledge.

The model on Pic. 4b is interesting if to see the teacher and as the expert, i.e. the specialist which is independently capable to generate new knowledge and which represents in a traditional kind, i.e. in the form of scientific articles, books, etc.

3. Model of knowledge representation by the lecturer during preparation and the proper educational process

Let us consider in more detail concept "teaching". The basic functions of teaching - prompting to the doctrine, a statement of the maintenance of a studied material, the organization of activity of pupils, the control of knowledge and skills. Teaching has two important stages: a preparatory stage and a stage of realization.

The teacher, according to the professionalism and teaching art, structures the material which is a subject for studying. Formulates the next question, specifies if necessary its sense, borders of its distribution (applicability). Then forms the answer to this question so that it has been apprehended and comprehended by that group of pupils for which the material prepares for studying. The true answer to a question, as a rule, is compared to close concepts (answers), but the validity already being behind borders outlining a right answer on a question. The teacher cares of that the explanation of the formula of the answer to a question has been given, i.e. to explain, why such formula of the answer is true. Often during an explanation of a problem the teacher results definitions of those or other applied special terms, the comment in relation to the some definitions is sometimes done, at a sight of a modern science (or at a sight of the teacher), is not true in relation to a studied problem. The basic and additional references are resulted. Such approach corresponds to requirements on the organization and conducting employment in a higher educational institution.

However uniform, precise requirements to the text structurization of the lecture, preparing the teacher for a statement in an audience, as a rule, are not present. The teacher is free at own discretion, to establish sequence of steps on structurization of the text.

At the same time, if the uniform system of knowledge structurization would be established, then at presence of corresponding computer system (program) for registration of knowledge under this script, it would be a real variant (method) of the decision of a problem on knowledge formalization. Such way could accelerate considerably process of carry of knowledge, from traditional physical carriers (books, tables, etc.) on electronic carriers and simultaneously would allow to formalize knowledge in knowledge bases. These problems were repeatedly discussed by authors at various international and local conferences [1,2,3,5].

At distance education appear one of difficultly surmountable problems - difficulty of direct dialogue of the teacher and the pupil (time delays, throughput of the channel, etc.). It will not be possible obviously, completely to solve this problem. It is a payment for the received convenience: to have an opportunity of system training of the pupil, being on the certain distance from the educational center (university, college, lyceum, school, etc.) or the educational center in which the pupil (trainee) studies, from the teacher (training). It partial decision sees in development of training intellectual systems which will partially compensate absence of opportunities of natural dialogue of a trainee with the teacher, for example, during the moments of time delays of communication networks, cost and other restrictions. A part of the functions which are usually carried out by the teacher during conducting of employment in an audience with pupils, at presence of such intellectual component, can automatically be carried out, the so-called virtual lecturer assistant, partially unloading during remote training the teacher and network channels, and other resources.

The system developed and described in [1,2,3], realizes a method of structurization of the lecture and practical material [5], preparing by the teacher before the audience, allowing simultaneously to represent this material in the form of the electronic knowledge base and to use it at remote training through the Internet.

The open access to any of parts of the knowledge base, at any moment allows the teacher to work, fill or supplement effectively with data any of cells of the knowledge base for which during the concrete moment of time there was suitable information. Whether results such method of representation of a lecture material in deterioration of preparation of lecture? Apparently from lead above the analysis the teacher approximately and should structure the text of lecture, anyway, such method can take place without drawing damage to quality of preparation.

The lecture and practical material is formed by the teacher in so-called to "the matrix of knowledge elements" [5], described in following section.

4. „The Matrix of knowledge elements"[2]

For describing some problem qualitative and full it is necessary to dispose of good training and capabilities of creation. But, having all mentioned capabilities, starting from conclusions made in psycho-pedagogical sciences, time constrains, creativity is rather limited if there is not made morphological analysis[7], for example, such as method of G.S. Alitsuler uses in invention, if it is not taken in consideration and not are used permanently another "knowledge about knowledge", methods of structurization and activations. Aristotelian categories [8] are another important instrument which contributes form knowledge structuration and activation.

Definition 1: "The matrix of knowledge elements" is some working environment for more complete description of some problem and raising of creativity, efficiency of work of expert, specialist, student, any separate man (next user) with the possibilities of consulting, interactively remembering, about multiply of possible questions which can be given and need answers.

Possibilities: "The matrix of knowledge elements" considerably reduces the risk of chaotic thinking of user, and thus contribute to increasing his creativity, systematizes process of work, structurize knowledge for a possibility of their activation and use by means of a computer in training systems. On every of given questions (given automatically) in the matrix environment is possible to registry in separate element, an answer with finite sense. The multitude of formulated by user answers is introduced separately in respective element of matrix, can be consulted separately by a command or assembled in a text, forming integral explanations of **some** content (such as problem, object, situation, etc.)

Definition 2: "The matrix of knowledge elements", is a module of some system for formation structure and registering knowledge about something in a base [5,10], which consist from some multitude of elements $a_c(i,j)$ from A_c for launching description of knowledge elements $E_c(i,j)$ about this **something**. Every of elements $a_c(i,j)$ is intended for description of knowledge elements $E_c(i,j)$, with finit sense, component part of whole C_p (those **something**), such as description of some problem, some object, situation, etc. Every

knowledge element ***E_c(i,j)*** in matrix ***C_p*** is marked thought question ***Q(i,j)*** which is forming from some word such as "**Describe**", to which the name of row ***i*** is added, and the name of a column ***j*** (or vice versa ***j,i*** - in accordance with logic of language, sense) and is added the name of a problem (object, situations) which can be described in an element ***a_c(i,j).***
Formal model of "the matrix of knowledge elements" can be presented as follows:

$$M = < A_c, C_p, R, s_0, d>,$$

where, A_c – finite multitude of states (A_c={ $a_c(i,j)$ }),

C_p – finite multitude of entry symbols, designate together that **something** (C_p={ $E_c(i,j)$}),

R - relation, between A_c X C_p and A_c

s_0 – initial state, element from multitude A_c,

d – finite state , element from multitude A_c.

Questions given in the environment of matrix, are formulated without being dependent from the domain area or concrete scientific problem. Matrix provide registering the user answer on the given in separate element ***E_c(i,j)*** question, which in future can be accessed directly to edit it or use it for consultation and other goals. The matrix environment permit permanent visualization, of all questions ***Q(i,j)*** and answers formulated in ***E_c(i,j)*** (at least initial phrases, depending of monitor resolution and text volume introduces in respective cell). The capacity of the activated cell can be increased in 2 or 10 times [10].

5. Restrictions in functionality

Integrity of knowledge registered in the respected element, do not need demonstration, and it is considered true, next **T**, and an the element where knowledge are not registered, the element is empty, it is considered false, next **F**. The text thought which are stated the knowledge, in the element can not be divided in components and identified as [**T**, **F**] **(**the case when the a_{ij}, element is not the matrix row**)**. Questions given to the user in the matrix are considered **correct**. In order not to limit the creativity of matrix user, in the process of explanation of some problem, can be stipulated the fields and strings of matrix which are not noted, or with the access to modify and mark them, by the user [10].

6. System functioning

The "QUEST" system (where the matrix is the base module aimed for introducing knowledge in activated element and long storing them in this element, to be consulted by necessity) with all active functions, permit:

- to get direct access to the knowledge, previously registered in some element of matrix, considered (as it was mentioned above) – "correct knowledge" ***T*** (True);
- to combine two or more elements of matrix to receive more full knowledge about some aspects of **something**;
- to combine all elements of knowledge registered in the matrix and their identification corresponding to restrictions mentioned above, as ***T***, to receive an answer considered in this system "full" and correct ***T***, referring to that something;

It is considered that real fullness of knowledge a priori registered in matrix, and their quality depends of sense and content formulated and described by user – creator of knowledge base.

A variety of questions ***Q(i,j)*** given to the user - the knowledge base former , are in the dependence of value ***i, j***, remembering the fact that in existent version of matrix:

i – is the marker of each row in correspondence with Aristotelian categories [8] {"essence", "quantity", "quality", "in comparison with", "where", "when", "state", "possession", "action", "support"};

j – is the marker if each column in correspondence with psycho-pedagogical aspects, such as:

"abstract"- concretization of aspects which will be explained for category ***i*** regarding the essence of something;

"what is" – the definition, such as - what is essence, quality and quantity etc. of that something; *"why"* - demonstration of essence definition which is correct; "how, for whom" – examples(methods), how it is made, for whom, etc; *"opposite opinions"* - alternative opinions, about definition given in columns "what is", "why", "how"; *"substance"* – the materia which constitute described form in columns "what is", "why", "how", "opposite opinions"; *"new terms"* – glossary, the field which in future can serve as link between different matrixes, where the terms will be described fully, which definition is placed in this field; bibliography.

The system interface in the matrix environment, present a extended on screen area table[10], with the direct access for the user for every of the elements of the matrix, for example, in one mouse click. Rows **i** and columns **j** of the matrix are accordingly marked, being a good help for the user, the indicators of components from which virtually proceeds the question ***Q(i,j)*** and shows the address of the element where can be placed the knowledge element about that **something**.

7. Logic of "the matrix of knowledge elements"

Environment in which knowledge in "knowledge elements matrix" are structured, we can schematically represent using table below (Fig. 5)

Categories of Aristotle	Abstract (what about?)	Definition (what is?)	Demonstration (Why?)	Example (How ?)	Example (whom for?)	Associations (with what?)	Other opinions (refered to „ what is?")	Material (what is made of??)	Glossary (external or internal elements?)	Bibliography (whom described?)
Sense	a_{00}	a_{01}	a_{02}	a_{03}	a_{04}	a_{05}	a_{06}	a_{07}	a_{08}	a_{09}
Quantity	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	a_{17}	a_{18}	a_{19}
Quality	a_{20}	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	a_{26}	a_{27}	a_{28}	a_{29}
Relation	a_{30}	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	a_{37}	a_{38}	a_{39}
Where ?	a_{40}	a_{41}	a_{42}	a_{43}	a_{44}	a_{45}	a_{46}	a_{47}	a_{48}	a_{49}
When ?	a_{50}	a_{51}	a_{52}	a_{53}	a_{54}	a_{55}	a_{56}	a_{57}	a_{58}	a_{59}

State ?	a_{60}	a_{61}	a_{62}	a_{63}	a_{64}	a_{65}	a_{66}	a_{67}	a_{68}	a_{69}
Possession	a_{70}	a_{71}	a_{72}	a_{73}	a_{74}	a_{75}	a_{76}	a_{77}	a_{78}	a_{79}
Action	a_{80}	a_{81}	a_{82}	a_{83}	a_{84}	a_{85}	a_{86}	a_{87}	a_{88}	a_{89}
Support	a_{90}	a_{91}	a_{92}	a_{93}	a_{94}	a_{95}	a_{96}	a_{97}	a_{98}	a_{99}

Figure 5. Scheme of matrix interface, in the mode of structuring knowledge about ***something***

Every element of set a_{ij} are accessible for text introduction, which, as it is underline above, may be identified only as ***T***. In cases when element a_{ij} is a list, then all list elements are interpreted as ***T*** too. As text notion we understand the set of characters c_k, where ***k=1,2,3,...*** . Text of element a_{ij} can be modified, but element identifier will remain ***T***. Element a_{ij} in which wasn't introduced the text (***k=0***) will be automatically eliminated from the knowledge base and identified as ***F***. User (expert, specialist, lector i.e. creator of knowledge from respective domain) can manually identify as ***F*** an element or set of elements from a_{ij}, for cases when respective elements wasn't complete enough or wasn't verified, but matrix content (knowledge base with already recorded elements) need to be useful in the concrete system.

Knowledge base using starts after filtering and eliminating all elements interpreted as ***F***. Knowledge base in the form of matrix can be successfully used, for example, for organization of the dialogs "student - virtual lector assistant" in the process of the distance learning throw the Internet.

8. Dialogs

The "QUEST" system, including base matrix module, was developed using logic programming language Prolog. Dialogs structure determines work principles of respective "QUEST" system function. We'll use logic programming formalism approach to demonstrate models of a different dialogs. As it is well known [1,7] using Horn clauses in logic programs are presented:

- facts a_{ij}**:-.**
- rules a_{ij}**:-** a_{lm}**, ...**Where, ***l*** şi ***m=0,1,...,9.***
- questions ?**:-** a_{lm}**, ...**

Using a set of the facts and rules we can describe real world. Facts and rules are written in program text in form of declarations in the base. Using questions we can appeal to this base with help of:

- the respective search strategy (depth-first search, breadth-first search etc),
- resolution an unification principles,
- notion of empty clause for resolving program stopping and output result problem

According to this take place calculation process of translation in the logic program and its interpretation by the Prolog interpreter.

Facts are always true by the definition and can be identify only by ***T***. The fact (or set of the facts same by the category and aspect form a list) may be conform only to the respective matrix element.

Quantity of the matrix elements in version described in this article can not be exceeded 100 elements (from a_{00} to a_{99}). Every single fact can be consider as the "virtual lector assistant" answer ("QUEST"-system answer) to the simple question from the set ***Q(i,j)***, for example by a student using the system in mode of consultation. As one correct and complete "QUEST"-system answer we can consider such answer, which represent to the user all facts in one string (continuous text) in the case when a_{ij} element contains list of facts.

Every answer, for example given by the student in the closed form for the "virtual lector assistant", in the mode of examination can initiate student answer in the form [yes, no].

It is possible, as mentioned above, to address complex questions to the "QUEST"-system using the same facts with the help of propositional logical connectives. For example, the question "Please give me definition and the sense of the ***something***" has an formal representation in system:

$$?:- a_{01}, a_{02}.$$

System answer will combine content of matrix elements a_{01} şi a_{02}.

It is possible to generate new knowledge's from the set of elements a_{ij} using other type of Horn-clauses - definite clauses (rules). For example on the question "Please give me full description of the something's state", formally

$$?:- state.$$

answer will be generated with appellation to the rules

$$state :- a_{60}, a_{61}, a_{62}, ..., a_{69}.$$

With this method can be generated some other new knowledge from the set of knowledge elements organized in matrix. A dialog "student - virtual lector assistant" on the concrete problem, which represented in the form of matrix, can last a long time, but such dialog has a little difference from the traditional dialog "student - lector". If we'll use Turing artificial intelligence test, proceeding from mentioned above, we'll consider that "QUEST"-system is an system with intelligent behavior.

9. Practical results

Introduction of the first version of system "QUEST ", allowed the authors to solve in current 1997-2003 at the University of Applied Sciences of Moldova the following problems:

1. to pass to the written knowledge control of all students of university over system " QUEST " with an opportunity of remote control by teachers, the texts of examination answers of students.
2. to prepare for subject matters for the organization of self-training and training through the Internet of persons distanced from university.
3. for students to develop in "QUEST environment course works and, at the same time, to study to structure knowledge, developing thus the logic of thinking to store them, providing effective access to them, including for the remote control and an assessment of works.
4. to control the knowledge of students over a mode "testing" of system "QUEST ", allowing to realize iterative dialogue "computer-student" (up to 4-5 mutual references).

5. Administrations of university to develop criterion of an estimation of quality degree of teachers preparation to the lecture, prepared in the environment of system "QUEST". The offered technology of preparation for lecture by means of the described system enables all collective of teachers of an educational institution better to be prepared for employment, to use at certifications and the examinations, alternative forms of the knowledge control, is direct on employment to use a computer and multimedia means for displaying already worked material to the screen and carrying out of necessary explanations.

10. About the prospects of knowledge structurization by means of "the matrix of knowledge elements"

During the next periods (beginning approximately with 2002-2003) and down to present time we carry out researches connected with knowledge structurization in bases, using on the one hand the psycho-pedagogical aspects, partially described in higher sections of present clause, on the other hand, categorical representation about objects, events and the phenomena in sense of Aristotelian, Kant, Hegel and others, and also our contemporaries living during an era of information of a society [5].

For practical realization of "the matrix of knowledge elements" the choice has fallen on Aristotelian categories, as a most convenient for knowledge structurization of different subject domains. As is known, their ten: essence, quantity, quality, the attitude, where, when, a condition, possession, action and suffer. These categories are the name of matrix rows. Columns of a matrix are named accordingly: concretization (it is short about what is in a category i?), definition (that?), the proof (why?), examples (as?, to whom?), alternatives (other opinions), a matter (from what?), a glossary and the literature (whence?).

In one matrix it is possible to describe one concrete problem, event, object, etc. Each crossing of columns and rows in a matrix "generates" the question on which there can be an answer. For example, the column "definition" and a line "essence" "generate" a question of type: "That is …?".

"The matrix of knowledge elements" has been used by students of some HIGH SCHOOLS of Republic Moldova and from abroad at a writing of reports, course and degree works. Results are unequivocally positive. Students penetrate into essence of the phenomena more deeply. Practically completely it is possible to exclude "blind" copying of a material from the Internet. It is easier for the teacher to estimate works of students objectively.

11. Summary

Carried out researches and the received practical results give the basis to speak about the real contribution to the problem decision of a stage-by-stage knowledge structurization in knowledge bases and their uses in systems of artificial intellect of the future. Knowledge structurization in "the matrix of knowledge elements" and systems "QUEST" as a whole enable the following:

- for the expert (trained) "to preserve" the (received) knowledge of concrete essence in the structured mode, quickly to activate this knowledge in case of need in the future;

- for the teacher of an educational institution to form electronic lecture by its preparation for employment and simultaneously to structure knowledge in base;
- for the student to carry out researches of internal structure of knowledge at course and degree working, at writing of dissertational work by PhD candidate;
- at presence of the filled knowledge base on a concrete subject domain to realize information system for consultation of interested students, teachers, etc.;
- to realize the process of training, self-training and the knowledge control, resulting the results of a knowledge estimation of one or on group of trainees;
- using the knowledge base for other purposes in systems of an artificial intellect;
- carrying out a comparative estimation of activity of the faculty during the activity on a number of criteria.

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[2] sections 4,5,6,7,8 and 11 was written with support from Alexandru Pelin, 4th year student, Faculty of Computer Science, Unviversity A.I. Cuza, e-mail: apelin@infoiasi.ro

STUDY OF EQUILIBRIUM PRICES, USING GENERAL EQUILIBRIUM MODELS

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Abstract: *The first part of the paper presents some theoretical aspects related to general equilibrium models and the motivation of formulating the general equilibrium models as mixed complementary ones. Then we present a general equilibrium application using GAMS software (General Algebraic Modelling Systems). The application is a general equilibrium model for the Romanian energetic system, considered as a component of the national economy.*

Key words: general equilibrium models; equilibrium prices; *General Algebraic Modelling Systems – GAMS*

1. Theoretical background

We use the complementarity format because: first - it facilitates the links between prices and equilibrium conditions on the market; second - it allows relaxing the 'integrability conditions', which is not possible in the standard formulation of the general equilibrium models. More than these, the complementarity format facilitates associating second order conditions of the dual problem, with real economical tools available for policy design (for instance related to taxation effects, or related to external effects, or market failures). [4]

The complementarity format is a suitable one for formulating mathematical models related to energy – environment, because it allows integrating 'bottom-up models', with 'top-down models'. More precisely, it facilitates integrating very technologically detailed models, but insufficient developed on the macroeconomic side, with models having a very strong macroeconomic component, but weak in describing the energy and environment technologies on the production side.[2]

The complementarity format for energy – environment models is specifically useful because: frequently, the regulation authorities impose price constraints (i.e. upper bounds), or quantities constraints (i.e. a given percentage out of the total produced energy in the economy to come from renewables energy sources, or to be of nuclear type).

The general equilibrium model Arrow-Debreu is the starting point for any rigorous general equilibrium study.[1]

The model' hypothesis, which ensure the existence of the equilibrium in an economy, are very general and related to initial endowments, consumers' preferences, production and consumption possibilities. Arrow and Debreu have proved the existence of the equilibrium in such a model using the *fixed point theorem*, issued by Kakutani.

The producers are characterized by all production possibilities $Y_f \subset R^n, \quad f = 1,2,...,m$, while the consumers by the utility functions – convex and belonging to C^2 group of functions, $U_h : R_+^n \to R, \quad h = 1,2,...,k$ and by the initial endowments $\overline{x_h} \in R^n$. The market is responsible for the price vector $p \in R_+{}^n$.

<u>Definition 1</u>: *An Arrow – Debreu model state* is given by a production and consumption allocation, as well as by a price vector:

$$\omega = (x, y, p), \quad where:$$

$$x = (x_{1,} x_2, ...x_h, ..., x_k) \subset R_+^n,$$

$$y = (y_1, y_2, ..., y_f, ..., y_m) \subset Y_1 x Y_2 x ... x Y_f x ... x Y_m = \underset{f=1}{\overset{m}{X}} Y_f \ and \ p \in R_+^n$$

<u>Definition 2</u>: *An Arrow – Debreu equilibrium* state represent a consumption allocation $x^* = (x^*{}_{1,} x^*{}_2, ..., x^*{}_k)$, a production allocation $y^* = (y^*{}_1, y^*{}_2, ..., y^*{}_m)$, and a price vector $p^* = (p^*{}_1, p^*{}_2, ..., p^*{}_n)$, verifying the following:

$$a) \sum_{i=1}^{m} y_i^* + \sum_{j=1}^{k} \overline{x_j} \geq \sum_{j=1}^{k} x_j^*$$

$$b) p^* y_i^* = \max_{y_i \in Y_i} p^* y_i, \quad i = 1,2,...,m$$

$$c) U_j(x_j^*) = \max\{U_j(x_j) / p^* x_j \leq p^* \overline{x_j} + \sum_{i=1}^{m} d_{ji} p^* y \ \}$$

In the following the Arrow – Debreu conditions will be rewritten.

Let us consider an economy with *n* goods (including production factors), *m* production sectors, and *k* consumers (households). Let *p* denote the prices vector ($p \geq 0$), *y* – the production vector based on constant returns to scale technologies ($y \geq 0$), M – the income vector, and a fictive agent which will be called 'market', establishing the prices.

The Arrow – Debreu equilibrium conditions in the considered abstract economy are as follows:

- the zero profit condition (no production sector has a positive profit)

  $-\Pi_j(p) \geq 0 \quad \forall j \in \overline{1,m}$

- the feasability condition for supply and demand:

  $$\sum_j y_j \frac{\partial \Pi_j(p)}{\partial p_i} + \sum_h \bar{x}_{ih} \geq \sum_h D_{ih}(p, M_h) \quad \forall i \in \overline{1,n}$$

where: $\bar{x}_{ih}$ - the initial endowment of household *h* with the good *i*

$D_{ih}(p, M_h)$ - the utility maximizing demand, for household *h,* the good *i*

- the income condition (the income of household *h* equals the value of initial endowments)

  $M_h = \sum_i p_i \bar{x}_{ih} \quad \forall h \in \overline{1,k}$

At equilibrium, the following relations will be satisfied:

$$y_j \Pi_j(p) = 0 \quad \forall j \in \overline{1,m} \qquad (1)$$

$$p_i \left[\sum_j y_j \frac{\partial \Pi_j(p)}{\partial p_i} + \sum_h \bar{x}_{ih} - \sum_h D_{ih}(p, M_h) \right] = 0 \quad \forall i \in \overline{1,n} \qquad (2)$$

So, at equilibrium, any production activity with a negative unitary profit is hidden, while the price of any good offered in excess in the economy is zero.

In a general equilibrium state, it cannot exist a consumption vector x_j so that:

$$x_j^q > \sum_{i=1}^{m} \max y_i^q + \sum_{j=1}^{h} \overline{x_j^q} = \overleftrightarrow{x_j^q} \qquad q = 1,2,....n$$

because the condition (a) cannot be fulfilled for the vector x_j , for any $y_{1,} y_2, ..., y_m$

It means the domain of the vectors $x_j, \quad j = 1,2,....k$ is not R_+^n, but only

$X = \{x \in R_+^n / 0 \leq x \leq \overleftrightarrow{x}\}$, where $\overleftrightarrow{x} = (\overleftrightarrow{x^1}, \overleftrightarrow{x^2}, ..., \overleftrightarrow{x^n})$.

To each state z of the model, we associate the following:

$Y_{1,} Y_2, ..., Y_m, X_1(z), X_2(z), ..., X_n(z), P$

where

$$X_j(z) = \begin{cases} \{x \in X / px \leq \sum_{i=1}^{m} d_{ji} py_i + p\overline{x_j}\} & if \quad \sum_{i=1}^{m} d_{ji} py_i + p\overline{x_j} \geq 0 \\ \{0\} & otherwise \end{cases}$$

We assume that the vector of initial endowments has positive components.

Then the functions z → $Xj(z), \quad j = 1,2,...k$ are continuous.

For a given z, $Xj(z)$ are convex, being associated to convex functions.

Let $f: R^{(m+k+1)n} \longrightarrow R^{(m+k+1)n}$ denote a function associated to the model:

$$f_i : R^{(m+k+1)n} \longrightarrow R^n, \quad i = 1,2,...m+k+1 \quad and$$
$$f_i(z) = -p, \quad i = 1,2,...,m$$
$$f_{m+j}(z) = -\nabla_{x_j} U_j(x_j), \quad j = 1,2,...,k$$
$$f_{m+n+1}(z) = \sum_{j=1}^{m} y_j + \sum_{j=1}^{k} \overline{x_j} - \sum_{j=1}^{k} x_j$$

where $\nabla_{x_j} U_j(x_j)$ represent the vector of the partial derivatives of U_j function against the components of the vector x_j.

<u>Theorem 1</u>: If Y_i are convex, compact and contain the origin point, and the utility functions are concave and belonging to C^2 class of functions, then the stationary points of the pair $(f, Y_1 x Y_2 x....Y_m x X_1(z) x...x X_k(z) x P)$ represent equilibrium states of the Arrow Debreu model. [

<u>Proof:</u>

Let $\overleftrightarrow{z} = (\overleftrightarrow{Y_1, Y_2,..., Y_m}, \overleftrightarrow{X_1(z), X_2(z),..., X_n(z), P})$ denote a stationary point of the pair mentioned within theorem1. The points $\overleftrightarrow{Y_i}, \quad i = 1,2,...,m$, $\overleftrightarrow{X_j}, \quad j = 1,2,...,k$ are stationary points for the pairs $(f_i(\overleftrightarrow{z}), Y_i)$, $\overleftrightarrow{X_j}$ are stationary points for the pairs $(f_{m+j}(\overleftrightarrow{z}), Y_i)$, while P is a stationary point for the pair $(f_{m+k+1}(\overleftrightarrow{z}), P)$. Based on the definition of f function, we conclude that for i=1,2,…,m,

$$f_i(z) = \nabla_{y_i}(py_i)$$
$$f_{m+k+1}(z) = -\nabla_p (p(\sum_{j=1}^{k} x_j - \sum_{j=1}^{m} y_j - \sum_{j=1}^{k} \overline{x_j}))$$

Condition (b) is a result of the properties of the stationary points for which $\overleftrightarrow{py_i} = \max_{y_i \in Y_i} \overleftrightarrow{p} y_i, \quad i = 1,2,...,m$.

But $U_j(\overleftrightarrow{x_j}) = \max_{x_j \in X_j(\overleftrightarrow{z})} U_j(x_j), \quad j = 1,2,...,k$, and having the hypothesis $0 \in Y_i$, we get:

$$\overleftrightarrow{py_i} \geq 0 \quad and \quad \sum_{i=1}^{m} d_{ji} \overleftrightarrow{py_i}$$

so the condition (c) and the income one are fulfilled as well.

We will prove that the stationary point $\overleftrightarrow{z}$ verifies condition (a) as well.

We assume that the goods $k_1, k_2, ..., k_r$ exist so that

$$\sum_{i=1}^{m} \overleftrightarrow{y}_i^{k_q} + \sum_{j=1}^{k} x_j^{k_q} < \sum_{j=1}^{k} \overleftrightarrow{x}_j^{k_q} \quad for \quad q = 1,2,...r$$

Then:

$$\sum_{j=1}^{n}\overset{\leftrightarrow}{x}_j^{k_q}-\sum_{j=1}^{k}x_j^{k_q}-\sum_{i=1}^{m}\overset{\leftrightarrow}{y}_i^{k_q}>0\geq\sum_{j=1}^{n}\overset{\leftrightarrow}{x}_j^{k_q}-\sum_{j=1}^{k}x_j^{k_q}-\sum_{i=1}^{m}\overset{\leftrightarrow}{y}_i^{k_q}\quad for\quad q=1,2,...,r\quad and\quad k\in\{1,2,...n\}\setminus\{k_1,k_2,...k_r\}$$

Because $\overset{\leftrightarrow}{P}$ is minimizing the function $P(\sum_{j=1}^{k}\overset{\leftrightarrow}{x}_j^{k_q}-\sum_{i=1}^{m}\overset{\leftrightarrow}{y}_i^{k_q}-\sum_{j=1}^{k}x_j^{k_q})$, then: $\sum_{q=1}^{r}\overset{\leftrightarrow}{P}_{k_q}=1$.

By summing in the inequalities above, we get a contradiction, so the condition (a) is verified.

Theorem 2: If Arrow – Debreu model has the properties (a), (b), (c), then it exists an equilibrium state.

Proof:

Let *T* denote the cartesian multiplication of the m+k+1 convex and compact results

$$T=Y_1xY_2x....Y_mxX_1x...xX_kxP$$

Using Theorem 1 above, it is sufficient to prove that exists one stationary point, z, of the pair $(f,Y_1xY_2x....Y_mxX_1(z)x...xX_k(z)xP)$

We take *g* function, g:T → T,

$$g(z)=Arg\min\|u-z+f(z)\|$$

$$u\in\prod_{j=1}^{m}Y_jx\prod_{i=1}^{k}X_i(z)xP$$

This function is continuous, and *T* is convex and compact. Using the Brower's Theorem for fixed points, we deduce that *g* has a fixed point, so the pair above has a stationary point.

We still need to prove that *g(z)* is a function, meaning $\|u-z+f(z)\|$ has a unique minimum on $Y_1xY_2x....Y_mxX_1(z)x...xX_k(z)xP,\quad\forall z\in T$

Because *T* is compact and $X_j(z),\quad\forall z\in T,\quad j=1,2,...,k$ are closed and bounded, then $Y_1xY_2x....Y_mxX_1(z)x...xX_k(z)xP,\quad\forall z\in T$ is also convex and compact.

If the production possibilities are specified explicitly, then can be established a link between Arrow – Debreu equilibrium states and the solutions of a complementary nonlinear problem.

Let

$$Y_i=\{y_i\in R^n/-k_i^1\leq(y_i)^Td_i\leq k_i^2\},$$

$$where\quad d_i\in R_+^n,\quad d_i\geq 0,\quad k_i^1,k_i^2\in R_+,\quad i=1,2,...,m$$

Corresponding to the *m* possibilities of production, we choose *m* scalars, which to fulfil the following condition:

$$m_i\geq\max_{y\in Y_i,k=1,2,...,n}(|\min y^k|),\quad i=1,2,...,m$$

Using the elements of Arrow – Debreu model, we consider the function $h:R^M\to R^M$, where M=m(n+2)+k(n+1)+n+2 with the components:

$$h = (h_1^1,...,h_m^1,h_1^2,...,h_n^2,h^3,...,h^8)$$
$$h_i^1(t) = -p + (z_i^1 - z_i^2)d_i, \quad i = 1,2,....,m$$
$$h_j^2(t) = -\nabla_x U_j(x_j) + z_j^3 p, \quad j = 1,...,n$$
$$h^3(t) = \sum_{i=1}^{m}(v^i - m_i e) + \sum_{j=1}^{k}(\overline{x}_j - x_j) + (z^5 - z^4)e$$
$$h_i^4(t) = k_i^2 - (v^i - m_i e)^T d_i, \quad i = 1,2,...,m$$
$$h_i^5(t) = k_i^1 - (v^i - m_i e)^T d_i, \quad i = 1,2,...,m$$
$$h_j^6(t) = \sum_{i=1}^{m} d_{ji} p(v^i - m_i e) + p(\overline{x}_j - x_j), \quad j = 1,2,...,k$$
$$h^7(t) = pe - 1$$
$$h^8(t) = 1 - pe$$

where

$$t = (v^1,v^2,...,v^m,x_1,x_2,...,x_k,p,z^1,...,z^5) \quad and \quad z^1,z^2 \in R_+^m, \quad z^3 \in R_+^k, \quad z^4,z^5 \in R_+,$$
$$e \in R_+^n, \quad e = (1,1,...,1)$$

Theorem 3: The allocation $\overline{z} = (\overline{y_1},\overline{y_2},....\overline{y_m},\overline{x_1},...,\overline{x_k},\overline{P})$ represents an equilibrium state of the Arrow – Debreu model if and only if it exist $\overline{z^1},\overline{z^2} \in R_+^m$, $\overline{z^3} \in R_+^k$, $,\overline{z^4},\overline{z^5} \in R_+$ so that $\overline{t} = (\overline{v^1},\overline{v^2},...,\overline{v^m},\overline{x_1},...,\overline{x_k},\overline{P},\overline{z^1},...,\overline{z^5})$ to represent a solution of the following non-linear complementary problem:

$$t \geq 0$$
$$h(t) \geq 0$$
$$t^T h(t) = 0$$

where $y_i = v^i - m_i e$

Proof:

We apply successively Kuhn-Tucker conditions to the following mathematical programming problems:

$$\min_{v_i \in V_i}(v^i)^T f_i^u(\overline{v^i}), \quad i = 1,2,...,m$$
$$\min_{p \in P} P^T f_{m+k+1}^u(\overline{P})$$
$$\min_{x_j \in X_j(u)}(x_j)^T f_{m+j}^u(\overline{x_j}), \quad j = 1,2,...,k$$

where $\overline{u} = (\overline{v^1},\overline{v^2},...,\overline{v^m},\overline{x_1},...,\overline{x_k},\overline{P})$ is fixed, and V_i are obtained based on Y_i, by changing $y_i = v^i - m_i e, \quad i = 1,2,...,m$ and forcing $u = \overline{u}$ to be an optimum point.

For revealing the link between the general equilibrium conditions, briefly mentioned above, with the complementarity format, we consider in the following the energy sector described by the model:

$$\begin{cases} \min \sum_t \overline{c_t} y_t \\ \sum_t a_{jt} y_t = \overline{d_j} \quad \forall j \\ \sum_t b_{kt} y_t \le s_k \quad \forall k \\ y_t \ge 0 \quad \forall t \end{cases}$$

where:

t - index for the possible energy production possibilities
j - index for the energy goods
k - index for the energy resources
y_t the production level based on technology *t*
a_{jt} - the net quantity of good *j*, produced based on technology *t*
$\overline{d_j}$ - the market demand for good *j*
$\overline{c_t}$ - the marginal cost associated to production technology *t*
b_{kt} - the unitary demand for the resource *k*, used with technology *t*
s_k - the aggregate supply of the energetic resource *k*

The above model is a costs minimization problem/model for the energy sector, so that the demand to be covered, and the technological constraints to be fulfilled.

For solving it, we apply Kuhn – Tucker method. So we associate positive multipliers λ_j and μ_k to the constraints. The optimum conditions are as follows:

$$\lambda_j (\sum_t a_{jt} y_t - \overline{d_j}) = 0 \qquad (1')$$

$$\mu_k (\sum_t b_{kt} y_t - s_k) = 0 \qquad (2')$$

$$\sum_j \lambda_j \overline{d_j} = \sum_t c_t y_t + \sum_k \mu_k s_k \qquad (3')$$

It can be noticed it exist similarities between the general equilibrium relations (1) and (2), and the relations obtained by applying Kuhn-Tucker conditions (1') and (2'). Also, there is a similarity between the duality relation (3') and the zero profit condition from the general equilibrium model.

2. Relevant aspects from the electricity market in Romania

The scope of making this insight into the Romanian electricity market is to facilitate the understanding of the entry data used in the applicative part of this paper, the last one.

Nuclear energy currently represent in Europe one of the most important energy resources without CO_2 emmissions. The nuclear plants ensure one third of the total electricity production in EU, so bringing a real contribution to sustainable development in the Union. In Romania, Unit 1 Cernavoda covers almost 10% of total electricity production. This year is expected to start to be used Unit 2 Cernavoda, and so to double the contribution of nuclear resource in covering electricity needs in Romania. The Romanian nuclear program is based on a secure tehnology, with a good recognition at international level, and being well perceived by the public opinion.

Based on some predictions for the evolution of several macroeconomic indicators between 2007 – 2020[4] (population, gross domestic product, energy intensity), the Economy and Commerce Ministery estimated the electricity needs for the same period (2007 – 2020), as well as the contribution of each energetic resources for covering those electricity needs [9]. Selected results[5] are displayed in the table bellow:

Table 1. Structure of electricity domestic production

	2003	2004	2005	2006	Estimated for 2010	Estimated for 2020
Electricity production for internal consumption coverage, TWh	54.55	55.3	56.48	58.99	66.1	85
Electricity export, TwH	2.08	1.18	2.93	3.41	4.5	15
Total electricity production, TwH	56.63	56.48	59.41	62.4	70.6	100
Electricity production in hydro plants + renewables, TwH	13.57	16.83	20.21	17.75	21.7	32.5
Electricity production in hydro plants + renewables, %	23.96%	29.80%	34.02%	28.45%	30.74%	32.50%
Electricity production in nuclear plants, Twh	4.9	5.55	5.54	5.55	10.8	21.6
Electricity production in nuclear plants, %	8.65%	9.83%	9.33%	8.89%	15.30%	21.60%
Electricity production in thermo plants, coal, Twh	23.34	21.47	21.66	27.1	27.1	34.9
Electricity production in thermo plants, coal, %	41.21%	38.01%	36.46%	43.43%	38.39%	34.90%
Electricity production in thermo plants, gas, Twh	11.19	10.46	10	10	9.5	9.5
Electricity production in thermo plants, gas, %	19.76%	18.52%	16.83%	16.03%	13.46%	9.50%
Electricity production in thermo plants, oil, Twh	3.63	2.17	2	2	1.5	1.5
Electricity production in thermo plants, oil, %	6.41%	3.84%	3.37%	3.21%	2.12%	1.50%

3. General equilibrium application

The application bellow is a general equilibrium model for the Romanian energetic system, considered as a component of the national economy. It is run with GAMS software (General Algebraic Modeling Systems), more specifically with the dedicated solver MPSGE (Mathematical Programming System for General Equilibrium). [3]

GAMS is a mathematical programming language, in use starting with 1987 in over 100 countries currently. It can solve complex problems of optimization and modelling: linear, linear mixed integer, non-linear, non-linear mixed integer, mixed complementary, general equilibrium, stochastic optimization, systems of non-linear simultaneously equations etc.

Let us consider a closed economy having:

- 2 goods being produced: electricity and the rest of the goods produced in the economy, aggregated (the non-energetic good)
- 3 production factors: labor, capital, and 5 types of energetic resources:
  - resources thermo-energetic (coal, gas, and oil)
  - resources hydro-energetic
  - nuclear resources

  Note: the aggregate good plays a double role: output, as well as input
- 1 representative consumer, endowed with the production factors, and responsible for the consumption of the goods produced
- 3 production sectors: for the non-energetic good, for the electricity, and for the consumer satisfaction based on his final consumption

  Note: the third sector is chosen like this for allowing the analysis of some relevant indices related to consumer satisfaction.

  With this specifications made, the general equilibrium model can lead to conclusions for both consumption and production activities in the economy, as well as for equilibrium prices.

Entry data for Scenario I :

We consider the following entry data for the production side:

- for the satisfaction of the representative consumer:

  The total of 100% comes from 3 sources:
  - usage of leisure (complementing the working time): 50%
  - consumption of the non-energetic goods: 40%
  - consumption of the electricity: 10%

  Note: conforming with the Romanian National Institute of Statistics, the value of the electricity consumption in total consumption is 10%

- for the production of the aggregate non-energetic good:

  The total of 40% is produced using the production factors as follows:
  - capital: 18.65%
  - labour: 18.65%
  - energetic resources: 2.7%

  Note: conforming with the Romanian National Institute of Statistics, the value of the production in the energetic sector in total value produced in all sectors of the economy is 6.8%, which leads to 2.7% input contribution, after weighting accordingly with the total

  Note: we assume that the production factors capital and labour equally contribute in producing the non-energetic good

- for electricity production

  The total of 10% is produced using the production factors as follows:

- o capital: 2%
- o labour: 2%
- o non-energetic good: 1%
- o energetic resources: 5%

Note: the energetic resources contribute to electricity production following exactly the distribution of electricity production at national level, as presented above in Table 1. For Scenario I, according to 2006 data, the weights should be:

- resources thermo-energetic, coal : 43.4 %
- resources thermo-energetic, gas: 16.0 %
- resources thermo-energetic, oil: 3.2 %
- resources hydro-energetic: 28.4 %
- nuclear resources: 8.9 %

These contributions are weighted before being input into the final model, so that to sum 5% at the end, and so to reach the assigned quota for energetic resources.

Note: it is assumed as a working hypothesis that labour and capital production factors equally contribute to production of the energetic good.

Entry data for the consumption side are presented in the following. It is assumed that all production factors, which are not intermediary goods, represent the endowment of a single consumer, a representative one in the economy considered.

- o capital: 20.65% (used in producing the aggregated non-energetic good, as well as in producing the energetic good, as it can be noticed from the entry data above)
- o human resource: 70.65% (this factor is used in goods production, as well as in consumer satisfaction production)
- o energetic resources: 5% (this factor is used only in producing the energetic good)

At equilibrium, the following results are obtained:

- the optimal production levels:

- o satisfaction from final consumption: 1.034
- o aggregated non-energetic good: 1.006
- o energetic good, split by production technologies:
  - resources thermo-energetic, coal : 0.613
  - resources thermo-energetic, gas: 0.649
  - resources thermo-energetic, oil: 0.015
  - resources hydro-energetic: 0.687
  - nuclear resources: 0.389

- relative equilibrium prices:

- o for the goods:

- utility index of final consumption: 1.125
- aggregated non-energetic good: 1.224
- energetic good: 0.514

- for the production factors:
  - human resources usage: 1.215
  - capital usage: 1.362
  - usage of resources thermo-energetic, coal: 0.191
  - usage of resources thermo-energetic, gas: 0.092
  - usage of resources thermo-energetic, oil: 0.004
  - usage of resources hydro-energetic: 0.156
  - usage of nuclear resources: 0.033

Entry data for Scenario II:

We consider the same entry data as for Scenario I, except for the electricity production structure. In this case, estimated data for 2010 are used:

- resources thermo-energetic, coal: 38.3 %
- resources thermo-energetic, gas: 13.0 %
- resources thermo-energetic, oil: 2.1 %
- resources hydro-energetic: 30.7 %
- nuclear resources: 15.3 %

The difference comes from increased contribution of the nuclear resource (almost doubled, compared to the previous scenario), so less contributions assigned to the fossil fuels based technologies. The motivation for simulating this scenario stands in the previous chapter of this paper.

The following results are obtained at equilibrium:

- the optimal production levels:

  - satisfaction from final consumption: 1.035
  - aggregated non-energetic good: 1.007
  - energetic good, split by production technologies:
    - resources thermo-energetic, coal: 0.619
    - resources thermo-energetic, gas: 0.524
    - resources thermo-energetic, oil: 0.035
    - resources hydro-energetic: 0.650
    - nuclear resources: 0.584

- relative equilibrium prices:

  - for the goods:
    - utility index of final consumption: 1.124
    - aggregated non-energetic good: 1.223
    - energetic good: 0.507

- for the production factors:
  - human resources usage: 1.215
  - capital usage: 1.362
  - usage of resources thermo-energetic, coal: 0.174
  - usage of resources thermo-energetic, gas: 0.061
  - usage of resources thermo-energetic, oil: 0.007
  - usage of resources hydro-energetic: 0.155
  - usage of nuclear resources: 0.079

4. Conclusions

The most important value in the economy considered is that of the aggregated non-energetic good (1.224), followed by the satisfaction of the representative consumer for the final consumption, and followed then by the energetic resources. The less important value is obtained for the energetic resource least used in the economy (oil, with 0.004).

By changing the structure of energetic resources usage, the equilibrium values are affected. It was shown how the equilibrium usage of the nuclear resource is changing from 0.033 to 0.079, once the nuclear contribution is almost doubling. Minor influences can be noticed at macroeconomic level as well, such as a decrease of the final consumption value and of the consumer's satisfaction (with 0.001 each of them).

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THE EFFECTS OF NON-NORMALITY ON TYPE III ERROR FOR COMPARING INDEPENDENT MEANS

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Abstract: *The major objective of this study was to investigate the effects of non-normality on Type III error rates for ANOVA F its three commonly recommended parametric counterparts namely Welch, Brown-Forsythe, and Alexander-Govern test. Therefore these tests were compared in terms of Type III error rates across the variety of population distributions, mean difference (effect size), and sample sizes. At the end of 100,000 simulation trials it was observed that the Type III error rates for four tests were affected by the effect size (δ) and sample size, whereas Type III errors were not affected from distribution shapes. Results of the simulation also indicated that increases in sample size and population mean difference decreased Type III error, and increased statistical test power. Across the all distributions, sample sizes and population mean differences (δ), the Alexander-Govern test obtained higher estimates for power, lower estimates of Type III error (γ).*

Key words: *Type I error rates, power of test, Type III error rates, normality, ANOVA*

1. Introduction

There are variety of alternatives to ANOVA F test under non-normality and homogeneity of variance. Among the most frequently cited parametric alternatives to ANOVA are Welch test, James second-order test, Marascuilo test, Brown-Forsythe test, K-statistic, Wilcox H_m test, Alexander-Govern test, trimmed mean (Welch, 1951; Brown and Forsythe, 1974; Alexander and Govern, 1994; Mehrota, 1997; Keselman, et al., 2002; Mendeş, 2002; Camdeviren and Mendes, 2005). Most of the studies related to test power were considered Type I and Type II error rates, however a third type of error has been suggested in the literature (Leventhal and Huynh, 1996; Leventhal 1999; MacDonald, 1999). Previous studies have investigated, in general, the power and Type I error rates for ANOVA F test and its various alternatives across variety of population distributions, variance patterns, sample sizes, and effect sizes (δ). Unfortunately in practice, Type III error is not taken into consideration. To date, the studies of the error rates control in statistical tests have not examined the probability of rejection in the wrong direction for ANOVA F test and its parametric alternatives when mean differences (effect size) exist. However, Type III error affects test power especially when sample sizes are small (Leventhal and Huynh, 1996; Leventhal 1999; MacDonald, 1999; Mendes, 2004).

The authors of previous studies have explicitly state that the tests for statistical significance would be two tailed. It is known that in a two-tailed hypothesis test, rejection of the null hypothesis means that the groups tested do not come from populations with a common μ. However, this information does not give an idea about the direction of the difference since conventional two-tailed tests evaluate non-directional statistical hypotheses and do not provide directional decisions (Shaffer 1972, Leventhal and Huynh, 1996; Finner, 1999). Recently, Leventhal and Huynh (1996), Leventhal (1999), Jones and Tukey (2000) have reviewed interest in the directional two-tailed t test, in part because, these authors maintain, knowing the null hypothesis is false implies that one of the alternative hypothesis is true, but not which true. The directional two-tailed test makes its contribution by telling us which directional alternative to accept (Leventhal, 1999, page 6). Camdeviren and Mendes (2005) had a simulation study for Type III error rates of some variance homogeneity tests

The power of a test is traditionally defined as the probability of rejecting a false null hypothesis (Cohen, 1988; Zar, 1999; Ferron and Sentovich, 2002). But, this definition is not always appropriate. Leventhal and Huyhn (1996) suggested that power can be defined as the probability of correctly rejecting a false null hypothesis and can be calculated as Power=1-β-γ. Type III error (γ) refers to correctly rejecting the null hypothesis, but incorrectly inferring the direction of the effect. Directional decisions on non-directional tests will overestimate power, underestimate sample size, and ignore the risk of Type III error under the definition of Leventhal and Huyhn (1996). By studying the Type III error rates for tests, one can evaluate, empirically, relative merits of using the statistical tests to analyze data. Correction of the power value adjusted to the Type III error rate is much lower than the power value classically calculated, especially in small samples (Muller and Lavange, 1992; Sansgiry and Akman, 2000).

For instance, if true mean differences exist between population A and population B, or among population A, population B, and population C on some measures of interest (e.g., for two populations $\mu_A \rangle \mu_B$, and for three populations $\begin{matrix} \mu_A > \mu_B \\ \mu_A > \mu_C \end{matrix}$), it would be possible for a researcher to commit two types of errors:

a) Type II error, which is the acceptance of a false null hypothesis with the conditional probability β.

b) Type III error, which is the rejection of a false null hypothesis with the conditional probability of γ and concluding a mean difference in the wrong direction (e.g., for two populations $\mu_A < \mu_B$, and for three populations $\begin{matrix} \mu_A < \mu_B \\ \mu_A < \mu_C \end{matrix}$).

Note that we are only considering the case where one mean μ_A differs from the rest as opposed to general departure from equality when there are more than two groups. These two types of errors directly affect the power of a test. Under this definition of power, the probability of making a Type III error must be eliminated (Leventhal and Huyhn, 1996; Sharon and Carpenter 1999) for calculations of power and sample size. If the direction of an effect is known, results will be more informative.

Another way to understand the directional two-tailed test is to view it as a single test evaluating three statistical hypotheses: H_0, H_1, and H_2. When testing the difference between two sample means, the hypotheses are

$H_0 : \mu_1 = \mu_2$, $H_1 : \mu_1 < \mu_2$ and $H_1 : \mu_1 > \mu_2$

Where H_0 is the null hypothesis, H_1, and H_2 are the alternative hypotheses.

Table 1. Relationship of the "Truth" and the decision about null hypothesis

Decision	Nature			
		H_1 true	H_0 true	H_2 true
Decision about nature	H_1 accept	Correct decision	Type I error (α)	Type III error (γ)
	H_0 accept	Type II error (β)	Correct decision	Type II error (β)
	H_2 accept	Type III error (γ)	Type I error (α)	Correct decision

Therefore, Type III error (γ) is only possible only when H_1 or H_2 is true. Two cells, accept H_2 when H_1 true and accept H_1 when H_2 true make different type of this error. There is no Type III error if null hypothesis is accepts. It can be seen that the non-directional two-tailed test does not provide for a directional decision and, hence cannot make a Type III error. Schaffer (1972) notified that a one-tailed test could make a Type III error by accepting directional alternative when the truth falls in the opposite direction. Therefore, in power studies, accordingly, with the revisited definition, the three-choice test's power is Power=1-□- γ for a given state of nature.

In the simplest case, two groups with equal variance; the Type III error rate can be analytically derived from the non-central t distribution. The difference in means $\overline{X}_A - \overline{X}_B$ has standard error $\sqrt{2S^2/n}$ for two samples of size n so if t_0 is the left tail critical value for example, the probability of rejecting for a given δ becomes

$$\Pr\{\frac{\overline{X}_A - \overline{X}_B}{\sqrt{2S^2/n}} < t_0\} = \Pr\{\frac{(\overline{X}_A - \mu - \delta\sigma) - (\overline{X}_B - \mu) + \delta\sigma}{\sqrt{2S^2/n}} < t_0\} = \Pr\{\frac{Z + \delta\sqrt{n/2}}{\sqrt{S^2/\sigma^2}} < t_0\}$$

Where $Z = \dfrac{(\overline{X}_A - \mu - \delta\sigma) - (\overline{X}_B - \mu)}{\sqrt{2\sigma^2/n}}$.

This probability can be computed from the non-central t distribution with non-centrality parameter $\delta\sqrt{n/2}$.

The major objective of this study is to investigate the effects of non-normality on Type III error for ANOVA F, Welch, Brown-Forsythe, and Alexander-Govern tests.

1.1. Definition of Statistical Tests

Let X_{ik} be the i^th^ observation in the k^th^ group. Where i=... n_k and k=1...K; let $\sum n_k = N$. The X_{ik}'s are assumed to be independent and normally distributed with expected values μ_k and variances σ_k^2. The best linear unbiased estimates of μ_k and σ_k^2 are

$$\overline{X}_{.k} = \frac{\sum X_{ik}}{n_k} \text{ and } S_k^2 = \frac{\sum\left(X_{ik} - \overline{X}_{.k}\right)^2}{\left(n_k - 1\right)} \text{ respectively.}$$

1.1.1. ANOVA F Test:

$$F = \frac{\sum_k n_k (\overline{X}_{.k} - \overline{X}_{..})^2 / (K-1)}{\sum_i \sum_k (X_{ik} - X_{.k}) / (N - K)} \qquad [1]$$

Where $X_{..} = \frac{\sum_k n_k \overline{X}_{.k}}{N}$, when population variances are equal. F is distributed as a central F variable with (K-1) and (N-K) degrees of freedom.

1.1.2. Welch Test

The test statistic for this test is $F_w = \frac{\sum_k W_k (\overline{X}_{.k} - X'_{..})^2 / (K-1)}{\left[1 + \frac{2}{3}(K-2)\Lambda\right]}$ [2]

Where $W_k = \frac{n_k}{S_k^2}$, $X'_{..} = \frac{\sum_k W_k \overline{X}_{.k}}{\sum_k W_k}$ and $\Lambda = \frac{3\sum_k (1 - W_k / \sum_k W_k)^2 / (n_k - 1)}{(K^2 - 1)}$ F_w statistic is approximately distributed as a central F variable with (K-1) and 1/∧ degrees of freedom.

1.1.3. Brown-Forsythe Test

Mehrota (1997) developed the following test

$$F_{BF} = \frac{\sum_k n_k (\overline{X}_{.k} - \overline{X})^2}{\sum_k (1 - n_k / N) S_k^2} \qquad [3]$$

In attempt to correct a "flaw" in the original Brown-Forsythe test. The "flaw" in the Brown-Forsythe testing procedure, as identified by Mehrota (1997), is the specification of the numerator degrees of freedom. In this study, Brown-Forsythe method proposes by Mehrota (1997) was used instead of the usual Brown-Forsythe method. Specially, Brown-Forsythe used K-1 numerator degrees of freedom whereas Mehrota (1997) used a Box (1954) approximation to obtain the numerator degrees of freedom, v_1, where

$$v_1 = \frac{\left[\sum_{i=1}^{K} (1 - n_i / N) S_i^2\right]^2}{\sum_{i=1}^{K} S_i^4 + \left[\sum_{i=1}^{K} n_i S_i^2 / N\right]^2 - 2.\sum_{i=1}^{K} n_i S_i^4 / N} \qquad [4]$$

and the denominator degrees of freedom; $v = \frac{\left[\sum_{i=1}^{K} n_i (1 - n_i / N) S_i^2\right]^2}{\sum_{i=1}^{K} (1 - n_i / N)^2 S_i^4 / (n_i - 1)}$ [5]

Under null hypothesis, F_{BF} is distributed approximately as an F variable with v_1 and v degrees of freedom (Mehrota, 1997).

1.1.4. Alexander-Govern Test

The test statistic for this test is $AG = \sum_{k=1}^{K} Z_k^2$ [6]

Where $Z_k = c + \frac{(c^3 + 3c)}{b} - \frac{(4c^7 + 33c^5 + 240c^3 + 855)}{(10b^2 + 8bc^4 + 1000b)}$

$a = v_k - 0.5$, $b = 48a^2$, $c = \sqrt{a * \ln(1 + \frac{t_k^2}{v_k})}$, $t_k = \frac{\overline{X}_k - X^+}{S_{\overline{X}_k}}$,

$X^+ = \sum_{k=1}^{K} W_k \overline{X}_k$, and $v_k = n_k - 1$.

AG statistic is approximately distributed as a chi-square distribution with (K-1) degrees of freedom (Alexander and Govern, 1994; Schneider and Penfield, 1997).

2. Material and Methods

Table 1. The characteristics of the distributions

Distributions	Mean	Variance	Skewness	Kurtosis
Normal (0, 1)	0.00	1.00	0.00	3.00
t (5)	0.00	1.67	0.00	6.00
χ^2 (3)	3.00	6.00	1.63	4.00
β (10, 10)	0.50	0.01	-0.001	-0.27
Exp (1.25)	1.25	1.60	2.00	6.08
W (1.5, 1)	0.92	0.37	1.07	1.38

N (0, 1): standard norlma dist., **t (5):** t-dist. with 5 df., χ^2 **(3):** Chi-square dist. with 3 df.
β (10, 10): Beta dist. with (10, 10) parameters, **Exp (1.25):** Exponential dist. with (1.25) parameter
W (1.5, 1): Weibull dist. with (1.5, 1) parameters

A computer simulation program was used Monte Carlo techniques to investigate the effects of non-normality on Type III error rates of ANOVA F and its three commonly recommended parametric alternatives across a variety of experimental conditions. The error rates of four tests were evaluated under six different population shapes (Normal (0, 1), t-distribution with 5 df, chi-square with 3 df, Exponential (1.25), Beta (10, 10), and Weibull (1.5, 1) and seven sample-size pairings (n_1, n_2, n_3) of (5, 5, 5), (10, 10, 10), (20, 20, 20), (30, 30, 30), (3, 4, 5), (5, 10, 15), and (10, 20, 30). Those distributions were selected since those distributions are predominantly used in literature (Alexander and Govern, 1994; Wilcox, 1994; Penfield, 1994; Keselman et al., 2002; Mendeş, 2002). Distributions were generated using random number generators from IMSL (functions RNNOA, RNSST, RNCHI, RNEXP, RNBET, and RNWIB) (Anonymous, 1994). Sawilowsky and Blair (1992) investigated effects of eight non-normal distributions, which were identified by Micceri (1989) on the robustness of Student's t test, and they found that only the distributions with the most extreme degree of skewness (e.g., skewness=1.64) affected Type I error control of the independent sample t statistics. In this study, maximum degree of skewness used was 2.00. In this study, only small sample size conditions were taken into consideration. Because in practice, researchers were studied with small sample sizes. The effects of Type III error on test power were more obvious, especially when sample sizes were small (MacDonald, 1999; Mendeş, 2004).

The populations were standardized because they have different means and variances. Shape of distributions was not changed while the means were changed to 0 and the standard deviations were changed to 1. The effect sizes (standardized mean differences (δ) of 0.8 and more standard deviation approximate those suggested by Cohen (1988) to represent large effect sizes. In this study, we used (0.25) standard deviation to represent small effect size, (0.75) standard deviation to represent medium effect size, and (1.0) standard deviation to represent large effect size. To make a difference between the population means in which generated samples were taken from, specific constant numbers in standard deviation form (δ=0.25, 0.75, 1.0) were added to the random numbers of the first population. We have done computations for many other parameter values as well; since the results are quite similar, for saving printing space, other results will not be given here. 100,000 runs were generated for each distribution and each given set of parameter values and frequencies of samples for the rejection regions were counted for the ANOVA F test, the Welch test, the Brown-Forsythe test, and the Alexander-Govern test. That is, for each pair of samples, ANOVA F (F), Welch (W), Brown-Forsythe (BF), and Alexander-Govern (AG) test statistics were calculated (for the F test we compute F and count the frequency satisfying F > F (k-1, N-k-1) d.f, for the Welch test we compute F_W values and count the frequency satisfying F_W > F (k-1, 1/$\wedge$) d.f, for Brown-Forsythe test, we compute F_{BF} and count the frequency satisfying F_{BF} > F (v_1, v) d.f., and for Alexander-Govern test we compute AG and count the frequency satisfying AG > χ^2 (k-1) and a check was made to see if the hypothesis which is actually true was rejected and which is actually false was rejected at α=0.05. The experiment was repeated 100,000 times and the proportion of observations falling in the critical regions was recorded. This proportion estimation is test power if the means from the populations do differ ($\mu_1 \neq \mu_2$). Type III error rate was obtained by counting how many times the highest mean population in real is smaller than the other population means (r_1) in the rejected sum of hypothesis and transforming this number into relative frequency ($\gamma=r_1$ / 100,000). That is, Type III (rejection of a false null hypothesis in the wrong direction) error rates were computed for conditions in which the null hypothesis was false. We wrote a FORTRAN program for Intel Pentium III processor to compute all tests.

3. Results and Discussion

The results are presented in Tablo 2-7. Table 2 contains the Type III error rates of four tests when distributions were normal. Across all sample sizes, the estimates of Type III error rates for W test ranged from 1.00 % to 1.52 % under small effect size (0.25), ranged from 0.09% to 0.80% under medium effect size (0.75), and ranged from 0.00% to 0.48% under large effect size (1.00). The estimates of Type III error rates for BF test ranged from 0.89% to 1.48% under small effect size (0.25), ranged from 0.09 % to 0.70 % under medium effect size (0.75), and ranged from 0.00% to 0.70% under large effect size (1.00). Under the same conditions, the estimates of Type III error rates for AG test ranged from 0.13% to 0.64%, from 0.05% to 0.26%, and from 0.00% to 0.17%, respectively, whereas the Type III error estimates for F test ranged from 1.31% to 2.20%, from 0.11% to 1.35%, and from 0.00% to 0.72% respectively. That result demonstrated that the alternative tests were more robust than the F test at controlling the probability of Type III error rates. On the other hand, it can be said that AG test is more robust than the others at controlling the probability of Type III error. As we expected, probability of a rejection in the wrong direction decreased as sample size and population mean differences increased. It was also seen that the effects of small sample sizes on Type III error is more pronounced. Leventhal and Huynh (1996) reported that the Type III error rate always less than 0,5α. Therefore, the difference between the tests is always less than 0,5α when two group means was compared. Similarly, Sarkar et al. (2002) stated that the chance of Type III error is less than that of Type I error (α). Results of this study are consistent with the reporting Leventhal and Huynh (1996), Sarkar et al. (2002), and the findings reported by MacDonald (1999) and Mendes (2004). However, nothing has been reported for the comparison of more than two group means. Neverlethess, Type III error rate might be found more than 0.5α under some experimental conditions. The reason for that might be the distribution shape, number of groups, variance ratio, and the relationship between the sample size and group variances (direct and inverse pairing).

When samples were drawn from three t (5) distributions, Type III error was higher for F test than that for W, BF, and AG test (Table 3). And, this was more obvious in small sample sizes and effect size (0.25). The Type III error rate was affected by total sample sizes rather than inequality in sample sizes. Under the same experimental conditions, when δ was 1.0, it was seen that the Type III error rate for F, W, BF, and AG test was found to be 0.94%, 0.65%, 0.56%, and 0.20% respectively, even if sample sizes were 5. Under this distribution, AG test is still superior to the others.

It can be seen that table 3, table 4, and table 6 gave similar results. Therefore, it can be said that the effects of t (5), χ^2 (3), and exponential (1.25) distributions on Type III error rates for all tests were similar. At he same time, the effect of table 2 and table 5 on Type III error were similar too.

When samples were drawn from three Weibull (1.5, 1) distributions, across all sample sizes, the estimates of Type III error rates for W test ranged from 1.02% to 1.43% for δ=0.25, ranged from 0.10% to 1.06% for δ=0.75, and ranged from 0.00% to 0.78% for δ=1.00. The estimates of Type III error rates for BF test ranged from 0.86% to 1.48% for δ=0.25, ranged from 0.10% to 0.88% for δ=0.75, and ranged from 0.00% to 0.61% for δ=1.00. Under the same conditions, the estimates of Type III error rates for AG test ranged from 0.24% to 0.83%, from 0.08% to 0.50%, and from 0.00% to 0.32%, respectively, whereas the Type III error estimates for F test ranged from 1.36% to 2.14%, from 0.10% to 1.40%, and from 0.00% to 1.02% respectively (Table 7). It can be seen that the results of Table 7 were similar to the results of the Table 2 and Table 5.

When Table 2-7 evaluated together, the superiority of the AG test can be seen for all distributions and sample sizes. Because, across the all distributions, sample sizes and population mean differences (δ), the AG test obtained higher estimates for power, lower estimates of Type III error (γ). Therefore, revisited version of test power of the AG test, Power=1- β- γ, will be higher than the others. Power of F test is smaller than the alternatives in general. Because, Type III error rates for F test were higher than W, BF, and AG test in general. On the other hand, simulation results suggested that Type III error rates for tests were not affected from distribution shape.

4.Implication

The results of the present simulation of the Type III error rates of the ANOVA F and its three commonly recommended parametric alternatives indicate that the AG test provides a considerable advantage over the F, W, and BF test in all experimental conditions. Because, in almost every experimental situation, the Type III error rates were lower for the AG test and the power of the AG test was higher than the others in many cases. On the other hand, simulation results indicated that the deviation from normality was not affect the Type III error even if distributions were exponential (1.25).

Table 2. Type III error (%) for different statistics when data are simulated from three Normal (μ_i, σ_i^2) distributions based on 100,000 simulations; α=0.05

	$\mu_1:\mu_2:\mu_3$=**0:0:0.25**				$\mu_1:\mu_2:\mu_3$=**0:0:0.75**				$\mu_1:\mu_2:\mu_3$=**0:0:1.0**			
	F	W	BF	AG	F	W	BF	AG	F	W	BF	AG
5:5:5	2.20	1.51	1.33	0.48	1.12	0.80	0.70	0.22	0.72	0.48	0.43	0.17
10:10:10	1.88	1.52	1.48	0.64	0.66	0.51	0.49	0.26	0.31	0.27	0.26	0.12
20:20:20	1.51	1.19	1.19	0.60	0.27	0.23	0.23	0.12	0.04	0.03	0.03	0.01
30:30:30	1.31	1.00	1.00	0.58	0.11	0.09	0.09	0.05	0.00	0.00	0.00	0.00
3:4:5	2.15	1.12	0.89	0.13	1.35	0.72	0.54	0.11	0.72	0.35	0.29	0.07
5:10:15	1.73	1.07	0.92	0.26	0.59	0.37	0.31	0.13	0.32	0.26	0.22	0.06
10:20:30	1.42	1.12	1.02	0.36	0.28	0.23	0.20	0.11	0.12	0.10	0.08	0.04

Table 3. Type III error (%) for different statistics when data are simulated from three t (5) distributions based on 100,000 simulations; α=0.05

	$\mu_1:\mu_2:\mu_3$=**0:0:0.25**				$\mu_1:\mu_2:\mu_3$=**0:0:0.75**				$\mu_1:\mu_2:\mu_3$=**0:0:1.0**			
	F	W	BF	AG	F	W	BF	AG	F	W	BF	AG
5:5:5	1.96	1.19	1.04	0.31	1.12	0.62	0.55	0.17	0.94	0.65	0.56	0.20
10:10:10	1.79	1.41	1.36	0.55	0.95	0.74	0.70	0.33	0.60	0.49	0.47	0.24
20:20:20	1.61	1.25	1.23	0.50	0.55	0.48	0.48	0.25	0.17	0.14	0.14	0.10
30:30:30	1.47	1.20	1.10	0.45	0.35	0.31	0.30	0.17	0.04	0.02	0.01	0.00
3:4:5	2.13	1.03	0.81	0.19	1.26	0.55	0.48	0.08	0.83	0.45	0.31	0.09
5:10:15	1.69	0.93	0.85	0.23	0.93	0.56	0.49	0.17	0.45	0.31	0.24	0.04
10:20:30	1.56	1.07	0.98	0.34	0.55	0.42	0.40	0.14	0.21	0.17	0.14	0.04

Table 4. Type III error (%) for different statistics when data are simulated from three Chi (3) distributions based on 100,000 simulations; α=0.05

	$\mu_1:\mu_2:\mu_3$=**0:0:0.25**				$\mu_1:\mu_2:\mu_3$=**0:0:0.75**				$\mu_1:\mu_2:\mu_3$=**0:0:1.0**			
	F	W	BF	AG	F	W	BF	AG	F	W	BF	AG
5:5:5	1.88	1.14	0.90	0.26	1.22	0.98	0.71	0.31	0.88	0.74	0.54	0.30
10:10:10	1.66	1.23	1.09	0.62	0.80	0.74	0.64	0.49	0.51	0.49	0.45	0.35
20:20:20	1.70	1.40	1.33	0.87	0.41	0.40	0.38	0.35	0.11	0.11	0.10	0.05
30:30:30	1.60	1.37	1.33	0.95	0.15	0.13	0.13	0.09	0.00	0.00	0.00	0.00
3:4:5	1.72	0.88	0.65	0.08	1.26	0.69	0.58	0.15	0.77	0.49	0.33	0.15
5:10:15	1.39	0.85	0.77	0.31	0.66	0.49	0.49	0.22	0.47	0.31	0.20	0.08
10:20:30	1.40	1.03	1.01	0.47	0.37	0.35	0.35	0.22	0.08	0.06	0.06	0.02

Table 5. Type III error (%) for different statistics when data are simulated from three Beta (10, 10) distributions based on 100,000 simulations; α=0.05

	$\mu_1 : \mu_2 : \mu_3$ **=0:0:0.25**				$\mu_1 : \mu_2 : \mu_3$ **=0:0:0.75**				$\mu_1 : \mu_2 : \mu_3$ **=0:0:1.0**			
	F	W	BF	AG	F	W	BF	AG	F	W	BF	AG
5:5:5	2.22	1.55	1.38	0.50	1.10	0.71	0.62	0.24	0.84	0.60	0.53	0.21
10:10:10	1.79	1.40	1.36	0.51	0.72	0.57	0.56	0.26	0.30	0.24	0.24	0.11
20:20:20	1.40	1.16	1.15	0.51	0.34	0.32	0.32	0.21	0.03	0.03	0.03	0.01
30:30:30	1.36	1.20	1.20	0.58	0.08	0.07	0.07	0.04	0.00	0.00	0.00	0.00
3:4:5	2.37	1.30	1.06	0.26	1.28	0.79	0.64	0.16	0.73	0.40	0.33	0.10
5:10:15	1.75	1.15	1.01	0.31	0.66	0.44	0.34	0.09	0.34	0.22	0.20	0.03
10:20:30	1.48	1.18	1.10	0.48	0.31	0.24	0.22	0.10	0.08	0.07	0.06	0.04

Table 6. Type III error (%) for different statistics when data are simulated from three Exponential (1.25) distributions based on 100,000 simulations; α=0.05

	$\mu_1 : \mu_2 : \mu_3$ **=0:0:0.25**				$\mu_1 : \mu_2 : \mu_3$ **=0:0:0.75**				$\mu_1 : \mu_2 : \mu_3$ **=0:0:1.0**			
	F	W	BF	AG	F	W	BF	AG	F	W	BF	AG
5:5:5	1.71	1.07	0.76	0.18	1.21	0.97	0.61	0.29	0.94	0.83	0.47	0.28
10:10:10	1.69	1.19	0.99	0.59	0.88	0.83	0.64	0.51	0.43	0.43	0.36	0.30
20:20:20	1.53	1.22	1.14	0.80	0.46	0.44	0.42	0.36	0.10	0.10	0.09	0.09
30:30:30	1.50	1.33	1.31	0.95	0.19	0.19	0.19	0.18	0.02	0.01	0.02	0.00
3:4:5	1.57	0.66	0.54	0.10	0.94	0.60	0.42	0.12	0.81	0.63	0.47	0.17
5:10:15	1.30	0.75	0.70	0.13	0.71	0.57	0.54	0.28	0.40	0.37	0.36	0.28
10:20:30	1.20	0.81	0.79	0.32	0.38	0.37	0.37	0.25	0.12	0.10	0.10	0.06

Table 7. Type III error (%) for different statistics when data are simulated from three Weibull (1.5, 1) distributions based on 100,000 simulations; α=0.05

	$\mu_1 : \mu_2 : \mu_3$ **=0:0:0.25**				$\mu_1 : \mu_2 : \mu_3$ **=0:0:0.75**				$\mu_1 : \mu_2 : \mu_3$ **=0:0:1.0**			
	F	W	BF	AG	F	W	BF	AG	F	W	BF	AG
5:5:5	2.14	1.43	1.15	0.40	1.40	1.06	0.88	0.28	1.02	0.78	0.61	0.29
10:10:10	1.79	1.34	1.26	0.64	0.91	0.81	0.74	0.50	0.51	0.46	0.44	0.32
20:20:20	1.75	1.51	1.48	0.83	0.30	0.29	0.28	0.20	0.03	0.02	0.02	0.00
30:30:30	1.58	1.40	1.39	0.81	0.10	0.10	0.10	0.08	0.00	0.00	0.00	0.00
3:4:5	1.94	1.02	0.86	0.24	1.35	0.75	0.62	0.13	1.04	0.67	0.55	0.14
5:10:15	1.66	1.06	0.96	0.27	0.81	0.55	0.54	0.24	0.37	0.31	0.30	0.13
10:20:30	1.38	1.04	0.99	0.39	0.44	0.40	0.40	0.20	0.09	0.08	0.08	0.03

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[1] Brief Description of the Fields of Statistical Expertise: Experimental Design, Statistical Data Analysis, Simulation Studies, Applied Regression analysis, Computer programming, Covariance analysis, Nonparametric Statistical Analysis, Statistical Package Programs, Multivariate Analysis Techniques, Analysis of Longitudinal data, Growth Curves.

AUTOMATED SOFTWARE TRANSLATION – THEORETICAL BACKGROUND AND CASE STUDY

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Abstract: *The necessity for software migration is presented. The concept of software migrator is introduced. A generality metric for software translations is proposed. The business feasibility of automated versus manual migration is studied. nTile PHPtoJava, a working software migrator, is reviewed.*

Key words: software translation; software migrator; programming languages; generality metrics; PHP; Java

1. Software Translation Overview

The evolution of programming languages has produced a wide variety of exponents, grouped into generations. Evolving computer hardware together with evolving operating systems have led to the emergence of new programming languages and to the marginalization of others. The O'Reilly History of Programming Languages poster [OREI07][2] displays more than 50 major programming languages that have been used in the last 50 years of software development, while Bill Kinnersley's Language List [KINN07] contains over 2500 known programming languages, ranging from the obscure to the widely used.

As a consequence, the allotment of specialists in different programming languages and architectures has changed over time. A programming language doesn't disappear, but once there are no tools to run it on new platforms, the language is less and less used and specialists are increasingly more difficult to find. This is the case of many COBOL dialects, for example.

Another cause of language outdating is that in time their features cover less and less of the current needs – lack of Web support is an example in this sense. That is why new and improved versions should be continuously developed for languages, their libraries and tools. When this does not happen, possibly because the vendor is out of business or shifts its priorities, some languages do get to a dead point. For instance, according to [REED07] the future of SAP ABAP language is uncertain precisely because a more suitable language (Java) is available to develop code for SAP systems.

In such situations it becomes necessary to migrate application systems developed with outdated languages towards modern languages and technologies, more adequate for business needs and with support from established vendors. The migration process also offers the possibility of switching the underlying hardware and software platform (e.g. migration from mainframes to PCs).

While this migration can be accomplished manually by a complete rewrite of the application system, there are situations when an automated process is more suitable. Some reasons are detailed in section 4 Economical Feasibility. Automated migration is performed using specialized products called software migrators.

The concept of software migrator derives from the one of language migration, which refers to a language transformation without altering semantics. A software migrator is a tool that translates sentences written in a source language into the semantically equivalent sentences in a target language. It also emulates the semantic dependencies generated by the libraries of the application system.

The theoretical background of software migrators is a generalization of the compilers theory. In this context, a compiler becomes a particular case of software migrator that produces sentences in a low-level language (assembly or machine code).

Many issues that a software migrator must solve depend on the characteristics of the source and target languages. These characteristics include:

- generations: for example, migrating from a structured language to an object-oriented one must provide mechanisms for fully making use of encapsulation, abstraction, polymorphism and inheritance;
- type systems: migrating from a weakly/dynamically-typed language to a strongly/statically-typed one requires type inference algorithms;
- execution model: migrating from an interpreted language to a compiled one means that the migrator must handle dynamic constructs (variables, procedures, dependencies), error reporting paradigms etc.

This paper presents the theoretical background and business rationale behind the nTile PHPtoJava software migrator developed by Numiton Ltd. The design and implementation of this migrator had to take into account all three challenges mentioned above.

2. nTile PHPtoJava Architecture

PHP is a programming language used for developing most of the small to medium public Web sites. It is a weakly typed interpreted language with several dynamic capabilities. Up to version 4 it was a structured language, afterwards being endowed with object-oriented features.

Java is a general-purpose programming language, widely used for desktop, Web and mobile applications. It is a strongly typed compiled language, with a pronounced object-oriented character. The Java Enterprise Edition platform powers most of the medium to large business applications.

As the name suggests, nTile PHPtoJava is a software migrator from the PHP language to Java EE. Figure 1 presents its overall architecture.

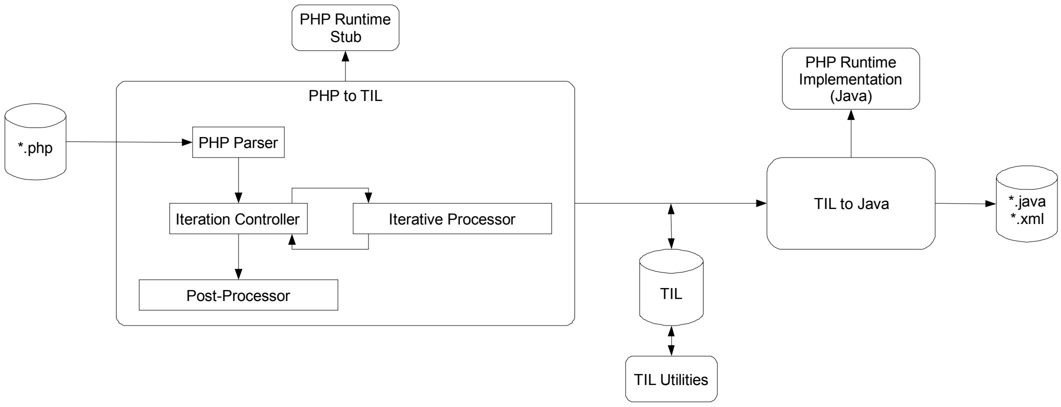

Figure 1. nTile PHPtoJava architecture

The software migrator is composed of two main modules: PHPtoTIL and PHPtoJava. PHP source files are processed by PHPtoTIL and stored in an intermediate representation called the **T**ranslation **I**ntermediate **L**anguage - **TIL**. TILtoJava then turns this intermediate representation into Java source files, packaged as a JavaEE application.

Further detailing the architecture, PHP2TIL is composed of several submodules, as follows:

1. PHP Parser – processes the source files based on the PHP grammar rules and builds a first version of the TIL representation. From this point on, all work is carried out on this representation;
2. Iterative Processor – the migration is performed in several iterations. Each iteration uses the already gathered information in order to further refine resolving of entities, type inference etc.
3. Iteration Controller – this component monitors iterations and decides when the gathered information can no longer be refined. Control is then transferred to the post-processor.
4. Post-Processor – performs some finishing touches on the intermediate representation, such as collecting translation statistics, and finalizing the type inference.

Throughout its operation PHPtoTIL collaborates with an utility module containing the interface of the PHP runtime, in order to have a fully resolved TIL model.

TILtoJava simply traverses the well-formed TIL representation and translates it into appropriate Java constructions. The Java abstract syntax tree (AST) is built in-memory, then saved as Java source code together with JavaEE support classes and XML descriptors. The Java implementation of the runtime is also linked to the final application.

A sample translation is presented below. The PHP input consists of the files *interpreterTest.php*, *included.php* and *included2.php*. This sample code performs a dynamic PHP include operation depending on the value of a HTTP session variable.

interpreterTest.php:	included.php:	included2.php:

`<?php`
`echo "Body -> interpreterTest.php\n";`
`$b = ".php";`
 	
`if($_SESSION['selector']=="included") {`
`    $a = 'included';`
`} else {`
`    $a = 'included2';`
`}`
 	
`$includeResult = require $a.$b;`
`echo "includeResult = $includeResult\n";`
 	
`?>`
	`<?php`
	`echo "Body -> included.php\n";`
	`return 3;`
	`?>`
		`<?php`
		`echo "Body -> included2.php\n";`
		`return 10;`
		`?>`

The migrator produces the Java output consisting of the source files *interpreterTest.java*, *included.java*, *included2.java* and *GlobalVars.java*. For brevity, the XML descriptors and some support classes are not presented.

interpreterTest.java:

```
public class interpreterTest extends NumitonServlet {
 public Object generateContent(PhpWebEnvironment webEnv) throws IOException, ServletException {
  gVars.webEnv = webEnv;
  VarHandling.echo(gVars.webEnv, "Body -> interpreterTest.php\n");
  gVars.b = ".php";
  if (VarHandling.equals(gVars.webEnv, gVars.webEnv._SESSION.getValue(gVars.webEnv,
     "selector"), "included")) {
   gVars.a = "included";
  }
  else {
   gVars.a = "included2";
  }
  gVars.includeResult = new DynamicConstructEvaluator<Integer>() {
   public Integer evaluate() {
    Integer evalResult = null;
    if (VarHandling.equals(gVars.webEnv, gVars.a, "included")
      && VarHandling.equals(gVars.webEnv, gVars.b, ".php")) {
     evalResult = (Integer) PhpWeb.include(gVars, gConsts, example.included.class);
    }
    if (VarHandling.equals(gVars.webEnv, gVars.a, "included2")
      && VarHandling.equals(gVars.webEnv, gVars.b, ".php")) {
     evalResult = (Integer) PhpWeb.include(gVars, gConsts, example.included2.class);
    }
    return evalResult;
   }
  }.evaluate();

  VarHandling.echo(gVars.webEnv, "includeResult = "
     + VarHandling.strval(gVars.webEnv, gVars.includeResult) + "\n");
  return null;
 }

 public interpreterTest() {
 }
}
```

included.java:

```
public class included extends NumitonServlet {
 public Integer generateContent(PhpWebEnvironment webEnv) throws IOException, ServletException {
  gVars.webEnv = webEnv;
  VarHandling.echo(gVars.webEnv, "Body -> included.php\n");
  return 3;
```

```
  }

  public included() {
  }
}
```

included2.java:

```
public class included2 extends NumitonServlet {
  public Integer generateContent(PhpWebEnvironment webEnv) throws IOException, ServletException {
    gVars.webEnv = webEnv;
    VarHandling.echo(gVars.webEnv, "Body -> included2.php\n");
    return 10;
  }

  public included2() {
  }
}
```

GlobalVars.java:

```
public class GlobalVars extends GlobalVariablesContainer {
  public GlobalConsts                gConsts;

  public GlobalVars() {
  }

  public String        b;
  public String        a;
  public int           includeResult;
}
```

Apart from objectification, the above sample illustrates some of the advanced migration processes available in nTile TILtoJava:

- generating declarations and type inference for variables – the declarations of global variables *a*, *b* and *includeResult* are generated inside *GlobalVars.java;*
- transforming dynamic constructs into static ones, by performing static analysis – see the include expressions in *interpreterTest.java*.

Applying to the migration output the source lines of code software metric [LAIR06],but not counting non-relevant source code lines (emtpy lines, commented lines, lines containing empty braces etc.), the results from Table 1 are obtained.

Table 1. Effective source lines of code comparison

Translated Entity	***eLOC in PHP***	***eLOC in Java***
interpreterTest	7	24
included	2	6
included2	2	6
GlobalVars	N/A	6
TOTAL	**11**	**42**

The results underlines that comparing applications based on the number of lines of code is not a relevant metric, especially when the compared applications are written in different programming languages. The substantially larger Java migration output has a much improved clarity as well as maintainability than the much more compact original PHP code. Additionally, there is a fixed overhead an average Java source file has over a PHP source file, whose overall percentage decreases as the source file gains in complexity.

3. Generality Metrics of Software Migrators

The design and implementation of a software migrator is a complex task. The migrator should ideally cover all variations of the source language syntax and semantics, and be able to translate them into optimal target language constructs. Nevertheless, a partially developed migrator could successfully translate a well chosen set of applications. An incremental approach to development is thus possible, each iteration increasing the coverage degree of the source language.

In order to track progress and have a decisional basis for the features of each iteration, some sort of metric must be devised. In [ENYE04] a generality metric for software migrators is proposed, referring to the coverage degree of source language constructions and runtime libraries.

Source language constructions are described in the language's grammar and include program structures, data and instruction definitions. Measurement of the generality degree for software migrators takes into consideration the following aspects:

a) The coverage degree for constructions and functionalities of the source languageThis degree does not only refer to the number of distinct constructions and functionalities. In the case of complex migrators, the implementation coefficient of each source language feature must be taken into account. A situation where some constructions are partially supported may appear during the development iterations. Determining the implementation coefficient is done by the migrator's development team, taking into account for example man-days or cost for the current implementation and the estimated effort to completion.

b) The importance coefficient of each constructionThe importance coefficient of a language construction is also determined by the translator's developers and is based on the average usage frequency of the construction in a representative set of applications.

c) The translation degree of runtime librariesUsually, apart from language constructions a software application uses a standard program library and possibly a set of third-party libraries. Translating an application also requires translating these libraries. A difficulty arises when the source code for third-party libraries is not available. Even more, for many languages not even the source code of the standard library is available. When the source code of a library is available, the translation degree of the library does not influence the migrator's generality. This is because the same migrator is used to automatically translate the library as well as the application. When the source code of a library is not available, automated translation cannot be accomplished. Translating the behavior of the source language library into an equivalent behavior in the target language becomes a manual operation. Because the standard library is used by any application written in the source language, it is mandatory that the generality metric include the translation degree of the standard library.

Taking these factors into consideration, the proposed generality metric formula is:

$$G_{TF}=C_L\cdot\frac{\sum_{i=1}^{n} CoImp_i\cdot CoImpl_i}{ConT}+(1-C_L)\cdot G_T B_{st},\ CoImp_i\in|0;1|,\ CoImpl_i\in|0;1|$$

where:

G_{TF} – the software migrator generality degree,
$CoImp_i$ – the importance coefficient for each construction of the source language,
$CoImpl_i$ – the implementation coefficient of each source language construction,
$ConT$ – the total number of constructions in the source language,
C_L – the importance coefficient of the language,
$G_T B_{st}$ – the translation degree of the standard library.

The first term of the formula represents the coverage degree of the language constructions.

The C_L importance coefficient is the translation generality ratio in relation with the translation generality of the standard library. It depends on the source language. When the source code of the standard library is available, C_L has maximum value 1 because the translator's generality is entirely conditioned by the coverage degree of the language constructions. This ideal situation does not often occur, because standard libraries usually have proprietary implementations. Availability might also depend on the licensing model for the source code of the standard library.

The development of software migrators should aim to increase the generality metric as much as it is economically feasible, the development costs are justified. Other aspects, such as execution speed and memory requirements of the software migrator, should also be put in balance.

Applying the above generality metric formula to the nTile PHPtoJava software migrator means analyzing the structure of the PHP language and assigning suitable values to the influencing factors.

With respect to source language constructs, Table 1 contains the importance and implementation coefficients that have been determined at a certain point in the development cycle of the migrator.

Table 2. PHP source language constructs

Source Language Construct	***Importance Coefficient***	***Implementation Coefficient***
Top-Level Constructs		
Class	1	1
Class Field	1	1
Function and Class Method	1	1
Source File	1	1
Statements		
BREAK/CONTINUE	1	0.7
Compound	1	1

Source Language Construct	***Importance Coefficient***	***Implementation Coefficient***
Display	1	1
DO-WHILE	1	1
Exception Handling	0.7	1
Expression Container	1	1
FOR	1	1
FOR-EACH	1	1
LIST	0.7	0.5
Multiple Decision (SWITCH)	1	1
RETURN	1	1
Simple Decision (IF-THEN-ELSE)	1	1
WHILE	1	1
Expressions		
Array	1	1
Binary	1	1
Class Instantiation	1	1
Dynamic Function Call	0.5	0
Dynamic Include	0.9	0
Dynamic Variable Reference	0.5	0
Function Call	1	0.9
Include	1	1
Literal	1	1
Ternary Conditional	1	1
Type Cast	1	1
Type Test (INSTANCEOF)	1	1
Unary	1	1
Variable Reference	1	1

Dynamic constructs - variables, function calls and includes - are not supported yet. Dynamic variables and function calls are not widely-used in PHP programs and therefore have a smaller importance coefficient. Dynamic includes however should be considered a priority in subsequent development iterations, because they are used very frequently.

Partially implemented language constructs are BREAK/CONTINUE statements (no nesting level jumps), LIST statements (no character strings can be used as assigners) and function call expressions (no optional arguments are supported).

The standard PHP library is divided into function groups. The implementation coefficient of each function group is presented in Table 2.

Table 3. PHP runtime implementation details

Function Group	***Total***	***Implemented***	***Implementation Coefficient***
Arrays	75	36	0.48
Date and Time	37	5	0.14
Directories	9	3	0.33
Error Handling and Logging	11	1	0.09
Filesystem	78	27	0.35
Function Handling	11	1	0.09
Mail	2	1	0.5
Mathematical	48	11	0.23
Miscellaneous	25	3	0.12
Network	32	4	0.13
Output Control	17	6	0.35
PHP Options&Information	47	10	0.21
POSIX Regex	7	4	0.57
Sockets	25	1	0.04
Strings	95	39	0.41
URLs	10	6	0.6
Variables handling	36	28	0.78
Zlib Compression	22	4	0.18
TOTAL	**587**	**190**	**0.32**

The more frequently used library functions have taken priority when developing the migrator's runtime support. Also, some other implemented functions are are not taken into account, as they belong to non-standard library extensions (MySQL, FTP, image handling).

According to these particularizations, the value of the generality metric for nTile PHPtoJava becomes:

$$G_{TF} = 0.6 \cdot \frac{26.65}{31} + (1-0.6) \cdot 0.32 = 0.64$$

This value can be increased by further development of the migrator, notably by implementing the dynamic constructs and by supporting a larger number of PHP runtime library functions. The current functionality is sufficient however for translating numerous real-life PHP projects.

4. Economical Feasibility

The need to migrate a software application to a new programming language appears in several cases. One of these cases is that the code base of the application has outgrown the possibilities of the source language and its tools, maintenance and development of new features becoming problematic. Another scenario is that vendor support is no longer satisfying or that the specialists for the source language have become/are about to become scarce. Usually all these aspects are interlinked and tend to occur simultaneously, due to the inherent life-cycle of programming languages.

Figure 2 illustrates vendor support and specialists' availability over time for a typical programming language.

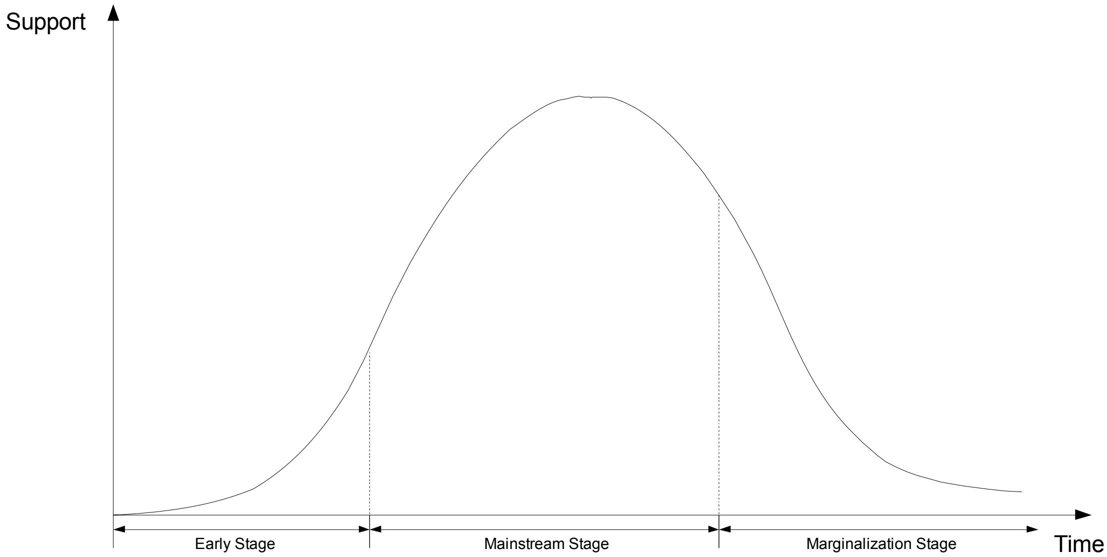

Figure 2. Programming language life-cycle

Once the need to migrate has been established, a matter to be thoroughly considered is that of the target language. The most suitable type of language is usually a general-purpose one, with high expressivity, well-supported by vendors. The available tools should be sophisticated enough to allow efficient control over the code base. Finally, the specialists with a suitable skill degree should be readily available.

The straightforward way of migrating a software application is to perform a complete manual rewrite. This approach presents several advantages:

- possibility of application redesign, having a better understanding of the business domain;
- optimal use of the technologies available for the target language;

There are however disadvantages as well:

- significant effort, as this involves a complete development life-cycle for what is in essence a new application: financial costs, long period of time, significant allocation of human resources;
- the inherent bugs that are produced by any software development process, even if most bugs in the original application had been detected and resolved throughout the application's usage over time;
- stakeholders will probably make pressures to add new features while rewriting the application; this multiplies the risks of defects;
- new features, or even existing features that are altered by the rewrite, might change the user experience and cause learning difficulties; users are normally capable of dealing with few changes at a time, but not with many/radical ones – affecting their productivity and incurring training costs.

Automated translation using a software migrator is by default limiting the scope of the change to porting existing functionality without adding new features. This can be done at a later stage, benefiting from all the advantages of the target language: refactoring support, more powerful technologies and tools.

Among the advantages of automated software translation are:

- lower effort, as the analysis, design and implementation processes are not executed; only testing and deployment need to be performed;
- as the existing functionality is closely reproduced, no application-specific bugs are introduced into the software;
- the usability closely matches that of the original application; even if the user interface changes (e.g. transform a text-based interface into a GUI), there is a close correspondence between each interface element of the old and new application;
- the back-end of the application can be re-engineered using optimization algorithms during the migration process; being automated rather than applied manually, the result is uniform and less prone to bugs;
- by-products of the migration process include detailed information about the structure and flows of the application, information that can be used by implementing analysis tools.

Inherent disadvantages of automated software migration are:

- not taking full advantage of the technologies available for the target language, since a generic automated process cannot capture project-specific optimization nuances as well as the human mind; refactoring can be efficiently performed a later stage though;
- all bugs that are still undetected in the original application will be ported into the new one (these are probably few in number and unimportant since the original application had been in use for a significant period of time);
- new bugs could be introduced into the new application, due to bugs in the software migrator itself; this risk can be minimized by thorough testing of the migrator and by test harnesses/pilot migration projects to check the translation of individual constructs.

These disadvantages can be countered by implementing software migrators that are customizable for specific translation projects. Individual particularities of each application can be better addressed this way.

These general considerations about the economical feasibility of software migration are particularized as follows in the case of nTile PHPtoJava.

PHP is suitable for the development of small-to-medium Web sites. Once the code base reaches a certain size, maintenance becomes difficult due to the characteristics of the language: procedural (up to version 4), weakly and dynamically typed, interpreted. Specialists are readily available, but they tend to be entry-level. Due to the permissive and sometimes inconsistent nature of the language, it is difficult to develop advanced tools for it, therefore these tools are not in widespread use.

Java is a widely used, well-supported and expressive language. Tools for Java and for the Java EE platform are in large supply. The number and quality of specialists is fully satisfactory.

The advantages of migrating from PHP to Java arise from the nature of the target language:

- better error detection and traceability, both at compile-time and at runtime;
- better maintenance, performance and scalability;
- easy access to many modern technologies, based on Java EE but not only;
- good tools, including the ones for refactoring.

Some of the qualitative improvements offered by the automated translation process in nTile PHPtoJava refer to extraction of objects and components (based on dynamic includes) and to detection of ambiguities (erroneous function returns, duplicated formal function parameters, class constructors used as regular functions etc.).

The migration process of nTile PHPtoJava produces detailed information about the structure of the translated application. This information could be used to implement various by-products, such as:

- visualization of control and data flows, source file dependencies;
- quality metrics and detection of problematic constructs;
- intelligent PHP source code editors (e.g. auto-completion, navigation to declaration/usage, syntax highlight, type hinting);
- refactoring features.

The detail level of the intermediate representation for the PHP source code can provide the basis for implementing all these analysis algorithms.

Finally, feasibility considerations apply to the development of software migrators themselves. Economical constraints must be balanced with quality needs, more stringently so because a migrator is a product and not a project. It thus needs to have a superior quality and to be designed for high maintainability, extensibility and reuse.

In practice, a software migrator will not offer a 100% coverage for the source language and its libraries. Each development iteration should prioritize the most commonly used constructions, whose implementation effort does not surpass a reasonable limit. The translator won't usually cover the constructions that are rarely used and/or require extensive effort to be translated – these shall be translated manually.

If a certain software application contains specific patterns, these can be translated in a special manner by elaborating heuristic algorithms that are custom-tailored to the respective situation. The disadvantages of automated translation using an off-the-shelf software migrator are thus minimized.

5. Conclusions

The natural evolution of programming languages induces the need to migrate legacy application systems towards modern languages and platforms. Economical factors play a role just as important as technical factors in the migration's decision-making process.

A viable alternative to manual migration is using a specialized tool called a software migrator. Software migrators have a life-cycle that is also determined by economical and technical factors. Their quality is extremely important and needs to be measured and continuously improved. Generality is one of the key metrics of software migrators.

The case-study presented in this paper, nTile PHPtoJava, was designed and developed with all these considerations in mind.

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HARMONIZATION MODELS FOR DESIGNING COMPOUND SYSTEMS

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Abstract: *A system to be designed and developed is composed of several sub-systems with complex configuration. The relationship between the sub-systems and the system cannot be fully expressed in analytical terms and has a high degree of uncertainty. Each sub-system can be designed and developed independently and is a subject of several possible measurable versions including both the cost of designing and creating the sub-system and its reliability. The problem is to assign reliability and cost requirements in the system design phase to all sub-systems, in order to:*

- *achieve a specified reliability goal for the system, and*
- *minimize the total costs of designing and creating of all the sub-systems.*

The corresponding dual problem is being solved as well. The third problem centers on optimizing the system's structure in order to maximize the system's utility by means of implementing local parametrical reliability and cost values.

Key words: *compound system; engineering design; cost-reliability optimization; harmonization model*

1. Introduction

The solution of engineering design problems generally requires a compromise between several objectives, including a trade-off among cost and reliability parameters. Those problems become extremely actual in cases when an overall compound system is composed of several sub-systems. The objective is to use the reliability model to assign reliability to the sub-systems so as to achieve a specified reliability goal for the system. The optimization model may be to minimize the total costs of developing the sub-systems subject to the condition that the reliability of the system must meet a certain pregiven level (the direct problem) or to maximize the reliability subject to certain cost constraints (the dual problem). However, it can be well-recognized that most of the publications on that area deal with relatively simple system configurations (e.g. for series and parallel systems) where the functional relationship between the sub-systems' failures and the top system failures is well known (see, e.g. [2, 4, 5][3]). In cases when this relationship is complex for other system configurations, e.g. when the linkage between the sub-systems is carried out under random disturbances, the number of such publications remains very scanty.

We will consider a complicated system to be designed which is composed of several sub-systems. The functional relationship between the sub-systems and the system outcome parameters can be formalized only by means of a simulation model which comprises a variety of random parameters. Sub-systems' failures are not independent, and the linkage between sub-systems is carried out via various information signals. Each sub-system can be designed and developed independently and is a subject of several alternative measurable versions, including the cost of designing and creating the sub-system and its reliability.

The problems to be considered are as follows: in the system design phase to assign optimal reliability and cost parameters (versions) to all sub-systems in order to minimize the total costs of designing and creating, subject to the specified reliability target for the system (the direct problem), and to optimize the sub-systems' reliability and cost parameters in order to maximize the system's reliability subject to the restricted total costs (the dual problem).

The solution of both problems is based on a two-level heuristic algorithm. At the upper level a search of optimal sub-systems' parameters is undertaken, while the lower level is faced with numerous realization of the simulation model to obtain representative statistics. The outcome data of the search procedure at the upper level is the input data for the simulation model.

The results obtained are later on considered within the general problem of the designed system standards harmonization. We formulate an optimization problem to assign optimal versions to all sub-systems in order to provide harmonization to the system reliability and cost standards.

2. Notation

Let us introduce the following terms:

S - the system to be designed and created;

$S_i \subset S$ - the i–th sub-system entering S, $1 \le i \le n$;

n - the number of sub-systems;

S_{ij} - the j–th version of designing sub-system S_i, $1 \le j \le m_i$;

m_i - the number of possible versions of designing and creating the sub-system S_i;

C_{ij} - the average cost of designing and developing S_{ij} (pregiven);

R_{ij} - reliability value of sub-system S_{ij} (pregiven);

SM - simulation model with input sub-systems' reliabilities and the outcome system reliability;

$R\{a_i\}$ - system reliability value obtained by means of simulation, $R\{a_i\} = SM\{a_i\}$, where integer value $a_i = j$, $1 \le a_i \le m_i$, is the ordinal number of version j of sub-system S_{ij}, $1 \le i \le n$;

C - the total costs of designing and creating the system, $C = \sum_{i=1}^{n} C_{ia_i}$;

R^* - pregiven specified system reliability;

C^* - pregiven restricted total cost amount to design and create system S;

ΔC - accuracy estimate (pregiven);

α_R - parametrical utility "weight" of the system reliability;

α_C - parametrical utility "weight" of the system total costs.

3. The Problem's Formulation

The direct cost-optimization problem is as follows:

Determine the optimal set of integer values a_i, $1 \le i \le n$, which requires the minimal amount of costs

$$\underset{\{a_i\}}{Min} \sum_{i=1}^{n} C_{ia_i} \tag{1}$$

subject to

$$R\{a_i\} = SM\{a_i\} \ge R^*, \quad 1 \le i \le n, \quad 1 \le a_i \le m_i. \tag{2}$$

The dual problem is as follows:

Determine the optimal set $\{a_i\}$, $1 \le i \le n$, in order to maximize the system reliability by means of simulation

$$R = \underset{\{a_i\}}{Max}\, R\{a_i\} \tag{3}$$

subject to

$$\sum_{i=1}^{n} C_{ia_i} \le C^*. \tag{4}$$

Note that the costs of unifying sub-systems $\{S_i\}$ into a complex system S are assumed to be negligibly small in comparison with the total costs of designing and creating all those sub-systems.

It can be well-recognized that if the number of sub-systems n, as well as the number of alternative options m_i to design sub-systems S_i, is high enough, both problems (1-2) and (3-4) are NP-complete [3]. Thus, an optimal solution can be obtained only by means of a look-over algorithm that checks the feasibility of each of $\prod_{i=1}^{n} m_i$ combinations $\{a_i\}$. If the number of combinations is high enough and taking into account that each combination requires numerous simulation runs, solving both problems by means of precise classical methods meets unavoidable computational difficulties. To avoid this obstacle, we suggest a high-speed two-level approximate heuristic algorithm. At the bottom level a simulation model to realize the functional relationship between reliability values of local sub-systems S_i, is implemented. At the upper level a search procedure to determine optimal values $\{a_i\}$, has to be carried out.

Note, in conclusion, that for any sub-system S_i increasing its version number $a_i = j$ results in increasing both costs C_{ij} and the reliability value R_{ij}. Thus, the m_i–th version has the highest reliability R_{im_i}, as well as requires the highest costs C_{im_i}. If for *each* S_i its <u>highest version has been chosen</u>, it can be well-recognized that the overall system S has the highest possible reliability $R^{**} = SM\{a_{m_i}\}$, $1 \le i \le n$. Thus, if relation $R^{**} < R^*$ holds, problem (1-2) has no solution.

We will assume henceforth that both relations

$$R\{a_{m_i}\} = SM\{a_{m_i}\} \ge R^* \tag{5}$$

and

$$\sum_{i=1}^{n} C_{i1} \le C^* \tag{6}$$

hold.

4. Two-Level Heuristic Algorithm for Solving the Direct Cost-Optimization Problem

As outlined above, the system reliability $R = SM\{a_i\}$ is a complicated non-linear function of values $\{a_i\}$. This enables solution of problem (1-2) by using the cyclic coordinate search algorithm ($CCSA$) with optimized variables $\{a_i\}$ [6]. The justification of using $CCSA$ is outlined in [1]. To solve the problem, SM is implemented to obtain representative statistics for calculating $R = SM\{a_i\}$. The expanded step-by-step procedure of $CCSA$ is as follows:

<u>Step 1</u>. Choose an initial search point $\overrightarrow{X}^{(0)} = \{m_1, m_2, \dots, m_n\}$. According to (5), search point $\overrightarrow{X}^{(0)}$ is a feasible solution.

<u>Step 2</u>. Start using $CCSA$ which minimizes value $\sum_{i=1}^{n} C_{ia_i}$ with respect to the coordinate variables. Decrease the first coordinate $x_1^{(0)} = m_1$ by a constant step equal 1, i.e., $x_1^{(0)} - 1 \Rightarrow x_1^{(1)}$, while all other coordinates $x_2 = m_2$, $x_3 = m_3$, … , $x_n = m_n$ are fixed (see *Step 1*) and remain unchanged. In the course of under-

taking the search steps the feasibility of every routine search point $\overrightarrow{X}$ is examined by performing numerous simulation runs by means of the SM in order to check relation

$$SM\left\{\overrightarrow{X}\right\} \geq R^{*}. \tag{7}$$

The process of decreasing the first coordinate $\mathbf{x_1}$ terminates in two cases:

- if for a certain value $x_1 = j \geq 1$ relation (7) ceases to hold;
- if for all values $1 \leq x_1 \leq m_1$ relation (7) remains true.

For the first case we set $x_1 = j+1$, while in the second case $x_1 = 1$ is fixed.

Step 3. After the first coordinate x_1 is optimized in the course of carrying out *Step 2*, we proceed with the $CCSA$ by decreasing the second coordinate x_2 by a constant step, i.e. $x_2^{(0)} - 1 \Rightarrow x_2^{(1)}$, while all other coordinates, namely, x_1 (the new optimized value at *Step 2*), $x_3, \ldots, x_n$ are fixed and remain unchanged. After examining the coordinate x_2 by a step-wise decrease via simulation, its newly obtained value is fixed, similarly to x_1, and we proceed with the third coordinate x_3, and so forth, until x_n is reached and checked by the constant step decreasing procedure.

Step 4. After all coordinates $\{x_i\}$ are checked by means of the $CCSA$ (first iteration), the process is then repeated starting with x_1 again. The $CCSA$ terminates after a current iteration does not succeed in bringing any changes to the search point $\overrightarrow{X} = (x_1, x_2, \ldots, x_n)$. Thus, the n-dimensional search point $\overrightarrow{X}$ is then taken as the quasi-optimal solution of the direct problem (1-2).

Call henceforth the above algorithm of $CCSA$ to solve the direct problem (1-2) - *Algorithm I*. Note that in the course of implementing *Algorithm I* the total costs $C = \sum_{i=1}^{n} C_{ia_i}$ decrease monotonously at each step $\overrightarrow{X} = \{a_i\}$.

After obtaining an approximate solution $\overrightarrow{X} = \{a_i\}$ we suggest to undertake a corrective random search procedure designated henceforth as *Algorithm II*. The enlarged step-by-step procedure of *Algorithm II* is as follows:

Step 1. Choose an initial search point $\overrightarrow{X}^{(0)} = \{a_i\}$ which has been determined in the course of implementing *Algorithm I*. Denote, in addition, the required total costs to design the system with $\{a_i\}$, by

$$C\left(\overrightarrow{X}^{(0)}\right) = \sum_{i=1}^{n} C_{ia_i} \,. \tag{8}$$

Step 2. Simulate n random independent values p_i, $1 \le i \le n$, uniformly distributed in the interval $[-1, +1]$.

Step 3. Introduce a random step $\overrightarrow{X}^{(1)} = \overrightarrow{X}^{(0)} + \Delta\overrightarrow{X}$ obtained by

$$\overrightarrow{X}^{(1)} = \overrightarrow{X}^{(0)} + \vec{\beta}, \qquad \vec{\beta} = (\beta_1, \beta_2, \dots, \beta_n), \tag{9}$$

where local steps equal 1 and

$$\beta_i = \begin{cases} +1 & \text{if} \quad p_i \ge 0 \\ -1 & \text{if} \quad p_i < 0 \end{cases},$$

subject to additional constraints for the i–th coordinate $\overrightarrow{X}_i^{(1)}$, $1 \le i \le n$,

$$\overrightarrow{X}_i^{(1)} = \begin{cases} m_i & \text{if} \quad X_i^{(0)} = m_i \quad \text{and} \quad p_i \ge 0 \\ 1 & \text{if} \quad X_i^{(0)} = 1 \quad \text{and} \quad p_i < 0. \end{cases} \tag{10}$$

Step 4. Calculate by means of the SM the frequency rate $R\left\{\overrightarrow{X}^{(1)}\right\}$ and compare the latter with R^*. If $R\left\{\overrightarrow{X}^{(1)}\right\} \ge R^*$ apply the next step. Otherwise go to *Step 6*.

Step 5. Calculate the total costs to design the system with $\overrightarrow{X}^{(1)} = \{a_i + \beta_i\}$. If relation

$$C\left(\overrightarrow{X}^{(1)}\right) = \sum_{i=1}^{n} C_{i,a_i+\beta_i} < \sum_{i=1}^{n} C_{ia_i} = C\left(\overrightarrow{X}^{(0)}\right) \tag{11}$$

holds, go to *Step 7*. Otherwise apply the next step.

Step 6. Set $C\left(\overrightarrow{X}^{(1)}\right)$ equal to K, where K is a very large number (take, e.g. $K = 10^{17}$). Go to the next step.

Step 7. Repeat *Steps* 2-6 Z times, i.e., undertake Z independent steps

$$\vec{X}^{(0)} + \Delta \vec{X} \;\Rightarrow\; \vec{X}^{(1)} .$$

Step 8. Determine the minimal cost value $C\left(\vec{X}^{(1)}\right)$ from Z values (11). Denote it by $C^{*(1)}$.

Step 9. If $C^{*(1)} \geq C\left(\vec{X}^{(0)}\right)$ the search process terminates. That means that search point $\vec{X}^{(0)}$ cannot be improved. Go to *Step 11*. In case $C^{*(1)} < C\left(\vec{X}^{(0)}\right)$ apply the next step.

Step 10. Set $\vec{X}^{(1)} \Rightarrow \vec{X}^{(0)}$, $C^{*(1)} \Rightarrow C\left(\vec{X}^{(0)}\right)$, and go to *Step 2*.

Step 11. Take $\vec{X}^{(0)}$, together with its corresponding budget value $C\left(\vec{X}^{(0)}\right)$, as the quasi-optimal solution of *Algorithm II*.

Note that since using a search step of pregiven length in the n-dimensional space with a finite number of feasible solutions cannot result in an infinite monotonic convergence, the random search process always terminates.

As outlined above, we suggest to use *Algorithm II* on condition that the initial search point $\vec{X}^{(0)}$ is determined by using *Algorithm I*.

5. The Dual Cost-Optimization Problem

The step-by-step algorithm to solve problem (3-4) (call it henceforth *Algorithm III*) is based on the bisection method [8] and runs as follows:

Step 1. Calculate reliability values by means of the SM

$$R_{min} = SM\left\{1, 1, \dots, 1\right\}, \tag{12}$$

$$R_{max} = SM\left\{m_1, m_2, \dots, m_n\right\}. \tag{13}$$

Step 2. Calculate cost values

$$C_{min} = \sum_{i=1}^{n} C_{i1} , \tag{14}$$

$$C_{max} = \sum_{i=1}^{n} C_{im_i} . \quad (15)$$

Note that relation $C_{min} \leq C^*$ holds, otherwise problem (3-4) has no solution. In case $C^* \geq C_{max}$ there is a trivial solution: $\{a_i\} = \{m_i\}$. Thus, we will assume that a reasonable relation

$$C_{min} \leq C^* \leq C_{max} \quad (16)$$

holds.

Step 3. Calculate

$$R' = 0.5 \cdot (R_{min} + R_{max}). \quad (17)$$

Step 4. Solve direct cost-optimization problem (1-2) with $R' = R^*$. Denote the minimal cost objective value obtained in the course of implementing *Algorithms I-II*, by C'.

Step 5. Compare values C' and C^*. If $|C^* - C'| < \Delta C$, go to *Step 9*. Otherwise go to *Step 6*. Here $\Delta C > 0$ designates the pregiven problem's solution accuracy as outlined in *Section 2*.

Step 6. Examine relation $C_{min} \leq C' < C^*$. In case it holds, go to *Step 7*. Otherwise, i.e., in case $C^* \leq C' \leq C_{max}$, go to *Step 8*.

Step 7. Set $R' \Rightarrow R_{min}$. Go to *Step 3*.

Step 8. Set $R' \Rightarrow R_{max}$. Go to *Step 3*.

Step 9. Solution $\{a_i\}$ of the direct problem (1-2) obtained at *Step 4*, is taken as the quasi-optimal solution of problem (3-4).

6. Harmonization Models in Designing Compound Engineering Systems

As outlined above, in *Section 1*, engineering design problems generally require a compromise between certain parameters of the system to be designed, e.g. a compromise between cost and quality parameters. If a system to be designed and created is compound in nature and consists of several local sub-systems with complex configuration, such a compromise may be realized by means of certain optimization problems. Let us describe two different situations which lead to a "compromise optimization":

Strategy A

A company is faced with designing and creating a new complicated technical system which consists of several sub-systems. The latter have to be designed and further on created at the company's design office. Each sub-system may be created in several technical versions, as outlined above. The problem is to determine optimal versions for each sub-system to be designed, in order to:

- meet the system reliability restriction from below;
- meet the system total cost restriction from above;
- optimize a trade-off function between reliability and cost parameters.

Both restrictions can be formalized by relations (2) and (4).

Strategy B

A highly complicated compound technical system has to be created (e.g. a new aircraft). The system comprises several sub-systems (with complex configuration) which are *already manufactured* by several different companies (and, quite possible, in different countries). Each company manufactures only one version of a certain sub-system while other companies may produce other versions. Thus, each sub-system is available in several alternative versions provided to the international market with pregiven cost and reliability parameters. The compromise optimization problem is similar to that outlined above for *Strategy A*.

It can be well-recognized, however, that both from the point of logical assumptions and considering the solution method, those optimization problems are different. *Strategy A* is based on the assumption that for each sub-system S_i reducing the costs C_{ij} results in reducing its reliability level R_{ij}, and vice versa. This simplifies essentially the solution method.

However, for *Strategy B* the relation between cost and reliability parameters for different competing versions may be entirely different, since certain sub-systems may be produced and purchased in different countries and thus affected by their domestic policies in business and standardization.

A detailed description of different strategies (there may be more than two of them), together with developing optimization problems and the corresponding methods of solution, do not lie within the framework of this *Appendix*. However, we will show the nature of the "compromise optimization" by an example of *Strategy A*.

We suggest to formalize the "compromise optimization" problem as follows:

Determine optimal integer values (versions) a_i to maximize a "system priority value" which is composed of local priority functions $\alpha_R(R)$ and $\alpha_C(C)$

$$\underset{\{a_i\}}{Max}\left(\alpha_R\left[R\{a_i\}\right]+\alpha_C\left[C\{a_i\}\right]\right) \quad (18)$$

subject to (2) and (4).

It goes without saying that decreasing the total cost C increases the corresponding priority function $\alpha_C(C)$, while decreasing reliability value R decreases value $\alpha_R(R)$.

Thus, we suggest to introduce the concept of harmonization by means of a compromise, trade-off optimization. Finally, we obtain:

$$\underset{\{a_i\}}{Max}\left(\alpha_R\left[R\{a_i\}\right]+\alpha_C\left[C\{a_i\}\right]\right) \quad (19)$$

subject to

$$R\{a_i\} \geq R^*, \quad (20)$$

$$C\{a_i\} \leq C^*. \quad (21)$$

This is a complicated stochastic optimization problem since value $R\{a_i\}$ is calculated through a simulation model and can be determined in frequency terms only. As to functions α_R and α_C, we suggest to assume they are deterministic.

7. Monte-Carlo Algorithm for the Harmonization Model

The enlarged step-wise procedure of the suggested problem's solution is as follows:

Step 1. Solve cost-optimization problem (1-2) by means of *Algorithms I-II*. Denote the quasi-optimal solution as $a_1^*, a_2^*, \ldots, a_n^*$.

Step 2. Solve cost-optimization problem (3-4) by means of *Algorithm III*. Denote the quasi-optimal solution by $a_1^{**}, a_2^{**}, \ldots, a_n^{**}$.

Step 3. Calculate $C' = \sum_{i=1}^{n} C_{ia_i^{**}}$.

Step 4. If relation $C' > C^*$ holds, problem (19-21) has no solution. Otherwise apply the next step.

Step 5. Determine three n-dimensional areas:

- area I which comprises n-dimensional points $\vec{X} = \{a_i\}$ between $\vec{X}^{(1)} = \{1, 1, \ldots, 1\}$ and $\vec{X}^{(2)} = \{a_i^*\}$;

- area II which comprises n-dimensional points $\vec{X} = \{a_i\}$ between $\vec{X}^{(2)} = \{a_i^*\}$ and $\{a_i^{**}\} = \vec{X}^{(3)}$;

- area III which comprises n-dimensional points $\vec{X} = \{a_i\}$ between $\vec{X}^{(3)} = \{a_i^{**}\}$ and $\{a_{m_i}\} = \vec{X}^{(4)}$.

Step 6. Note that solution $\{a_i^*\}$ of problem (1-2), as well as solution $\{a_i^{**}\}$, are approximate ones. However, it can be well-recognized that:

- an overwhelming majority of n-dimensional points $\vec{X}$ entering area I does not meet reliability level R^*;
-
- an overwhelming majority of n-dimensional points $\vec{X}$ entering area III does not meet total cost restriction C^*.

Both assertions can be easily checked by simulating points $\vec{X}$ by means of the Monte-Carlo method in areas I and III with coordinates $X_i^{(1)}$ and $X_i^{(3)}$ as follows:

$$X_i^{(1)} = \left[a_i^* \cdot \beta_i \right] + 1, \quad 1 \le i \le n, \quad \beta_i \in U(0,1),$$

$$X_i^{(3)} = \left[a_i^{**} + \left(m_i - a_i^{**} \right) \cdot \alpha_i \right] + 1, \quad 1 \le i \le n, \quad \alpha_i \in U(0,1),$$

where $[x]$ denotes the whole part of x and α_i, β_i are random values uniformly distributed in $[0,1]$.

Later on, by means of the SM, the outlined above assertions can be easily verified. Practically speaking, points $\vec{X}$ in areas I and III do not meet restrictions (20) and (21).

Step 7. A Monte-Carlo sub-algorithm (call it henceforth *Algorithm IV*) is suggested to solve problem (19-21) for area *II*. The sub-steps of *Algorithm IV* are as follows:

Step 7.1. Simulate by means of the Monte-Carlo method points $\overrightarrow{X}$ in area *II* with co-ordinates $X_i^{(2)}$,

$$X_i^{(2)} = \left[\left(a_i^{**} - a_i^{*} \right) \cdot \beta_i + a_i^{*} \right] + 1, \quad 1 \le i \le n, \quad \beta_i \in U(0,1).$$

Step 7.2. Check by means of SM and $C' = \sum_{i=1}^{n} C_{ia_i^*}$ restrictions (20-21). If at least one restriction does not hold apply *sub-Step 7.1*. Otherwise go to the next sub-step.

Step 7.3. Calculate for point $X_i^{(2)}$, by means of the SM and $C = \sum_{i=1}^{n} C_{ia_i}$, system priority value $\alpha_R \left(SM \left\{ a_{ia_i} \right\} \right) + \alpha_C \left(\sum_{i=1}^{n} C_{ia_i} \right)$.

Step 7.4. Undertake a random search outlined in *Algorithm II*, by substituting maximization for minimization. Take the local optimum obtained in the course of the random search, as a local solution.

Step 7.5. Check the number of local solutions generated in the course of implementing the optimum trial random search method. If the number of such solutions exceeds N, go to the next sub-step. Otherwise apply *Step 7.1*.

Step 7.6. Choose the maximum of local solutions obtained at *Steps 7.1-7.5*. The result should be taken as the approximate solution of the trade-off problem (19-21).

Note that the above global random search method is highly recommended in [7] and can be considered as an effective one for solving harmonization problems of type (19-21).

As for harmonization problems related to *Strategy B*, using the global random search method is less effective. This is because optimization methods for *Strategy B* may deal with a lot of isolated n-dimensional points in both areas *I* and *II* (see *Algorithm IV*). It normally causes much computational troubles to detect those points.

8. Conclusions and Future Research

1. The problem of multi-parametrical optimization, i.e., harmonization models, can be applied to design an optimal structure for compound engineering systems. Practical achievements in that area are outlined in [1].

2. For single network projects harmonization may be effective by analyzing a PERT-COST type project with random activity durations. The project comprises several essential parameters which practically define the quality of the project as a whole:
   - the budget assigned to the project (*C*);
   - the project's due date (*D*);
   - the project's reliability, i.e., the probability of meeting the project's due date on time (*R*).

   To establish the utility of the project, the concept of the project's utility may be introduced. In order to maximize the project's utility, a three-parametric harmonization model is developed [1]. The model results in a certain trade-off between essential project's parameters and is, thus, a compromise optimization model. The model's algorithm is a unification of a cyclic coordinate search algorithm in the two-dimensional area (cost- and time values) and a harmonization model to maximize the project's reliability subject to the preset budget and due date values. The model comprises a heuristic procedure to reassign the budget among project's activities, and a simulation model of the project's realization.

3. Harmonization approaches in Reliability and Safety Engineering can be successfully used to develop various cost – reliability optimization models. The latter are applicable to a broad spectrum of hierarchical technical systems with a possibility of hazardous failure at the top level and a pregiven multi-linkage of failure elements at different levels.

4. The newly developed harmonization models in Reliability and Safety Engineering cannot be compared with any similar research outlined in former publications in the regarded area. The existing references do not cover multi-parametrical optimization for hierarchical production plants with the possibility of hazardous failures at the top level.

5. The results of our research can be expanded in future for a broad spectrum of other parameters - attributes which actually form both the utility and marketability values of the newly developed product. Besides the area of product marketing, harmonization models can be applied as well to unique technical devices which function under random disturbances and may trigger hazardous failures. Thus, the developed models can be applied to various hierarchical organization systems, e.g. industrial systems, project management systems, creating new urban areas, developing various service systems, etc.

Acknowledgement

This research has been partially supported by the Paul Ivanier Center on Robotics and Production Research, Ben-Gurion University of the Negev.

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PARALLEL ALGORITHMS FOR LARGE SCALE MACROECONOMETRIC MODELS

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Abstract: *Macroeconometric models with forward-looking variables give raise to very large systems of equations that requires heavy computations. These models was influenced by the development of new and efficient computational techniques and they are an interesting testing ground for the numerical methods addressed in this research. The most difficult problem in solving such models is to obtain the solution of the linear system that arises during the Newton step. For this purpose we have used both direct methods based on matrix factorization and nonstationary iterative methods, also called Krylov methods that provide an interesting alternative to the direct methods. In this paper we present performance results of both serial and parallel versions of the algorithms involved in solving these models. Although parallel implementation of the most dense linear algebra operations is a well understood process, the availability of general purpose, high performance parallel dense linear algebra libraries is limited by the complexity of implementation. This paper describes PLSS – (Parallel Linear System Solver) - a library which provides routines for linear system solving with an interface easy to use, that mirrors the natural description of sequential linear algebra algorithms.*

Key words: *parallel algorithms; linear algebra; macroeconometric models*

1. Introduction

Macroeconometric models with forward-looking variables are a special class of models which generates large systems of equations. The clasical method used to solve such models is the *extended path algorithm* proposed by Fair and Taylor (Fisher, 1992). They use Gauss-Seidel iterations to solve the model, period after period, for a given time horizon. The convergence of this method depend on the order of the equations.

In this paper we'll take another approach – we'll solve the system by the Newton method together with direct and iterative techniques that are well suited for large models. This approach was avoided in the past because it is computationally intensive. The new techniques described in this paper shows that the Newton method is an interesting and cost-effective alternative even for very large macroeconometric models.

The advantages of the Newton method are its quadratic speed of convergence and some modifications leading to a global convergent behavior. The nonlinear model with rational expectations can be represented like this:

$$h_i(y_t, y_{t-1}, \dots, y_{t-r}, y_{t+1|t-1}, \dots, y_{t+h|t-1}, z_t)=0 \quad i=1,\dots m \qquad (1)$$

where $y_{t+j|t-1}$ is the expectation of y_{t+j} conditional on the information available at the end of the period $t-1$ and z_t represents the exogenous and random variables. For consistent expectations, the forward expectations $y_{t+j|t-1}$ have to coincide with the next period's forecast when solving the model conditional on the information available at the end of period $t-1$. These expectations are therefore linked in time and solving the model for each y_t conditional on some start period 0 requires each $y_{t+j|0}$ for $j = 1,2, \dots T-t$ and a terminal condition $y_{T+j|0}$ $j = 1,2 \dots, h$.

Stacking up the these equations for successive time periods give rise to a large nonlinear system of equations. The Newton method for this model gives the following algorithm:

```
NEWTON Method
Given an initial solution y(0)
For k = 0,1,2, ... until convergence
        Evaluate b(k) = - h(y(k),z)
Evaluate J(k) = ∂h(y(k),z)/∂y'
Solve J(k)s(k) = b(k)
y(k+1) = y(k) + s(k)
end
```

The most computational intensive step in the Newton method is the linear system $J(k)s(k) = b(k)$ when this system is very large. Direct methods for computing the solution of the system can be very expensive because of the computational cost and high memory requirements. That's why, high performance parallel algorithms are an efficient alternative to the classical serial algorithms.

Another alternative to the serial direct methods are iterative methods that computes only an approximation of the solution. This does not influence the convergence of the Newton method.

An important problem is to decide which level of precission for the solution of the linear system guarantees the rapid convergence of the Newton method at the lowest possible cost. To address this problem we define $r(k) = b(k) - J(k)s(k)$ the residual for the approximate solution of the linear system at the kth Newton iteration. It can be shown that the Newton method is locally convergent if $||r(k)|| / ||b(k)||$ is a sequence uniformly less than 1.

Parallel versions for the iterative algorithms can also be developed quickly.

2. Iterative and direct methods for linear systems

Iterative methods

An interesting alternative to the stationary iterative methods such as Jacobi or Gauss-Seidel are Krylov techniques. These techniques use information that changes from iteration to iteration. For a linear system *Ax = b* Krylov methods compute the *i*th iterate *x(i)* as :

x(i)=x(i-1)+delta(i)i = 1,2,... *(2)*

The operations involved to compute the *i*th update *delta(i)* are only inner products, saxpy and matrix-vector products, all these beeing level 2 BLAS operations. This is a very good reason to use Krylov methods for very large systems. They are computational attractive comparatively with direct methods that use level 3 BLAS operations.

The best known of the Krylov methods is the *conjugate gradient* (CG) method that solves symmetric positive definite systems. The main idea of the CG method is to update the iterates *x(i)* in a way to ensure the largest decrease of the objective function $\frac{1}{2}x'Ax - x'b$ while keeping the direction vectors *delta(i)* A-orthogonal. The implementation of this method uses only one matrix-vector multiplication per iteration. In exact arithmetic, the CG method yields the solution in at most *n* iterations. The complete description of the CG method can be found in (Golub, 1996). Another Krylov method implemented by the author of this paper is the *BiConjugate Gradient* (BiCG) method. *BiCG* takes a different approach based upon generating two mutually orthogonal sequence of residual vectors and A-orthogonal sequences of direction vectors. The updates for residuals and for the direction vectors are similar to those of the CG method, but are performed using A and its transpose. The disadvantages of the *BiCG* method are an erratic behavior of the norm of the residuals and potential breakdowns. An improved version that solves these disadvantages, called *BiConjugate Gradient Stabilized* (BiCGSTAB) is presented bellow:

BiCGSTAB
Given an initial solution x(0) compute r = b – Ax(0)
$\rho_0 = 1$, $\rho_1 = r(0)'r(0)$, $\alpha = 1$, $\acute{\omega} = 1$, p = 0, v = 0
for k = 1,2, ... **until** convergence
$\beta = (\rho_k/\rho_{k-1})(\alpha/\acute{\omega})$
$p = r + \beta(p - \acute{\omega}v)$
$v = Ap$
$\alpha = \rho_k/(r(0)'v)$
$s = r - \alpha v$
$t = As$
$\acute{\omega} = (t's)(t't)$
$x(k) = x(k-1) + \alpha p + \acute{\omega}s$
$r = s - \acute{\omega}t$
$\rho_{k+1} = -\acute{\omega}r(0)'t$
end

The BiCGSTAB method needs to compute 6 saxpy operations, 4 inner products and 2 matrix-vector products per iteration The memory requirements are to store matrix A and 7 vectors of size *n*.

A very widely used Krylov method for general nonsymmetric systems is the *Generalized Minimal Residuals* (GMRES). The pseudo-code for GMRES is:

GMRES
Given an initial solution x(0) compute r = b – Ax(0)
$\rho = ||r||_2$, $v(1) = r/\rho$, $\beta = \rho$
for k = 1,2,... **until** convergence
    for j = 1,2, ... k,
        h(j,k) = (Av(k))'v(j)
    end
    v(k+1) = Av(k) - $\sum_{j=1}^{k} h(j,k)v(j)$
    (Gram-Schmidt orthogonalization)
    $h(k+1,k) = ||v(k+1)||_2$
    v(k+1,k) = v(k+1)/h(k+1,k)
end
$y(k) = \text{argmin}_y ||\beta e_1 - H(k)y||_2$
x(k) = x(0) + [v(1) ... v(k)] y(k)

The main difficulty of the GMRES methods is not to lose the orthogonality of the direction vectors *v(j)*. In order to do this the GMRES method uses a modified Gram-Schmidt orthogonalization process. GMRES requires the storage and computation of an increasing amount of information at each iteration: vectors *v* and matrix *H* . To overcome the increasing memory requirement, the method can be restarted after a chosen number of iterations *m* using the current intermediate results as a new starting point.

The operation count per iteration cannot be used to directly compare the performance of BiCGSTAB with GMRES because GMRES converges in much less iterations than BiCGSTAB.

Direct methods

The direct solution for a linear system $Ax = b$ takes two steps:

- In the first step the classical decomposition $A=LU$ is computed (L is a unit lower triangular matrix and U is an upper triangular matrix)
- In the second step the two triangular systems $Ux = y$ and $Ly = b$ are solved by back substitution and forward elimination.

For symmetric positive definite matrices the factorization is achieved by using the Cholesky decomposition $A = LL^T$. A detailed description of the serial algorithms can be found in (Golub, 1996).

3. Parallel algorithms for linear systems

Software packages for solving linear systems have known many generations of evolution in the past 25 years. In '70, LINPACK was the first portable linear system solver package. At the end of '80 the next software package for linear algebra problems was LAPACK (Anderson, 1992) which, few years later, was adapted for parallel computation resulting the ScaLAPACK (Choi, 1992) library. Although parallel algorithms for linear systems are well understood, the availability of general purpose, high performance parallel dense linear algebra libraries is limited by the complexity of implementation. For the purpose of solving very large macroeconometric models we have developed a software package PLSS (Parallel Linear System Solver) that implements parallel algorithms for linear system solving. The PLSS library was designed with an easy to use interface, which is almost identical with the serial algorithms interface. This goal was obtained by means of data encapsulation in opaque objects that hide the complexity of data distribution and communication operations. The PLSS library was developed in C and for the communication between processors we used MPI library (Gropp, 1994) which is a "de facto" standard in message passing environments. The structure of the library is described in (Oancea, 2002),(Oancea, 2003). Here are the most important details about the internal structure of the library.

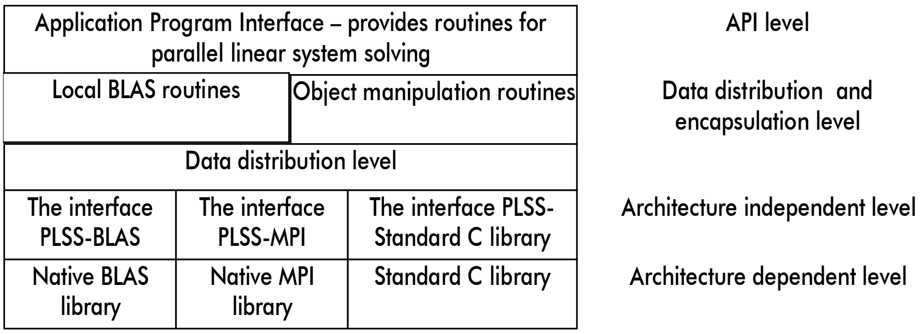


Figure 1. The PLSS structure

The first level contains the standard BLAS, MPI and C libraries. This level is architecture dependent. The second level provides the architecture independence. It implements the interface between the base level and the rest of the PLSS package. Using such an approach, the base libraries (BLAS, MPI) can be easily replaced without influencing the rest of the package. This interface has the following components:

- **BLAS-PLSS interface**. Each processor uses the BLAS routines for local computations. Because BLAS library is written in FORTRAN, an interface is needed to call FORTRAN routines from C programs.
- **MPI-PLSS interface**. PLSS uses the following communication operations: MPI_Bcast, MPI_gatherv, MPI_scaterv, MPI_Allgatherv, MPI_Allscatterv, MPI_Reduce, MPI_Allreduce, MPI_Send, MPI_Receive, MPI_Wait. All these MPI operations are encapsulated in PLSS functions in order to decouple the PLSS from MPI.
- **PLSS-Standard C library interface**. This interface encapsulates the standard C library functions (e.g. malloc, calloc, free) in PLSS functions.

The next level implements the data distribution and encapsulation model. All details regarding distribution of vectors and matrices on local processors are placed at this level. Also at this level we can found data encapsulation in opaque objects, hiding the complexity of communication operations. This level defines:

- Objects that describe vectors and matrices.
- Object manipulation routines – object creation, destroying and addressing routines.
- Local BLAS routines. Because matrices and vectors are encapsulated in objects, we must extract some information from these objects such as vector/matrix dimension, their localization etc, before calling a BLAS routine to perform some computations. Local BLAS routines extract these information and then call the standard BLAS routines.

- Communication functions – these functions implement the communication operations between processors.

The top level of the PLSS library is the application program interface. PLSS API provides a number of routines that implements parallel BLAS operations and parallel linear system solving operations based on LU and Cholesky matrix factorization.

The PLSS library uses a bidimensional mesh of processors. We have chosen this model of processor interconnection based on scalability studies of matrix factorization algorithms (Grama, 2003, Oancea, 2002). For a linear system $Ax = b$, vectors x and b are distributed on processors in a block column cyclic model and the system matrix A is distributed according to the vector distribution – the column $A_{*,j}$ will be assigned to the same processor as x_j.

Here are some examples of parallel implementation of some basic operations in the PLSS package. One of the most used operation in linear system solving is matrix-vector multiplication: $Ax = y$. Figure 2 shows the necessary steps to implement parallel matrix-vector multiplication. The matrix in this example has 8 rows and 8 columns.

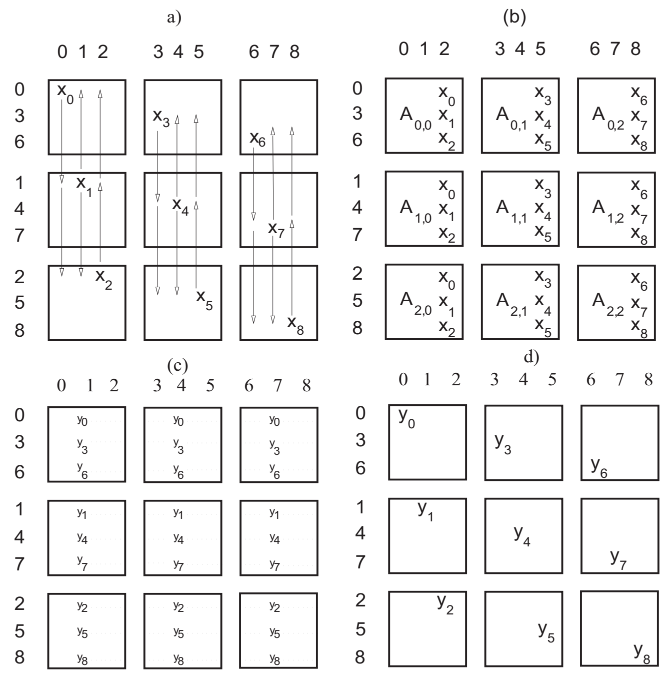


Figure 2. Matrix-Vector multiplication procedure

In the first step (Figure. 2a) the vector components are distributed on the processors columns. After vector distribution it follows a step consisting of local matrix-vector multiplications (Figure. 2b). At this moment each processor owns a part of the final result (Figure. 2c). In the last step, these partial components are summed up along the processor rows (Figure. 2d).

Another frequently used basic operation is rank-1 update. It consists in the following computation: $A = A + yx^t$.

Assuming that x and y have identical distributions on processor columns and rows, each processor has the data needed to perform the local computations.

These two basic operations, matrix-vector multiplication and rank-1 update can be used in order to derive a parallel algorithm for matrix-matrix multiplication. It is easy to observe that the product $C = AB$ can be decomposed in a number of rank-1 updates:

$$C = a_0 b_0^t + a_1 b_1^t + \ldots + a_{n-1} b_{n-1}^t \quad (4)$$

where a_i are the columns of matrix A and b_i^t are the rows of matrix B.

Parallelization of matrix-matrix multiplication is equivalent with parallelization of a sequence of rank-1 updates. In order to obtain an increase in performance, the rank-1 update can be replaced with rank-k update, but in this case x and y will be rectangular matrices. We conclude this section with the implementation of the block Cholesky factorization. Cholesky factorization consists in finding the factorization of the form $A = LL^T$ where A is a symmetric positive definite matrix. Figure 3 shows the partitioning of matrices A and L.

$$A = \begin{pmatrix} A\_11 & * \\ A\_21 & A\_22 \end{pmatrix}$$

$$L = \begin{pmatrix} L\_11 & 0 \\ L\_21 & L\_22 \end{pmatrix}$$

Figure 3. The partitioning of matrices A and L

From $A = LL^T$ we can derive the following equations :

$$A_{11} = L_{11}L_{11}^T \quad (5)$$

$$L_{21}L_{11}^T = A_{21} \quad (6)$$

$$A_{22} - L_{21}L_{21}^T = L_{22}L_{22}^T \quad (7)$$

If matrix L will overwrite the inferior triangle of A, then the Cholesky factorization consists in the following three computations:

$$A_{11} \leftarrow L_{11} = Cholesky(A_{11}) \quad (8)$$

$$A_{21} \leftarrow L_{21} = A_{21}L_{21}^{-T} \quad (9)$$

$$A_{22} \leftarrow A_{22} - L_{21}L_{21}^T \quad (10)$$

The dimension of matrix block A_{11} is computed such that A_{11} will be stored on only one processor and the factorization from equation (8) will be a local operation. Under these conditions A_{21} is stored on the same column of processors and L_{11} will be distributed to these processors. The parallel Cholesky factorization can be described as follows:

1. Determine the block size such that A_{11} is stored on a single processor.
2. Split matrix A into blocks A_{11}, A_{21}, A_{22} according to the block size computed in step 1.
3. Compute the Cholesky factorization of submatrix A_{11} – this is a local operation.
4. Distribute A_{11} on the column of processors.

5. Solve the triangular system given by equation (9) – this is a local operation because A_{11} was distributed in the pervious step to all processors that participate in this computation.
6. Compute the symmetric rank-k update given by equation (10).
7. Recursive apply the same steps to matrix A_{22}.

4. Experimental results

We have conducted performance experiments with both serial and parallel versions of the algorithms for two iterative methods – GMRES(40) and BiCGSTAB and with the direct method that consists in matrix factorization. For our experiments we have considered nonlinear systems with the number of variables between 10000 and 38000. The tolerance for the solution was fixed at 10^{-4} for all methods. The serial algorithms are implemented using the C++ programming language under the Linux operating system. Both iterative methods behave relatively well for our problems but BiCGSTAB is less expensive in number of floating point operations and memory requirements. Table 1 shows the number of floating point operations per iteration for each Newton variant to converge and the amount of memory needed.

Table 1. The number of MFLOP/iteration and memory requirements

Matrix dimension	GMRES(40)		BiCGSTAB	
	MFLOP	Memory (Mb)	MFLOP	Memory (Mb)
10000	2100	3.12	723	1.24
14000	4800	4.92	2880	1.88
18000	14100	6.31	12800	3.12
22000	29500	8.23	27500	3.66
26000	58000	8.99	52000	4.99
30000	125000	12.11	112000	5.82
34000	140000	12.55	120000	8.02
38000	200000	15.02	175000	8.82

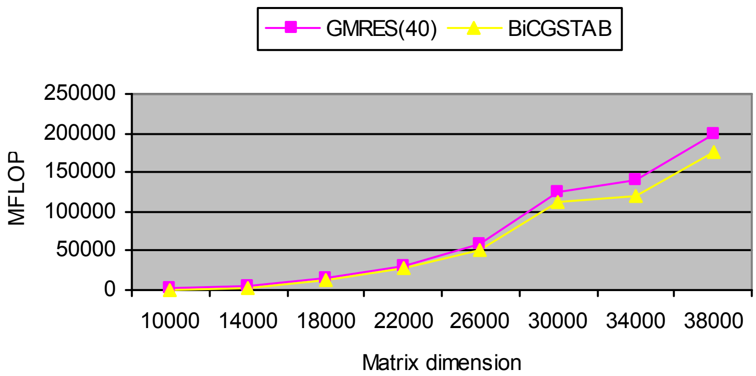


Figure 4. The number of floating point operations per iteration

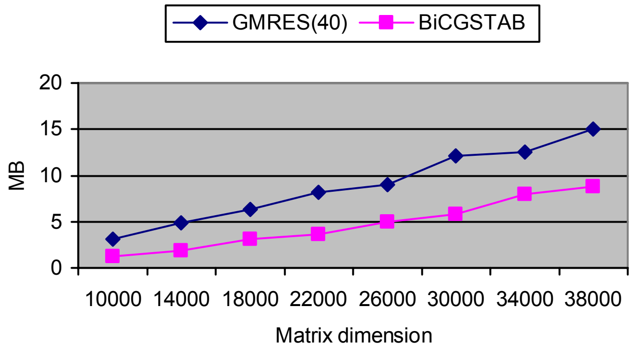
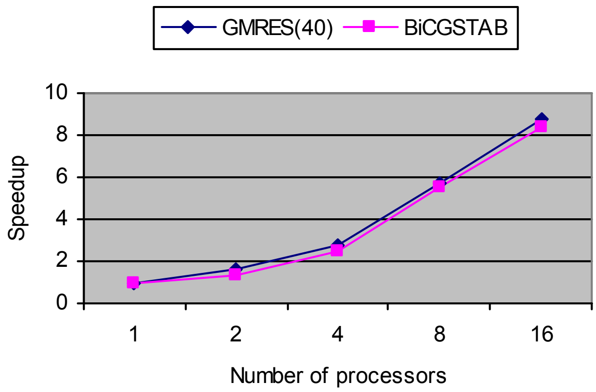


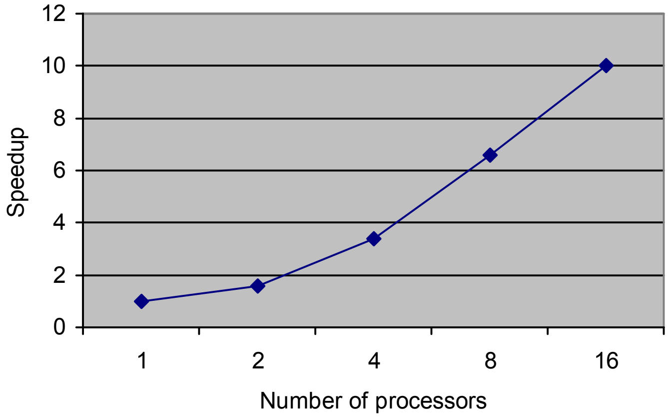
Figure 5. Memory requirement per iteration

These results show that the iterative methods can be a good alternative to direct methods for very large systems of equations.

Parallel versions of the algorithms were executed on a cluster of workstations, connected through a 100Mb Ethernet local network, each station with 1GB of main memory. We have tested the PLSS package for both iterative and direct methods, for 1, 2, 4, 8, and 16 processors. The dimension of the matrix was maintained fixed with 22000 rows and columns. Figure 6(a) shows the speedup of the parallel algorithms in the case when iterative methods are used for solving the model and figure 6(b) shows the speedup in the case of using the direct methods. It can be observed that the direct method has a better speedup the the iterative ones.



a) Parallel iterative methods



b) Direct method (LU factorization)

Figure 6. The speed-up for parallel versions of the algorithms

5. Conclusion

In this paper we have described algorithms for solving macroeconometric models with forward-looking variables based on the Newton method for nonlinear systems of equations. The most computational intensive step in the Newton method consists in solving a large linear system at each iteration. We have compared the performance of solving this linear system for two iterative methods – GMRES(40) and BiCGSTAB and the direct method based on matrix factorization.

For serial algorithms, iterative Krylov methods proved to be an interesting alternative to exact Newton method with LU factorization for large systems. Both the computational cost and memory requirements are inferior in the case of iterative Krylov methods compared with LU factorization.

We have developed a library (PLSS - Parallel Linear System Solver) that implements parallel algorithms for linear system solving. Because of the complexity of parallel algorithms it is difficult to design an easy to use parallel linear system solver. The PLSS infrastructure was designed to provide users a simple interface, close to the description of the serial algorithms. This goal was achieved through data encapsulation, hiding the complexity of data distribution and communication operations from users. PLSS was developed in C using MPI and can be run on many different kinds of parallel computers – it can be run on real parallel computers as well as on simple cluster of workstations

Comparing the performance of the parallel algorithms, LU factorization showed a better scalability then the iterative methods because the iterative algorithms involve a global communication step at the end of each iteration. This communication step slows down the overall execution of the program.

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JOURNAL OF APPLIED QUANTITATIVE METHODS

TENDENCIES IN THE UNIVERSITY SYSTEM IN ROMANIA

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Abstract: *Here is a short presentation of the main statistical indicators for higher education. The analysis was structured on the national and regional level and takes into account the differences between private and state universities. We have focused on some indicators regarding student and teacher flows. The case of Romania is peculiar in that there was no private education during the communist era, followed by an exponential development after 1990.*

Key words: *higher education; Romania; universities; statistical indicators*

1. Calculated indicators for the higher educational system

To characterise the higher educational system in Romania, the National Institute of Statistics (NIS) publishes every year a series of indicators featuring important aspects of the academic education. Thus, indicators are being calculated and reported to characterise universities, faculties, students, and teaching staff. Below are presented the indicators referred every year by NIS:

1. The number of universities, faculties, registered students and teaching staff in the superior system, at the beginning of every academic year.
2. The number of students in the higher educational system, by types, forms of education, gender, and forms of property, at the beginning of every academic year.
3. The number of students in the higher educational system of short term, colleges, by types, forms of education, gender, and forms of property, at the beginning at the academic year.

4. The number of universities, faculties, registered students, and teaching staff in the higher educational system by regions of development and forms of property, at the beginning of the academic year.
5. The number of students registered in colleges, by regions of development and forms of property at the beginning of every academic year.
6. The qualitative situation of students' education in the higher educational system, by forms of education and property, at the end of the academic year 2005-2006.
7. The qualitative situation of the education of students registered in colleges by forms of property and education at the end of the academic year.
8. The number of promoted students and graduates in the higher educational system by types of education and gender at the end of every academic year.
9. The number of promoted students and graduates in the short term educational system by types of education and gender at the end of every academic year.
10. The results of the licence exam in the higher educational system by forms of property and education at the end of every universities year.
11. The number of didactic and non-didactic staff in the higher educational system by forms of property at the beginning of every academic year.
12. Indicators for characterising the material basis in the higher education.
13. Indicators for financial characterisation of higher education units.

2. The evolution of the number of students in the transition period

The indicators calculated by the Institute of Statistics or by the ministry of resort can be used in various studies. In the realisation of this basis, at the first level was considered according to the indicators included in the basis, *a viable analysis at the level of the Romanian educational system, in order to observe the transformations during a period, with the purpose of identifying future evolutions of this system.*

The transition also generated a series of important changes in the higher educational system. The process of informing the Romanian university system was accelerated after signing the Bologna Treaty. During the 17 years of transition a spectacular growth of the number of students took place. Thus, if in the academic year 1990-1991, 192.810 students were registered, all in the public system, in the academic year 2003-2004, 620.785 students were registered, of which 476.881 attend classes in the public system. In contrast, during this period, the proportion of the number of pupils in the number of registered students decreased. Thus, if in the year 1990-1991 the ratio was 5.61, in the year 2003-2004 the value was situated at the level of 1.22. However, in this period, the number of students per 10.000 inhabitants multiplied three times.

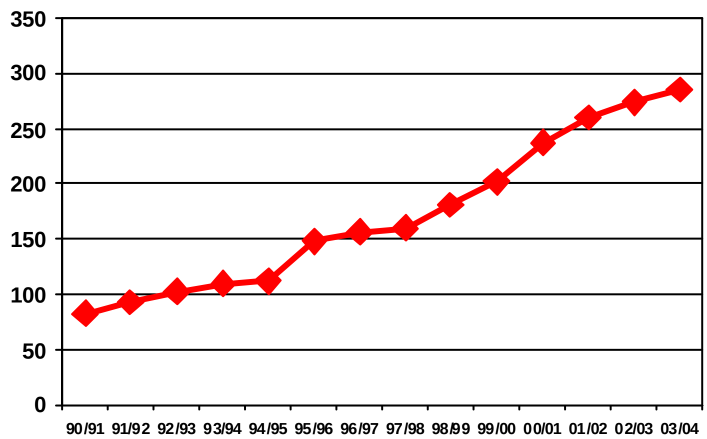

Figure 1. The number of students per 10000 inhabitants

In Romania, the number of high school graduates continuing academic studies has increased. The interest of graduates on this level of education increased every year, and so in the academic year 2005-2006, 716.5 thousand students, 66 thousand (10.2%) more compared to the previous year, were attending the classes of a university. Compared to the first year after the Revolution - 1989, the number of students multiplied three times. Equally, the proportion of students in the total number of scholastic population in the national educational system increased with over 16.4% compared to the previous academic year.

In the period 2000-2006, we observe a substantial growth in the number of students in universities. The table below contains the annual increases of students and teaching staff. The results in the table show that:

i) During the entire analysed period, the growth in the number of students was 34.4%

ii) The most substantial growth (over 10%) was registered in the academic year 2005, compared to the previous year.

iii) The growth was much slower at the level of teaching staff, where over the entire period the rate of growth was 12.8%.

iv) The increase of teaching staff was relatively constant during the entire period.

Table 1. Annual indexes of students and teaching staff between 2001-2006

	2002	2003	2004	2005	2006
Students	109.2	102.4	104.1	104.7	110.1
Didactic personnel	102.5	103.2	101.7	102.3	102.2

Another characteristic of the university system is represented by the larger proportion of female students compared with male students. Thus, for the recently finished academic year, female students represented 55.4% in the total number of students. The new form of organizing the higher educational system, in three cycles, determined a substantial decrease of the percentage of students attending the courses of colleges. The new value of 27.9 thousand students only represents 3.9% of the total population included in the university system. In the university system, the dominant percentage belongs to the students registered in day courses. Still, there are significant differences, as can be seen in the graph bellow, between private and state universities. Thus, while in state universities most of the students (80.5%) attend day courses, in private universities these students only represent 52.1% of the total.

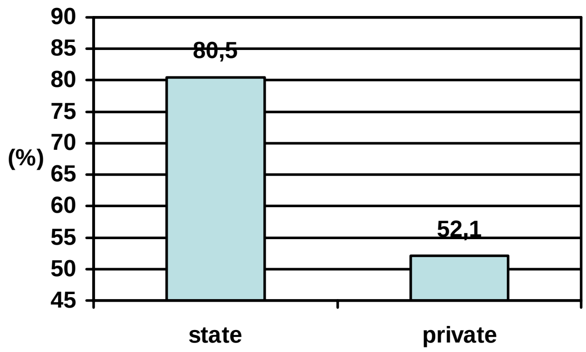

Figure 2. Share of day education students

Another feature of the university system is the continuous growth of the number of students attending distance education. Thus, during the recently finished year the percentage of students attending courses at distance was 15.4% in the total number of students in public universities, of which 27% in the total number of students in private universities.

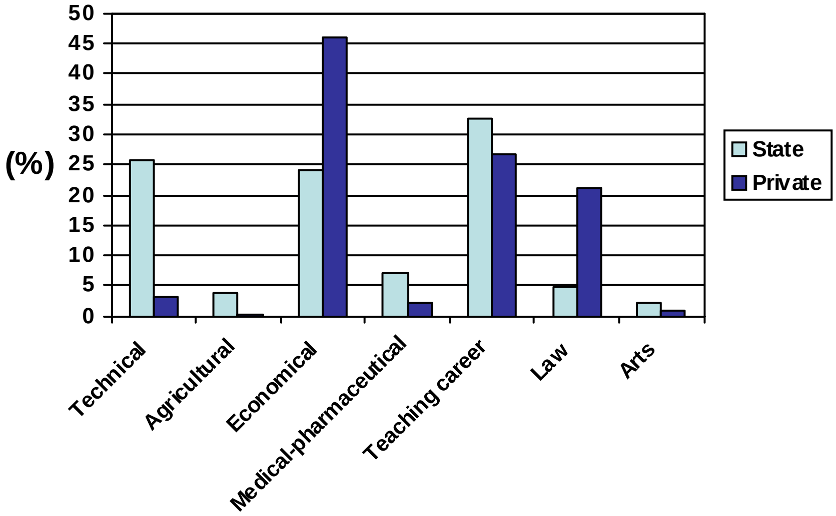

Figure 3. Students' structure from specializations point of view

The graph above shows a few unbalances at the level of universities in classifying students by specializations:

i) Private universities have a very small percentage in technical profiles (3%) compared to state universities.

ii) The economic education has the largest percentage in private universities (over 46%) while in public universities the largest percentage belongs to university profiles (32.5%).

iii) Technical education has a larger percentage compared to economic education at the level of public universities.

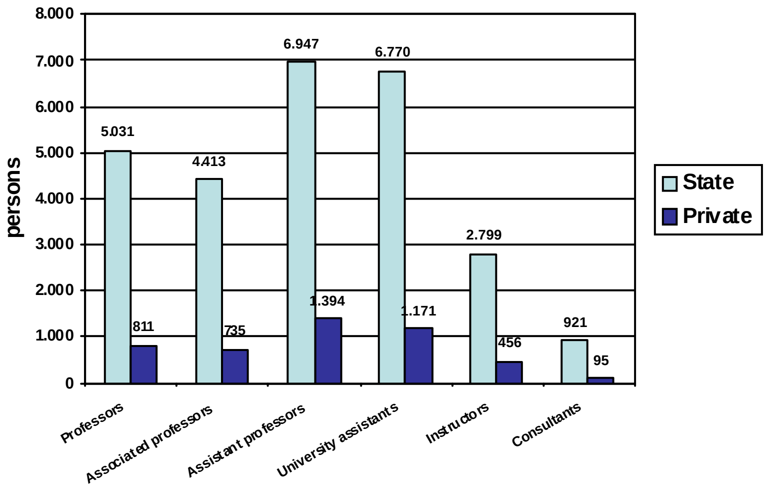

Figure 4. Didactic personnel by categories for the 2005/2006 academic year

Referring to the teaching staff in the university system, the conclusions are the following:

i) The largest percentage for both types of universities represents the assistant professors.

ii) The assistant professors, university assistants and instructors, represent more than 65% of the total places at the level of state universities, respectively at the level of private universities.

iii) The student-teacher ratio is bigger in the case of private universities (24.8) compared to public universities (19.1)

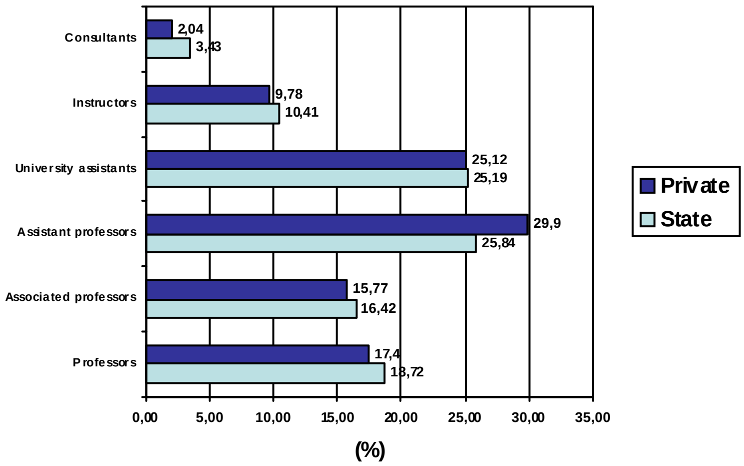

Figure 5. Classification of didactic personnel by positions

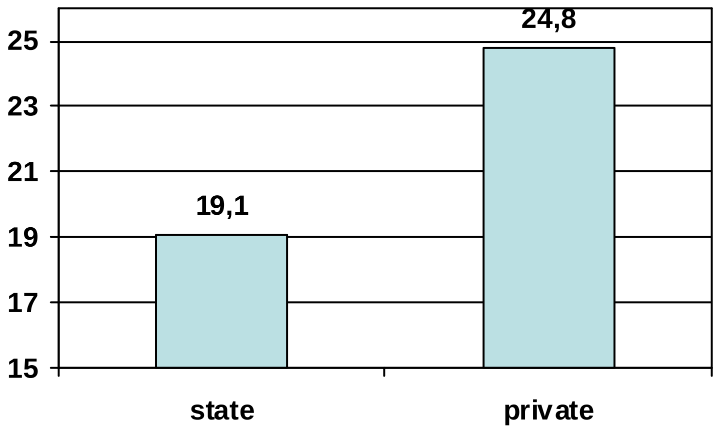

Figure 6. Student-teacher ratio

3. The Wagner model for the analysis of expenses for education

Using panel data for European countries, a series of common features and peculiarities can be identified regarding the evolution of expenses in the university system. At the level of the European Union (EU) countries there is a series of fundamental transformations in the area of higher education.

These changes are equally accelerated by the process of integration that countries recently accepted by the EU have to face. More than that, the Bologna Treaty leads to significant transformations at the level of all countries in the European space, including those with a strong tradition in the university field. The social movements in the year 1989 in Eastern Europe also determined substantial changes in education in general, in higher education in particular. Using a range of macroeconomic indicators and indicators belonging to the university area, a series of analyses at the level of the European space can be accomplished for the period 1990-2007. Considering that throughout the project the specific data bases are created, one can estimate the parameters of some econometric models with panel data.

In literature, there is a consensus regarding the role played by human capital and by education in economic growth (see Greenway and Haynes-2003; Krueger and Lindahl-2001). Using econometric methods, a series of similarities and differences shall be highlighted in the assignment of public expenses for education at the level of the countries recently made members of the European Union. Baqir (2002) shows that there are significant differences in the allocation of these expenses even at the level of countries similarly developed. Moreover, there are considerable variations from one period to another, in this type of countries. Wagner (1883) proves a tendency of faster growth of public expenses compared to the growth of economic activity in industrialized countries. The same tendency is manifested after the Second World War. A vast literature developed on the theme in this period : Gupta [1967], Wiseman [1968], Pryor [1968], Goffman [1968], Bird [1971], Tarschus [1975], Mann [1980] etc. The development in economic techniques of co integration, the Granger causality etc, have determined the appearance of new studies in this area: Demirbas[1999], Murthi [1993], Oxley [1994] etc.

In economic literature six types of functions have been drafted in defining Wagner's Law. They use absolute values or the indicators in the model are calculated per capita:

The **Peacock-Wiseman** [1968] proposes a linear function of analysis for public expenses (G) reported to the GDP (GNP):

$$\ln G_t=\alpha+\beta \ln GNP_t+\varepsilon_t \quad (1)$$

The **Pryon Model** [1968] proposes a linear model for analysing the dependence between private consumption (C) and GDP (GNP):

$$\ln C_t=\alpha+\beta GNP_t+\varepsilon_t \quad (2)$$

The **Gupta Model** proposes a linear model of analysing the linear dependence between public expenses and GDP per capita $(GNP/P)_t$:

$$\ln(G/P)_t=\alpha+\beta(GNP/P)+\varepsilon_t \quad (3)$$

The **Goffman Model** [1968] uses a linear model having as exogenous variable GDP per capita in describing public expenses:

$$\ln G_t= \alpha+\beta(GNP/P)+\varepsilon_t \quad (4)$$

The **Musgrave Model** [1969] analyses the linear dependence between the percentage of public expenses in GDP and GDP per capita:

$$\ln(GNP/P)_{t=} \alpha+\beta(GNP/P)+\varepsilon_t \quad (5)$$

The **Mann Model** proposes the following model:

$$\ln (GNP/P)_t= \alpha+\beta GNP_t)+\varepsilon_t \quad (6)$$

In the ulterior phases of the project the viability of Wagner's Law in the case of Eastern countries is verified, using a disintegrated variant of public expenses. Thus, in every model, expenses from the area of education are used. The results are compared to those of the model utilising other public expenses, such as military or health. For the aggregated analysis of public expenses or of those disintegrated by various sectors, models like Peacock, Wiseman, Gupta, Goffman, Musgrave and Mann are utilised.

To identify factors determining the dimension of expenses in education, it is necessary to estimate the parameters of the regression model

$$CBE_{it} = f(CB_{it}, x_{1t}, ..., x_{kt}) + \varepsilon_{it}$$

where :

- CBE_{it} represents budgetary expenses for education in a given country *i*, in the year *t;*
- CB_{it} represents budgetary expenses;
- and x_{1t},......x_{kt} are other independent variables that are influential to seizing budgetary expenses for education.

The literature highlights a series of papers that try to explain the modifications in budgetary expenses for education in a certain period of time: Verbina and Chowhury (2004) for an analysis over Russia; Falch and Ratto (1997) for an analysis over the federal countries, etc. For estimating the parameters of a model, panel data are used, with fix or variable effect.

Starting from a series of studies based on panel data at the level of some groups of countries (Temple 1999), a small degree of dependence between elements of education and economic performances of the countries is demonstrated. Thus, ex-socialist countries were characterized by low values of important indicators that feature the university system, like the number of students at 10000 inhabitants, the number of students for one teacher, number of specializations.

In the '90s, in most of these countries, the private educational system was implemented and developed as an alternative to state educational system. The proposed models are an attempt to identify the factors contributing to the increase of number of students in these countries, and also to identify the economic and social impact of these transformations from the university system, at the level of labour force markets. The statistics used in estimating the mentioned models come from the following sources:

- the National Institute of Statistics
- the World Bank
- Eurostat

For studying the viability of Wagner's Law by total expenses as well as in disintegrated form one can use: the regression models estimated on the base of data series at the level of one country, models of regression with panel data in the two variants: fix and variable effect; ECM or VEC models.

4. Territorial modifications regarding the university system

The statistical indicators calculated in this basis, allow analysis at the national level as well as at a territorial profile.

The current statistics allow the classification of other number of total students by public and private universities, and by gender, or economic regions. According to INS the classification of the teaching staff in the academic system by regions in the previous academic year is: 13.1% North-East, 5.6% South-East, 3.9% South Muntenia, 5.0% South West Oltenia, 12.2% West, 16.5% North West, 8.6% Centre, 35.0% Bucharest- Ilfov. For the private and public universities, the classification of students and teaching staff are represented by the graph (fig. 7 and 8):

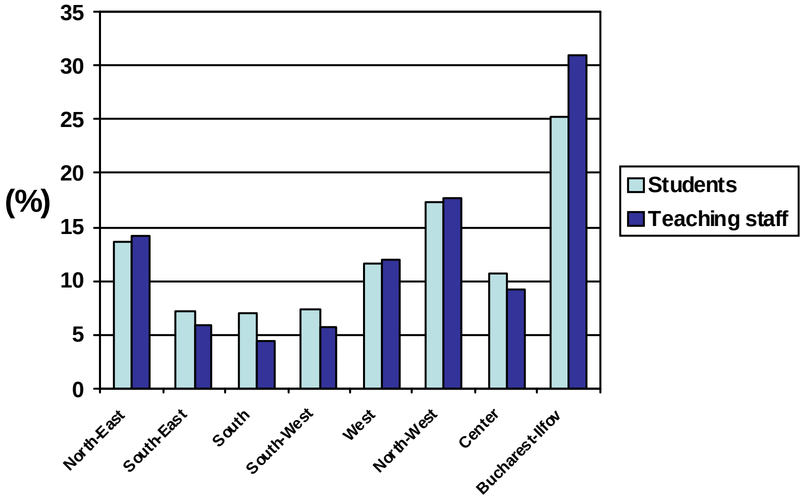

Figure 7. The structure of students and teaching staff in the public system, by regions

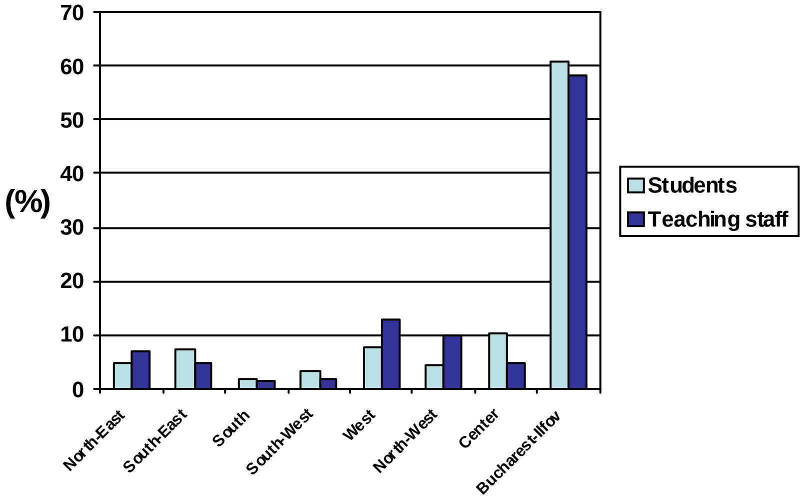

Figure 8. The structure of students and teaching staff in the private system, by regions

Comments on the results on territorial profile:

i) In territorial profile there is a large discrepancy in assigning the number of students per teacher. In private universities, in most of the regions, the values are almost three times bigger than the average of the country. At the level of the Centre region, the indicator has the value of 93.7 students per teacher.

ii) At the level of public universities, the values are in the normal limits. The only exception is in South Muntenia, where the indicator has the value 30.8. At the level of Bucharest-Ilfov where there is the largest percentage for students registered to public universities, the value of the indicator is 15.6.

iii) In public universities, the Bucharest-Ilfov region has a significant percentage of students, but which is not clearly distinct from the next two regions. On the other hand, at the level of private universities, this region has undeniable monopoly, with over 60% of the students.

Table 2. Studens teacher ratio

	National	State	Private
North-East	22.7	18.3	29.2
South-East	19.1	23.4	67.4
South – Muntenia	28.7	30.8	56.9
South-West - Oltenia	32.1	25.5	81.7
West	28.4	18.4	25.8
North-West	19.5	18.6	20.0
Center	18.7	22.1	93.7
Bucharest-Ilfov	28.0	15.6	45.4

5. The characterization of the infrastructure in universities

The system of indicators must allow featuring some important aspects regarding the infrastructure of higher educational institutions.

At the national level, there are statistics for the characterization of infrastructures of universities by forms of property. A series of derived indicators can be calculated in characterizing the infrastructure. Thus, the state universities have superior endowment regarding the number of students per amphitheatre. The value of this indicator is 214.2 students per amphitheatre in public universities while in private universities, 364.1 students per amphitheatre. The same situation exists in the case of the number of students per seminar room or laboratory. The two values are represented in figure 9.

Table3. The universities' infrastructure

	Amphi-theatres	seminar rooms	gymnastic halls	Labora-tories	workshops	play grounds	swim pools
National	2955	4096	181	8116	573	195	11
State	2398	3065	149	7704	552	177	9
Private	557	1031	32	412	21	18	2

In the 2005-2006 academic year in the Romanian higher educational system there were 107 institutions of higher education; these institutions included 770 faculties and colleges. In the public system were included 55 institutions with 554 faculties. The territorial distribution shows that most of them are in the traditional university centres: 14 institutes (99 faculties) in Bucharest, 6 institutes (49 faculties) in Cluj-Napoca, 5 institutes (47 faculties) in Iasi and 4 institutes (35 faculties) in Timisoara. Regarding the private system, most of its institutions are located also in the traditional university centres. Thus, there are 20 universities in Bucharest, 6 in Iasi, and 4 in Timisoara.

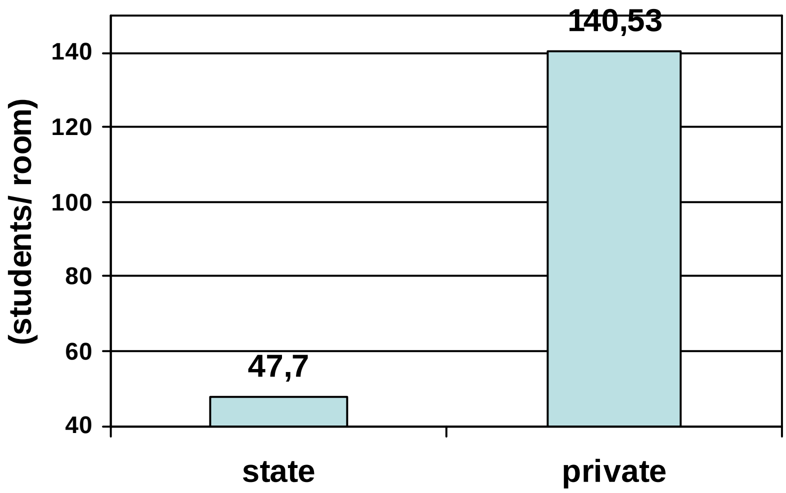

Figure 9. Number of students per seminar room and laboratory

The system of indicators must allow the characterization of some financial aspects at the level of the institutions in the higher educational system. For the financial year 2005, the expenses for education were at the level of 11.644 million lei, from which the percentage assigned for academic education was at the level of 30.8%.

6. Conclusions

Worldwide, education and professional training are essential elements in the development of a country or an economic region. The entire evolution of human society, in general, highlights the significant connection between the human capital and the general level of socio-economic development.

That is why a careful analysis is necessary to determine the purpose and the consequences that the system of education and professional adaptation has, in the general view of the socio-economic evolution of a society. *The investment in education is a long term investment, and currently, considering the priorities manifested in the socio-economic perspective, transformations in mentality, preferences and attitudes – it can be said that all these factors make education a less attractive investment.*

In all developed countries, the segment of population interested in academic education faced fundamental transformations which led to the necessity of abandoning the traditional forms of training, based on providing courses in a formal institutional environment, or on classic, conservative didactic methods. New technologies have brought about new alternative methods of education, meant to make education accessible to other untraditional segments of the market.

Presently, competent institutions of higher education address not only students but also adults willing to specialize in areas more and more various and dynamic in economy, to reorient themselves professionally, to obtain certain competences necessary to the dynamic evolution of economy and society or to maintain to efficient standards their job.

The transformations in economy and society inevitably influence the education system. The transformation of the university has become an essential element in understanding the modern higher educational system.

The reorganization of the educational and financial processes started in Romania after the year 1989, and is a direct consequence of the main tendencies manifested on the market of higher education, extensively presented in the present paper, namely: mass higher education, the decline in public finances, the growth of demographic and socio-economic diversification, the request for a constant education of adults the unique development of informational technologies, the globalization of the higher education market.

For Romania, the integration in the European Union, politically assumed, has significant effects on the employment of the labour force, and in the same time on education and professional training as a part of education. The education and the professional training of the labour force in Romania will contribute to defining the place and the role of Romania in the structure of the European Union.

The reform in education does not advance as spectacularly as it would be wanted to in the field of financial decentralization or the participation of community and parents in the decisional process. The present necessities include the clear identification of the external factors blocking the reform measures in education, the constant monitoring of the evolution of these factors, the use of flexible planning strategies.

The reorganization appears as a dynamic process of structuring the institutions of public higher education in Romania, the didactic and research processes as well as the administrative ones, for a better response to the changes produced in Romanian society during transition, especially in the demand for university services, but also in the mechanism of finance adopted by the main financer- the State, in 1999, and the decrease of the contribution of State in financing the today's mass higher educational system.

The problem is of the maximum importance for the creation of an efficient and competitive educational system, according to the new realities, and implies the assurance of the financial resources, as well as implementing an efficient management and productive use of funds.

In Romania, both the national education and the politics regarding professional training should adapt to a regional development strategy, and yet, this centralized adaptation might not be adequate. The decisional factors should continue the present efforts in order to emphasize the educational and professional training strategies of the Regional development Agencies.

Romania is in great need of a higher educational system based on the local requirements of the communities, and on the special needs of the poor families that do not dispose of the financial means to send their children to long distanced faculties. However the existent colleges are sometimes incorrectly looked upon as inferior to universities, and not as distinct institutions offering a different type of quality education. In Romania, there is an impressive number of new private institutions for higher education; while many of these institutions are not completely accredited as universities, they could be transformed into colleges, offering a short cycle of higher education, according and adapted to the local conditions.

The higher educational system is confronted with the development of "new domains" of study in a context of both financial and administrative constrains. Education in areas such as market economy, democratic processes, and civil society and cybernetics, could substantially advance if colleges and universities would benefit from the important number of young persons attending courses of specialization abroad or in Romania, in programs stimulating creativity. For the full transformation and modernization of the higher education curriculum, a priority is represented by the grant of special stimuli for the recruitment, professional development and retention of these young university cadres.

The reconsideration of the role of education and professional and technical training, in the context of the educational system and of providing labour force, is crucial, especially considering the need of improving the general access to permanent education. Secondly, improvements are required at the level of transition from scholastic regime to a productive one; of significant influence in this purpose, could also be the use of national qualification standards for the initial formation, as well as for the ulterior one, and the collaboration of a comprehensive and transparent approach in evaluating competences.

In the same time it necessary to reanalyse the level and quality of the qualifications obtained through the educational, professional, and technical formation system, as well as their harmonization with the demands in the labour market. This process includes: the adaptation or elaboration of new plans of education, the professional development of teaching staff and administrative personnel, the elaboration of new quality control mechanisms, etc.

Based on the international classification systems, the Ministry of Education should elaborate a list of approved professions; the list must include well established roles and responsibilities between the social partners and other partners.

The reform process must include all levels and forms of education and professional and technical formation. It is necessary to elaborate and apply a new policy of extending the results obtained so far during the reform process. The improvement of managerial processes in education and professional and technical formation can be accomplished only through an enhancement in informing and instructing administrators responsible with mobilising resources and participative management.

Innovative financial politics must be encouraged by identifying other resources besides state budget – the stimulation, through appropriate mechanisms, of investments in instruction activities financed by the employers, the social partners and others. The Ministry of Labour must be preoccupied with the elaboration of a national politics of continuation of formation; this policy must include all resort ministries, administrative regions, and social partners, and identify the roles that are assigned for each in promoting the activities of training adults, and in associated mechanisms (e.g. finance application, etc.).

The training component must be clearly presented in the plans for regional development, and the positive experience gained in the training units must be put to good use to its best. All those participating in the educational process (vocational schools, private and state centres of training, etc) must promote quality and innovative elements; this aspect must be taken into account and shared to all potential partners and students.

The particularities of the educational system require taking into consideration the establishment of the main objectives of principles that individualises it compared to other sectors of activity. These objectives, elements of a strategy, have the purpose of applying an accelerated transformation process, concentrated on operational elements that are determined by a strategic objective.

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MATHEMATICAL MODEL FOR OPTIMIZING THE PROFIT OF THE PORK MEAT CHAIN

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Abstract: *The research of the present study answer the question whether using measures for reducing the losses on the pork meat chain enables acquiring a higher level of effectiveness. In pursuing this question, a mathematical model for optimizing the profit of the chain is elaborated and implemented in two situations: scenario 1 – without measures for preventing the losses, and scenario 2 – with measures for preventing the losses. The results show that in the second situation the level of profit is higher, because of reducing the losses by applying measures for their prevention: farms' re-technology, implementing an automatically system for feeding the animals, ensuring medication through feeding system, improving ventilation system, using devices for monitoring continuously the microclimate, establishing the optimal supply using scientifically methods etc. The conclusions have strong implications for chain operators who may acquire a higher level of profit by applying these measures of reducing the losses.*

Key words: *agro-food chain; effectiveness; mathematical model; performance*

Introduction

The objective of this study is to elaborate and implement a mathematical model of increasing economical efficiency of the pork meat chain. The results answer the question whether using measures for reducing the losses on the pork meat chain enables acquiring a higher level of effectiveness. In achieving this purpose, it is studied the pork meat chain in two possible situations: scenario 1 – without measures for preventing the losses, and scenario 2 – with measures for preventing the losses. The economical data used have been reported by an agricultural unit that has as main activities: porks' growing and slaughtering and meat and meat products' marketing.

In previous studies (La Gra, 1990), the topic of economical efficiency of agro-food products' chain is related to the losses that may result from the system. Any measure of losses' prevention enables an increasing of performance of the chain. Losses might be quantitative and qualitative and they start from the biological material and continue in each stage of the chain, until the products reach the shelves on the supermarket (Ion, 2005).

In the case of agricultural products of animal origin, the first losses occur in choosing the species and breeds. If they are not in elite category, there will result losses in yields. For instance, on the pork meat chain, in the maternity stage, the losses of pigs are 9%. Other losses result from diseases: 3% in pork growing area, 0.5% for base hers, and 1.5% for fat pork. Diseases may be prevented by vaccination and ensuring proper microclimate conditions.

Other losses occur to animal transportation. These animals loose weight because of stress. Weight loss must not overrun 7%. In practice the weight loss is situated between 5% and 7%.

For agricultural products of animal origin there are losses in slaughtering houses as well. These losses reach the level of 0.5%. In the stage of storing the meat, the humidity factor is very important. Fresh agricultural products like meat loose water. This is the reason why the humidity must be high during storage. For pork meat, there are losses of freezing and defrosting of 1.,5-1.8%, respectively 2-2.5% and technological losses of 2% for full and 2-2.5% to organs (Pîrjol, 2006).

In the last stage of the chain – marketing – there are occurring qualitative losses because of laying out the merchandise in inappropriate hygiene conditions or under direct action of sun, or psychological losses (Istudor, 2006). In the case of pork meat, the marketing losses are between 0.2-0.5%.

Model for assessing economical efficiency

Preventing the losses represents a way of increasing economical performance on the agro-food products' chain.

In this paper it is elaborated a model for increasing economical performance on the pork meat chain. This model is then implemented based on data provided by one economic agent who integrates several economical activities on the chain: porks' growing and slaughtering, meat processing and meat and meat products' marketing.

In elaborating the model of optimizing the profit of the pork meat chain, there are considered two possible situations: scenario 1 – without measures for preventing the losses, and scenario 2 – with measures for preventing the losses. The profit of the pork meat chain is equal to the sum of profits of each stage of the chain (Manole, 2006). This total profit may be expressed in the two situations as follows:

Scenario 1:

$$P_1 = \left[\left(V_{fnc} - C_{fnc} \right) - \sum_{h=1}^{m} p_{fnch} \right] + \left[\left(V_{cî} - C_{cî} \right) - \sum_{i=1}^{n} p_{cîi} \right] + \left[\left(V_{ab} - C_{ab} \right) - \sum_{j=1}^{o} p_{abj} \right] +$$

$$+ \left[\left(V_c - C_c \right) - \sum_{k=1}^{p} p_{ck} \right]$$

Scenario 2:

$$P_2 = \left[\left(V_{fnc} - C_{fnc} \right) - \sum_{h=1}^{m} p'_{fnch} \right] + \left[\left(V_{cî} - C_{cî} \right) - (C_{mî} + \sum_{i=1}^{n} p'_{cîi}) \right] + \left[\left(V_{ab} - C_{ab} \right) - \left(C_{mab} + \sum_{j=1}^{o} p'_{abj} \right) \right] +$$

$$+ \left[\left(V_c - C_c \right) - \sum_{k=1}^{p} p'_{ck} \right]$$

In which:

$P_1 =$ profit for scenario 1 – without measures for preventing the losses on the pork meat chain

$P_2 =$ profit for scenario 2 – with measures for preventing the losses on the pork meat chain

$V_{fnc} =$ revenue in the stage of obtaining the mixed feed

$C_{fnc} =$ expenditure in the stage of obtaining the mixed feed

$p_{fnch} =$ losses of type *h* resulted in the stage of obtaining the mixed feed, without respecting the measures of preventing the losses

$p'_{fnch} =$ losses of type *h* resulted in the stage of obtaining the mixed feed, respecting the measures of preventing the losses

$V_{cî} =$ revenue in the stage of growing the pigs

$C_{cî} =$ expenditure in the stage of growing the pigs

$p_{cîi} =$ losses of type *i* resulted in the stage of growing the pigs, without respecting the measures of preventing the losses

$p'_{cîi} =$ losses of type *i* resulted in the stage of growing the pigs, respecting the measures of preventing the losses

$V_{ab} =$ revenue in the stage of slaughtering

$C_{ab} =$ expenditure in the stage of slaughtering

$p_{abj} =$ losses of type *j* resulted in the stage of slaughtering, without respecting the measures of preventing the losses

$p'_{abj} =$ losses of type *j* resulted in the stage of slaughtering, respecting the measures of preventing the losses

$V_c =$ revenue in the stage of marketing the meat and meat products

$C_c =$ expenditure in the stage of marketing the meat and meat products

$p_{ck} =$ losses of type *k* resulted in the stage of marketing the meat and meat products, without assessing the optimal stock

p'_{ck} = losses of type *k* resulted in the stage of marketing the meat and meat products, with assessing the optimal stock

$C_{m\hat{i}}$ = expenditure with measures for preventing the losses in the stage of growing the pigs

C_{mab} = expenditure with measures for preventing the losses in the stage of slaughtering

h = type of losses in the stage of obtaining the mixed feed

i = type of losses in the stage of growing the pigs

j = type of losses in the stage of slaughtering

k = type of losses in the stage of marketing the meat and the meat products

m = number of losses in the stage of obtaining the mixed feed

n = number of losses in the stage of growing the pigs

o = number of losses in the stage of slaughtering

p = number of losses in the stage of marketing the meat and the meat products.

The data needed for implementing the model of optimising the profit on the pork meat chain have been provided by an agricultural unit. It has a capacity of 92130 pigs, used 100%. Meat production accounts for 6,687,257 kilograms. Yield of slaughtering is 70%.

For assessing performance of the pork meat chain, there have been collected data about costs and revenues for each stage. They have been assessed without taking into account the quantitative and qualitative losses of production. Thus, the profit for the first stage of the chain – obtaining the mixed feed – is 5,182,661.33 lei. The profit rate, calculated as ratio between profit and total expenditure, is 14.66%, and the rate of returns, calculated as ratio between profit and revenues, is 12.79% (Table 1).

Table 1. Economical results in the stage of obtaining the mixed feed, for the whole production, 2006

- lei -

No.	Specification	Value
I	**TOTAL EXPENDITURE**, of which:	**35340869.63**
1.	Expenditures with raw materials	29475126.21
2.	Expenditures with auxiliary materials	2404486.72
3.	Expenditures with fuels	143626.96
4.	Expenditures spare parts	160160.17
5.	Expenditures with expendable materials	280205.79
6.	Expenditures with energy and water	618677.89
7.	Expenditures with merchandises	50411.18
8.	Expenditures with maintenance and repairs	36248.75
9.	Expenditures with rents	1872.37
10.	Expenditures of transportation	766057.67
11.	Other expenditures with services	97330.35
12.	Expenditures with duties and taxes	14360.83
13.	Expenditures with salaries	794319.55
14.	Expenditures with social insurance	200651.05
15.	Expenditures with unemployment	23829.35
16.	Expenditures with health insurance	55603.81
17.	Other expenditures with social protection	500
18.	Expenditures of exploitation regarding depreciation	217400.98
II	**TOTAL REVENUE,** of which:	**40523531.00**
1.	Revenues from selling the final products	2082.62
2.	Revenues from services	1384.21
3.	Revenues from rents	14465.44
4.	Revenues from selling the merchandise	52291.58
5.	Revenues from diverse activities	2630
6.	Total revenues (701-708)	72853.85

No.	Specification	Value
7.	Stock variation	36398324.01
III	**PROFIT**	**5182661.33**
IV	Profit rate (%)	14.66
V	Rate of returns (%)	12.79

In the second stage of the chain, growing the pigs, the profit is 7,505,717.35 lei, the profit rate is 15%, and the rate of returns is 13% (Table 2).

Table 2. Economical results in the stage of growing the pigs, for the whole production, 2006

- lei -

No.	Specification	Value
1.	Days of feeding	32152624.00
2.	Increase	12042304.00
3.	Weight	25055429.00
4.	Stock weight at 31.12.2005	4606547.00
5.	Non-suckler pigs	158780.00
6.	Suckler pigs	15159.00
I	**Current expenditure**, of which:	**50435559.60**
1.	DIRECT EXPENDITURE	46853320.35
a.	Feed	36614648.47
b.	Medication	2115356.60
c.	Materials, repairs	1956595.62
d.	Spare parts	129495.23
e.	Other expendable materials	1069714.33
f.	Sperm dosages	220595.89
g.	Maintenance and repairs	536790.17
h.	Fuels	335627.64
2.	EXPENDITURES WITH PERSONNEL	3849801.80
a.	Salaries	2833095.15
b.	Social insurance	733406.13
c.	Unemployment	84986.96
d.	Health insurance	198313.56
3.	Expenditures with livestock	0.00
4.	Depreciation	655051.13
5.	Energy and water	1326239.09
6.	INDIRECT EXPENDITURES	3582239.25
a.	Other common expenditure	1714866.42
b.	Packaging materials	1455.00
c.	Expenditures with transportation	58808.61
d.	Expenditures with displacement	27.80
e.	Expenditures with services	309750.04
f.	Expenditures with duties and taxes	56457.37
g.	Expenditures with social protection	2500.00
h.	Expenditures with exploitation	0.00
i.	Subsidies	0.00
j.	Expenditures with object in custody	38081.30
k.	Expenditures with actives given in	0.00
l.	Expenditures with merchandise	4336.00
m.	Expenditures with seeds	0.00
n.	Expenditures with auxiliary materials	1744.80
o.	Mechanical sector	1241705.50
p.	Expenditures with auxiliary sectors	1867372.83
7.	Cost per feeding day	1.57
8.	Cost kilogram/increase	4.19
9.	**Cost kilogram/weight**	**2.86**
II	**Revenues**	**57941276.95**
III	**Profit**	**7505717.35**

No.	Specification	Value
IV	Profit rate (%)	**15**
V	Rate of returns (%)	**13**

The expenditures, revenues and profit in the stage of slaughtering are presented in Table 3. Profit rate is 57.4%, and the rate of returns is 36.4%.

Table 3. Economical results in the stage of slaughtering, for the whole production, 2006

- lei -

No.	Specification	Value
I	**Total expenditure,** of which:	**44196547.67**
1.	Expenditures with raw materials	40773139.87
2.	Expenditures with auxiliary materials	16963.2
3.	Expenditures with fuels	887352.2
4.	Expenditures with packaging materials	35022.4
5.	Expenditures with spare parts	23476.12
6.	Expenditures with expendable materials	129490.23
7.	Expenditures with objects in custody	11713.62
8.	Expenditures with energy and water	319698.75
9.	Expenditures with maintenance and repairs	68651.96
10.	Expenditures with transportation	155910.47
11.	Other services	331672.7
12.	Expenditures with duties and taxes	17342.06
13.	Expenditures with salaries	975696.1
14.	Social insurance	250330.68
15.	Unemployment	29270.78
16.	Health insurance	68297.82
17.	Expenditures with depreciation	102518.71
II	**Total revenue**, of which:	**69545942.08**
1.	Revenues from selling final products	51999125.42
2.	Revenues from services	86741.29
3.	Total revenues (701-708)	52085866.71
4.	Stock variation	279170
5.	Other revenues	11617230
III	**Profit**	**25349394.4**
IV	Profit rate %	57.4
V	Rate of revenues %	36.4

The meat is stored in freezing system in order to be put on the market. The revenues and expenditures of the last stage of the chain are presented in Table 4. The marketing activity is finalised with losses, on the one hand, because high level of production losses, and, on the other hand, because of low level of selling prices.

Table 4. Economical results in the stage of marketing, for the whole production, 2006

- lei -

No.	Specification	Value
I	**Total expenditures**	**2213203.6**
1.	Expenditures with fuels	717129.42
2.	Expenditures with spare parts	301393.94
3.	Expenditures with expendable materials	113208.03
4.	Expenditures with objects in custody	69074.91
5.	Expenditures with merchandise	1260.24
6.	Expenditures with maintenance and repairs	217447.09
7.	Expenditures with insurance	27989.56
8.	Expenditures of transportation	15878.82
9.	Expenditures with travelling	600.6
10.	Other expenditures with services	118479.88

No.	Specification	Value
11.	Expenditures with taxes and duties	7040.82
12.	Expenditures with salaries	442509.24
13.	Social insurance	100958.22
14.	Unemployment	13273.43
15.	Health insurance	30975.3
16.	Expenditures with depreciation	35984.1
II	**Total revenues**	**1650087.64**
1.	Revenues from services	1000087.64
2.	Revenues from selling the merchandise	650000.00
4.	Stock variation	0
III	**Profit/loss**	**-563115.96**

Scenarios regarding economical efficiency on the pork meat chain

In Table 5. there are centralised data regarding expenditures, revenues, profits and losses on the pork meat chain, in two situations: scenario 1 – without measures for preventing and reducing the losses, and scenario 2 – with measures of updating the technologies for preventing and reducing the losses.

Table 5. Scenarios regarding profit assessment on the pork meat chain

No.	Specification	Value (lei)	
		Scenario 1	Scenario 2
I.	OBTAINING MIXED FEED		
1.	Production (kg)	21686411.1	22827801.17
2.	Revenues	40523531.00	40523531.00
3.	Expenditures	35340869.63	35340869.63
4.	Losses in the stage of obtaining mixed feed (10% scenario 1, respectively 5% scenario 2)	4052353.1	2026176.55
5.	Profit/loss [2-(3+4)]	1130308.23	3156484.82
6.	Rate of revenues (5/2*100), %	2.79	7.78
II.	GROWING THE PIGS		
1.	Production (kg)	29134219.77	32371355.3
2.	Revenues	57941276.95	57941276.95
3.	Expenditures	50435559.60	50435559.60
4.	Expenditures with measures of preventing the losses*	-	1200000
5.	Losses in the stage of growing (14% scenario 1, respectively 10% scenario 2)	8111778.77	5794127.70
6.	Profit/loss [2-(3+4+5)]	-606061.42	511589.66
7.	Rate of revenues (6/2*100), %	-	0.88
III.	SLAUGHTERING		
1.	Production (kg)	7268757.6	7732721
2.	Revenues	69545942.08	69545942.08
3.	Expenditures	44196547.67	44196547.67
4.	Expenditures with measures of preventing the losses**	-	1300000
5.	Losses during slaughtering (8% scenario 1, respectively 4% scenario 2)	5563675.37	2781837.68
6.	Profit/loss [2-(3+4+5)]	19785719.04	21267556.73
7.	Rate of revenues (6/2*100), %	28.44	30.58
IV.	MARKETING		
1.	Production (kg)	7268757.6	7732721
2.	Revenues	1650087.64	1650087.64
3.	Expenditures	2213203.60	2213203.60
4.	Losses during marketing (0.5% scenario 1, respectively 0.25% scenario 2)	8250.4	4125.2
5.	Profit/loss [2-(3+4)]	-571366.4	-567241.16
V.	Total profit (I.6.+II.6.+III.6.+IV.5)	19738599.5	24368390.05

* - expenditures with measures of preventing the losses in the stage of growing the pigs refer to updating the technology with an automatic feeding system, realising medication throughout feeding etc. The new technology suffers depreciation in time. While the model is not implemented in dynamic, it is considered that, for one year, the expenditures with investment depreciation are 1200000 lei.

** - expenditures with measures of preventing the losses in the stage of slaughtering refer to expenditures for improving the system of ventilation, updating the technology of monitoring the temperature etc. The investment with the new technology suffers depreciation in time. While the model is not implemented in dynamic, it is considered that, for one year, the expenditures with investment depreciation are 1300000 lei.

In the first stage of the chain – obtaining the mixed feed – the losses decrease from 10% to 5% as a result of implementing agro-technical and plant protection measures more efficient. The cost per kilogram decreases from 1.63 lei to 1.55 lei. The profit grows from 1130308.23 lei to 3156484.82 lei.

In the stage of growing the pigs, there are registered high levels of losses – 14% in scenario 1, of which: 9% in maternity shelter, 3% in youth shelter, 1.5% in fat pigs shelter, and 0.5% for base herd. Thus, the activity of growing the pigs has not finalised with profit (as seen in Table no.2, the profit resulting from the activity of growing the pigs is 7505717.35 lei; but this level is achieved when the losses are not taken into consideration), but with a loss of 606061.42 lei.

A solution for reducing the losses is upgrading the technology of growing the pigs, by implementing an automatic system for feeding the livestock, ensuring medication through feeding etc. The losses are not all put out, but they might be reduced from 14% to 10%.

Reducing the losses means increasing efficiency for the activity of growing the pigs, even there are registered additional costs with depreciation of the investment realised for up grading the technology (1200000 lei per year). Thus, the activity of growing the pigs finalised with a profit of 511589.66 lei, the rate of returns being 0.88%.

In the stage of slaughtering the animals it results losses of 8% (scenario 1), of which: 2% technological losses because of freezing the meat and another 2% because of freezing the organs, 0.5% for meat hunk, 1.5% losses of deep-freezing, and 2% losses of un deep-freezing. As a result, this activity finalised with a lower level of profit: 19785719.04 lei (as seen in Table 3, the profit for slaughtering activity is 25349394.4 lei, but it was not taken into account the losses of production). The rate of returns is 28.44%.

A solution for reducing the losses could be upgrading the slaughterhouse by improving the system of ventilation, providing devices for monitoring the climate conditions, ventilation, temperature from slaughterhouse and storehouse, and for measuring the meat temperature etc. The losses are not all put out, but they might be reduced from 8% to 4% (with 50%).

Reducing the losses means increasing efficiency for the activity of slaughtering the pigs, even there are registered additional costs with depreciation of the investment realised for upgrading the technology (1300000 lei per year). Thus, the activity of slaughtering the pigs finalised with a profit of 21267556.73 lei, the rate of returns being 30.58%.

In the stage of selling the meat and the meat products, there are losses of 0.5%. This activity is finalised with losses of 571366.4 lei (as seen in Table no.4, the activity of selling the products finalises with a loss of 563115.96 lei, without taking into consideration the losses of production).

In scenario 2, a solution for reducing the losses might be the assessment of optimal stock using scientifically methods. Thus, by assessing the optimal stock, the economic agent will determine the exact quantity of merchandise needed for selling, so there were no breakings in stocks or over stocks (Istudor, 2005). It is underlined the importance of assessing the optimal stock especially in the case of meat, which is a very perishable product. The losses are not all put out, but they might be reduced from 0.05% to 0.025%. Hereby, the losses are reduced from 571366.4 lei to 567241.16 lei.

Conclusions

Losses' cutting down on the pork meat chain is a way of increasing economical performance of chains' activities, because, by implementing the model of augmentation the economical efficiency, the total profit in scenario 2, in which there are applied measures for preventing the losses, is 16% higher than in scenario 1, in which there are not applied any measures of preventing the losses. The profit has increased in absolute values from 19738599.5 lei to 24368390.05 lei.

Increasing performance on the pork meat chain by reducing quantitative and qualitative losses as a result of implementing measures for their prevention represents the main objective for each economic agent. This approach is even more important in the context of Romanian agro-food sector integration into European Union. In this context, the competition on European single market will increase and the fight for customers will be gained by those economic agents that provide high quality products for the lowest costs.

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THE INCIDENCE OF PECTORIS ANGINA POST-ACUTE MYOCARDIAL INFARCTION IN ROMANIA – RO-STEMI DATABASE

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Abstract: *Cardio-vascular diseases are the major cause of mortality, with ischemic cardiac disease as the major form, followed by stroke. Each of these diseases accounts for some 15 million deaths per year, representing 30% of the total number of death. The highest mortality is registered in the countries of former USSR and those of Eastern Europe. France and Japan had the lowest rate of mortality by ischemic heart disease. This study is based on a retrospective analysis of the medical information provided by RO-STEMI database.*

Key words: *pectoris angina; myocardial infarction; RO-STEMI database; quantitative methods*

1. Introduction

Cardio-vascular diseases are the major cause of mortality, with ischemic cardiac disease as the major form, followed by stroke. Each of these diseases accounts for some 15 million deaths per year, represting 30% of the total number of death. The highest mortality is registered in the countries of the former USSR and those of Eastern Europe. France and Japan had the lowest rate of mortality by ischemic heart disease.

The World Health Organization observed the population of North America, Europe, China, Australia and Asia for ten years by MONICA project (MONItoring of trends and determinants in CArdiovascular diseases) to compare the mortality and the incidence of fatal events caused by cardiovascular diseases. The incidence of ischemic heart disease was highest in UK and Finland and lowest in China and Mediterranean countries. The explanation given by investigators was based on the different incidence of the risk factors: the serum level of cholesterol is highest in UK and Finland and lowest in China and Spain, while smoking has the highest incidence in Scotland and Ireland.

Despite the sustained effort for establishing the correct diagnostic and therapeutical approach for acute myocardial infarction (AMI), this still remains in the last 30 years the most important question of the health in developed countries.

In the USA around 1million persons are diagnosed each year with acute myocardial infarction. Although, the mortality rate has decreased by 30% in the last 10 years, one third of the patients still suffer fatal cardiovascular events.

Myocardial ischemia is the most common cause of mortality and morbidity. The most important ischemic causes of the chest pain after myocardial infarction are pectoris angina (PA) and reinfarctisation. Depending on the time interval when the angina appears, after myocardial infarction, we note two types: early - that appears in the first two weeks after AMI; and late – that appears after two weeks from AMI.

2. Methods

In this study we included 10.037 patients with AMI with ST elevation (STEMI) admitted in many departments of cardiology and internal medicine between 1996-2006 in different hospitals from Romania. This study was retrospective and it analyzed the medical information noted medical records of these patients. The incidence of earlier PA and its correlation with other medical events was analyzed in RO-STEMI database that records more then 60 variables both qualitative and quantitative.
Statistical analysis was performed by SPSS, ANOVA test and contingency tables.

3. Results

The incidence of earlier PA in RO-STEMI was 11.9%. Patients in RO-STEMI were between 18 and 94 years old. In order to study the correlation between earlier PA and age of patients we divided in several groups by age. We observed that there is a statistically significant correlation between earlier PA and age in each group. This correlation is presented in table 1.

Table 1. Correlation earlier PA – age

Age (years)	Patients rate	Incidence of earlier PA
18-30	0,8%	7,8%
31-40	5,2%	9,5%
41-50	20,3%	12,9%
51-60	30,8%	13,4%
61-70	35,1%	13%
71-80	7,4%	8,7%
81-94	0,5%	5,6%

*significance (P) is 0,002

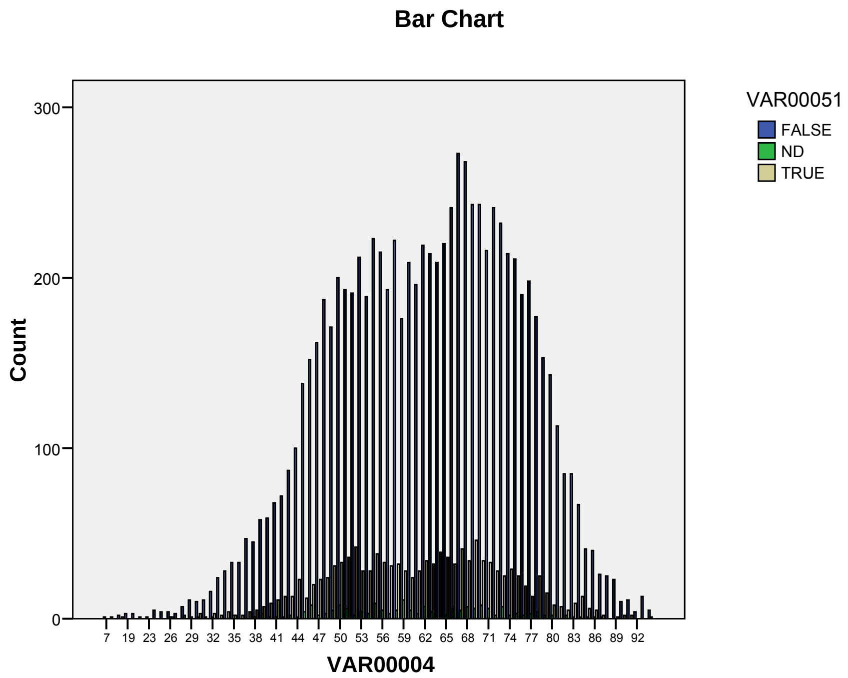

Figure 1. Distribution of earlier PA on age

From 10.037 patients 68,9% were males and 30,8% were females. Despite the higher number of males, the incidence of earlier PA was similar in both groups: 11,6% for males and 12,8% for females (p = 0,005). The risk factors which we studied to establish the correlation with the appearance of earlier PA were: smoking dislipidemia obesity mellitus diabetes, arterial hypertension and the history of myocardial infarction. Smoking was noted at 49,2% patients, the rest of 50,% was non-smoker. The incidence of earlier PA was 13,1% for smokers and 10,7% for non-smokers (p = 0,0001). 35,7% patients had dislipidemia and 64,3% had normal level for cholesterol and triglycerides. 15,4% patients with dislipidemia have earlier PA and 10% patients without this risk factor (p<0,0001).

At the physical examination, obesity was noted in the medical records at 21,5% patients. The incidence of earlier PA was 16,6% for these patients 78,5% patients had normal BMI in this group 10,6% patients were developed earlier PA (p<0,0001).

20,3% patients had the mellitus diabetes diagnostic. The incidence of earlier PA was 23,5% in diabetics group versus 11,5% in non-diabetics group (79,7% patients) (p=0,01). Arterial hypertension was registered in 50,9% patients, 49,1% had normal blood pressure. 13,7% was incidence of earlier PA in hypertensive's group and 10,1% in the group with normal blood pressure (p<0,0001). Positive history of MI were recorded at 9,9% patients. In this group 10,5% patients were developed earlier PA. The incidence of earlier PA in group without prior MI (90,1%) was 12,1% (p<0,0001). The incidence of earlier PA depending on the presence of the risk factors is presented in table 2.

Table 2. Incidence of earlier PA depending on RF

Risk factor	Incidence of earlier PA in population with risk factor	Significance (P)	Rate of risk factor in population
Smoking	13,1% RF 10,7% NRF	0,0001	49,2%
Arterial hypertension	13,7% RF 10,1% NRF	0,0001	50,9%
Dsilipidemia	15,4% RF 10% NRF	0,0001	35,7%
Melitus diabetes	23,5% RF 11,5% NRF	0,01	20,3%
Obesity	16,6% RF 10,6% NRF	0,0001	21,5%
Prior MI	10,5% RF 12,1% NRF	0,0001	9,9%

The localization of AMI was established on EKG and echocardiographic criteria. At 49,1% patients AMI was localized on the anterior wall of the left ventricle, other localization (inferior, posterior, lateral or different combinations of these) were registered at 46,7% patients. 4,2% patients didn't have note in database the localization of AMI. In group of patients with anterior AMI the incidence of earlier PA was 12,9% versus 11,2% for patients with other localization for AMI (p=0,003).

Another important correlation at incidence of earlier PA was with Killip class of congestive heart failure at presentation. 67,9% patients with AMI-with elevated ST was in Killip I class at presentation, 17,2% in Killip II class, 8,7% in Killip III class and 6,1% Killip IV class. The higher frequency of appearance for earlier PA was at patients in Killip II class at presentation: 15,8%. Other distributions of earlier PA incidence was: 11,6% for Killip I class, 10% for Killip III class and 7,8% for Killip IV class.

The treatment of patients with AMI with ST elevation included many class of medication according to actual European and American guidelines for treatment. Medical drugs used were: thrombolytics, anticoagulants, antiagregants, beta-blockers, angiotensine-converting enzyme inhibitors and statins.

55% patients were treated by thrombolythic therapy. 14,3% of these were developed earlier PA (p<0,0001). It is known that there is a time limit (8 hours from the onset) until it is possible to administrate the thrombolyhtic therapy. We investigated if there is a correlation between the incidence of earlier PA and the promptitude of administration of this treatment. In the first 60 minutes from onset thrombolytic therapy was administrated at 89,8% patients, incidence of earlier PA was observed at 12,9% from this. Between 61 and 360 minutes 9,7% patients received thrombolytic therapy, from these, earlier PA was registered at 10,9%. From the other time intervals: 361-480 minutes, 481-720 minutes, 721-1440 minutes, > 1441 minutes the number of patients which received thrombolytic therapy were statistically insignificant (<30 patients) (p=0,015).

The successful of thrombolyses was established on clinic, EKG and bioumorale criteria. Based on this criteria, the rate of successful of thrombolyses was registered at 31,7% patients. From these, 13,9% were developed earlier PA. Unsuccessful of thormbolyses was registered at 44,9% patients and the incidence of earlier PA in this group was 15% (p<0,0001). It is important to notice that 23,4% patients didn't have registered in database this variable ("Success rate of thrombolyses").

Antiagregant platelet medication was administrated at 84,9% patients with AMI with ST elevated, earlier PA was registered at 14,5% from these patients (p<0,0001). In patients group without antiagregant drugs (15,3%) incidence of earlier PA was 6,1%. The incidence of earlier PA according to the type of the antiagregant drugs is presented in table 3.

Table 3. The incidence of earlier PA according to the type of the antiagregant drugs

Type of treatment	Patients rate	Incidence of earlier PA
Aspirin	61,7%	13,2%
Clopidogrel	1,5%	22%
Aspirin + Clopidogrel	20,1%	11,8%
Integrilin + Aspirin + Clopidogrel	0,8%	12%
Aspirin + Integrilin; Integrilin; Tirofiban	insignificant	insignificant

*significance (P) is lower than <0,0001

Anticoagulant drugs was administrated to 93,4% patients. 12,3% patients with this kind of treatment were developed earlier PA (p<0,0001). From the 5,8% patients without anticoagulant treatment, 6,2% patients developed earlier PA. Similar to the case of antiagregant treatment we found a correlation between incidence of earlier PA and type of anticoagulant drug. The results registered were: heparin was administrated to 59,6% patients, from these were developed earlier PA 13,7%; enoxaparine was administrated to 23,1% patients, in this group earlier PA was noted at 10,7% patients; other types of anticoagulant drugs were administrated to 11% patients, the incidence of earlier was 9,3% for these patients (p<0,0001).

ACE-inhibitors was used to 65,3% patients, earlier PA appears to 15,3% from these (p<0,0001).

63,7% patients received beta-blocker treatment and the incidence for earlier PA was 14% in this group (p<0,0001).

Statins were used for 55,6% patients, earlier PA were developed at 15,7% patients (p,0,0001).

An important point of this study was to find the correlation between the incidence of earlier PA and other complications (determined by AMI or treatment). Congestive heart failure was registered in the final diagnosis at 24% patients, 22,2% of these having earlier PA too. Major bleeding defined that acute loss of blood which determines hemodynamic instability or severe decrease of hemoglobin, appears like an adverse event of thrombolytic therapy, anticoagulant or antiagreagnt drugs, were registered in the case of 0,5% patients, from these 33,3% developed earlier PA (p<0,0001). Pericarditis, another complication of AMI that appears like earlier PA in the first two weeks, was noticed at 0,5% patients 18,4% from these were developed earlier PA also (p<0,0001).

We studied the rate of incidence of earlier PA at patients with cardio pulmonary resuscitation because the most important complication of AMI is cardio respiratory arrest. In the first 12 hours from the onset of AMI was resuscitated 4,8% patients from these developed earlier PA 12,4% (p=0,05). Between 12 and 24 hours from the onset of AMI was resuscitated 0,08% patients and the incidence of earlier PA was 9,4% (p=0,013). 1,4% patients was resuscitated after the first 24 hours from the onset of AMI, 18,2% from these were developed earlier PA (p=0,043).

4. Discussion

The database created for the analysis of patients with AMI with elevated ST is the first one in Romania. The novelty character consists in realizing the first national study about this kind of pathology. Because of the lack of experience in this field, during the creation of the database and the data analysis we encountered some difficulties: the absence of a unitary methodology in completing the database fields, the usage of multiple codes, and the absence of a clear definition of the variables.

For data analysis we used comparison between our results and those published in medical literature. The incidence of earlier PA obtained using RO-STEMI corresponds with that of other medical sources: 20-30% in Heart disease – 7^{th} edition – E. Braunwald, 8,2% in CAPTIM trial, 6,6% in ASSENT 3 trial. These differences are explained by socioeconomic and cultural tradition in Romania versus USA or west European countries.

The results obtained in RO-STEMI showed that males develop twice more times AMI with ST elevated. Despite this, the incidence of earlier PA was greater with females. The same results were obtained in the GUSTO 1 trial that showed the recurrence of post myocardial ischemia is more frequent at females. We explained these results by the fact that females have a higher tendency to come to the emergency room later because they minimalize the simptomatology, and this leads to treatment that does not include thrombolytic drugs.

The highest incidence of earlier PA was in 41-70 age groups. Analysis of the database show us that these patients have many risk factors and frequently localization of AMI at anterior wall of left ventricle. ASSENT 3 trial and ASSENT 3 PLUS trial showed the same results. In the 81-94 age group were included 0,5% patients, a very low number, that is determined by the highest mortality at this kind of patients because of the most frequently complications of AMI and because of the cultural model of these patients who refused the hospitalization.

Surgeon General's report published that the smoking increases the mortality by cardiovascular events with 50%. The highest incidence of earlier PA at smoker versus non-smoker was explained by the systemic atherogen effects induced by this risk factor.

INTERHEART trial noticed that the arterial hypertension is the third risk factor in development of adverse events post AMI, the incidence of earlier PA in this study has similar values with RO-STEMI.

The diagnostic of PA is based on clinical criteria. From this point of view we remained that the diabetic patients which have a lower level of pain is possible to obtain a false negative results for incidence of earlier PA.

The high number of patients with Killip I class is due to the fact that they rapidly come to the hospital. The literature data show that the incidence of earlier PA is highest at patients with Killip III and IV class. In our study the number of patients with Killip III and IV class is lower than in the international trials maybe because the mortality is higher.

In our study the incidence of earlier PA related with the treatment (beta-blokers, ACE-inhibitors, statins, antiagregant, anticoagulant) is similar to the incidence presented in the international trails. The great number of patients that presented in the first 60 minutes on the onset of AMI at hospital is beneficial for the success of the treatment mostly because of the thrombolytic therapy that can be administrated.

5. Conclusion

The results of RO-STEMI database are similar with the ones published in medical international literature. RO-STEMI is the first database which recorded the cardiovascular pathology at the national level. It is necessary to extend this study by including other variables according to the international trials adapted to the Romanian geographic, cultural and socioeconomic particularities.

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JOURNAL
OF
APPLIED
QUANTITATIVE
METHODS

DATA MINING TECHNIQUES IN PROCESSING MEDICAL KNOWLEDGE

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Abstract: *Data mining is an evolving and growing area of research and development, both in academia as well as in industry. It involves interdisciplinary research and development encompassing diverse domains. In this age of multimedia data exploration, data mining should no longer be restricted to the mining of knowledge from large volumes of high-dimensional data sets in traditional databases only. The aim of the paper is to develop a new learning by examples PCA-based algorithm for extracting skeleton information from data to assure both good recognition performances, and generalization capabilities in case of large data set. The classes are represented in the measurement/feature space by continuous repartitions, that is the model is given by the family of density functions* $(f_h)_{h \in H}$*, where H stands for the finite set of hypothesis (classes). The basis of the learning process is represented by samples of possible different sizes coming from the considered classes. The skeleton of each class is given by the principal components obtained for the corresponding sample.*

Key words: *data mining; principal component analysis; fuzzy clustering; c-means algorithm; supervised learning; cluster analysis*

1. Introduction

The last decade has witnessed a revolution in interdisciplinary research where the boundaries of different areas have overlapped or even disappeared. New fields of research emerge each day where two or more fields have integrated to form a new identity. Examples of these emerging areas include bioinformatics (synthesizing biology with computer and information systems), data mining (combining statistics, optimization, machine learning, artificial intelligence, and databases), and modern heuristics (integrating ideas from tens of fields such as biology, immunology, statistical mechanics, and physics to inspire search techniques). These integrations have proved useful in substantiating problem-solving approaches with reliable and robust techniques to handle the increasing demand from practitioners to solve real-life problems.

In the old days, system analysts faced many difficulties in finding enough data to feed into their models. The picture has changed and since databases have grown exponentially, ranging in size into the terabytes within these masses of data being hidden information of strategic importance, the reverse picture becomes a daily problem-how to understand the large amount of data we have accumulated over the years. When there are so many trees, how do we draw meaningful conclusions about the forest? Research into statistics, machine learning, and data analysis has been resurrected. Unfortunately, with the amount of data and the complexity of the underlying models, traditional approaches in statistics, machine learning, and traditional data analysis fail to cope with this level of complexity. The need therefore arises for better approaches that are able to handle complex models in a reasonable amount of time.

The newest answer has been named data mining (sometimes data farming), to distinguish them from traditional statistics, machine learning and other data analysis techniques. In addition, decision makers were not interested in techniques that rely too much on the underlying assumptions in statistical models. The challenge is not to have any assumptions about the model and try to come up with something new, something that is not obvious or predictable (at least from the decision maker's point of view). Notwithstanding, models that are free from assumptions-or at least have minimum assumptions-are expensive to use because of the inherent complexity due to the high dimensionality of the processed data. The dramatic search space cannot be navigated using traditional searching techniques, and his has highlighted a natural demand for the use a special tailored methodology. Data mining is a process that uses a variety of data analysis tools to discover patterns and relationships in data that may be used to make valid predictions.

According to the Gartner Group , "Data mining is the process of discovering meaningful new correlations, patterns and trends by sifting through large amounts of data stored in repositories, using pattern recognition technologies as well as statistical and mathematical techniques".

There are also other definitions:

- "Data mining is the analysis of (often large) observational data sets to find unsuspected relationships and to summarize the data in novel ways that are both understanble and useful to the data owner (Hand, 2001)
- "Data mining is an interdisciplinary field bringing together techniques from machine learning, pattern recognition,statistics,databases,and visualization to address the issue of information extraction from large data bases" (Cabena,1998)

Data mining is an evolving and growing area of research and development, both in academia as well as in industry. It involves interdisciplinary research and development encompassing diverse domains. In this age of multimedia data exploration, data mining should no longer be restricted to the mining of knowledge from large volumes of high-dimensional data sets in traditional databases only. Researchers need to pay attention to the mining of different datatypes, including numeric and alphanumeric formats, text, images, video, voice, speech, graphics, and also their mixed representations. Fuzzy sets provide the uncertainty handling capability, inherent in human reasoning, while artificial neural networks help incorporate learning to minimize error. Genetic algorithms introduce effective parallel searching in the high-dimensional problem space.

2. Cluster analysis

Cluster analysis is a method of grouping data with similar characteristics into larger units of analysis. Since Zadeh, 1965, first articulated fuzzy set theory which gave rise to the concept of partial membership, based on membership functions, fuzziness has received increasing attention. Fuzzy clustering, which produce overlapping cluster partitions, has been widely studied and applied in various area (Bezdek, 1999).

So far, there have been proposed a relatively small number of methods for testing the existence/inexistence of a natural grouping tendency in a data collection, most of them being based on arguments coming from mathematical statistics and heuristic graphical techniques (Panayirci and Dubes,1983, Smith and Jain,1984,Jain and Dubes,1988, Tukey,1977, Everitt,1978).

The data are represented by *p*-dimensional vectors, $X=\left(x_1,...,x_p\right)^t$, whose components are the feature values of a specified attributes and the classification is performed against a certain given label set. The classification of a data collection $\aleph=\left\{X_1,...,X_n\right\}\subset\Re^p$ corresponds to a labelling strategy of the objects of $\aleph$.

In the fuzzy approaches, the clusters are represented as fuzzy sets $\left(u_i,1\le i\le c\right)$, $u_i:\aleph\to\left[0,1\right]$, where $u_{ik}=u_i\left(X_k\right)$ is the membership degree of X_k to the *i*-th cluster, $1\le i\le c$, $1\le k\le n$. A c-fuzzy partition is represented by the matrix $U=\left\|u_{ik}\right\|\in M_{c\times n}$. The number of labels *c* has to be selected in advance, the problem of finding the optimal *c* is usually referred as cluster validation.

The main types of label vectors are *crisp* N_c, *fuzzy* N_p, *and possibilistic* N_{poz}, defined as follows,

$$N_c=\left\{y\mid y\in\Re^c, y=\left(y_1,y_2,...,y_c\right), y_i\in\{0,1\}, 1\le i\le c, \sum_{i=1}^{c}y_i=1\right\}=\{e_1,e_2,...,e_c\}, \quad (1)$$

where $$\left(e_i\right)_j=\delta_{ij}=\begin{cases}0, i\ne j\\ 1, i=j\end{cases} \quad (2)$$

$$N_p=\left\{y\in\Re^c\mid y=\left(y_1,y_2,...,y_c\right),\forall i, y_i\in[0,1], \quad \sum_{i=1}^{c}y_i=1\right\}, \quad (3)$$

$$N_{poz}=\left\{y\in\Re^c\mid y=\left(y_1,y_2,...,y_c\right),\forall i, y_i\in[0,1], \quad \exists j, y_j\ne 0\right\}, \quad (4)$$

Obviously, $N_{pos}\supset N_p\supset N_c$. If we denote by $U=\left[U_1,...,U_n\right]=\left\|u_{ij}\right\|$ a partition of $\aleph$, then, according to the types of label vectors, we get the *c*-partition types M_{pos}, M_p and M_c,

$$M_{pos}=\left\{U\mid U\in M_{c\times n}, U=\left[U_1,...,U_n\right], \forall k, U_k\in N_{pos,} \forall i, \sum_{k=1}^{n}u_{ik}>0\right\} \quad (5)$$

$$M_p=\left\{U\middle|U\in M_{pos},\forall k,U_k\in N_p\right\} \quad (6)$$

$$M_c=\left\{U\middle|U\in M_p,\forall k,U_k\in N_c\right\} \quad (7)$$

Note that $M_c\subset M_p\subset M_{pos}$.

3. C-MEANS model

The *C-MEANS* algorithm is the most popular non-hierarchical iterative clustering algorithm. When it is applied on a set of data $\aleph = \{X_1, ..., X_n\} \subset \Re^p$ the c-means finds some of the most natural c-groups exiting in data.

C-Means Clustering Algorithm

(1) Choose *c* cluster centers to coincide with *c* randomly-chosen patterns or *c* randomly defined points inside the hypervolume containing the pattern set.
(2) Assign each pattern to the closest cluster center according to a certain pre-specified metric or dissimilarity measure.
(3) Recompute the cluster centers using the current cluster memberships.
(4) If a convergence criterion is not met, go to step 2.
else the computation is over and the current clusters correspond to the c- groups identified by the algorithm in the data.

Typical convergence criteria are: no (or minimal) reassignment of patterns to new cluster centers, or minimal decrease in squared error.

Several variants (Anderberg, 1973) of the c-means algorithm have been reported in the literature. Some of them attempt to select a good initial partition so that the algorithm is more likely to find the global minimum value.

In fuzzy clustering, the fuzzy c-means clustering algorithms are the best know and most powerful methods used in cluster analysis (Bezdek, 1981).

The variational problem corresponding to *c-means* model is given by

$$\min_{(U,V)} \{J_m(U,V;w)\} \qquad (8)$$

where

$$J_m(U,V;w) = \sum_{i=1}^{c}\sum_{k=1}^{n} u_{ik}^m D_{ik}^2 + \sum_{i=1}^{c} w_i \sum_{k=1}^{n} (1-u_{ik})^m$$

$U \in M_c / M_p / M_{pos}$, $V = (v_1, ..., v_c) \in M_{c\times p}$, v_i is the centroid of the *i*-th cluster, $w = (w_1, .., w_c)^T$ is the penalties vector corresponding to the cluster system, $m \geq 1$ is the fuzzyfication degree, and $D_{ik}^2 = \|x_k - v_i\|^2$.

Let us denote by $(\hat{U}, \hat{V})$ a solution of (8). Then,

1. The crisp model:

$$(U,V) \in M_c \times M_{c\times p}; w_i = 0, 1 \leq i \leq c, \; \hat{u}_{ik} = \begin{cases} 1, D_{ik} \leq D_{ij}, i \neq j \\ 0, \text{otherwise} \end{cases} \qquad (9)$$

$$\hat{v}_i = \frac{\sum_{k=1}^{n} \hat{u}_{ik} x_k}{\sum_{k=1}^{n} \hat{u}_{ik}}; \quad 1 \leq i \leq c, 1 \leq k \leq n \qquad (10)$$

2. The fuzzy model:

$$(U,V) \in M_p \times M_{c\times p}; m > 1, w_i = 0, 1 \leq i \leq c$$

$$\hat{u}_{ik} = \left[\sum_{j=1}^{c} \left(\frac{D_{ik}}{D_{jk}} \right)^{\frac{2}{m-1}} \right]^{-1} \quad (11)$$

$$\hat{v}_i = \frac{\sum_{k=1}^{n} u_{ik}^m x_k}{\sum_{k=1}^{n} u_{ik}^m}; \quad 1 \le i \le c, 1 \le k \le n \quad (12)$$

3. The possibilistic model:

$(U,V) \in M_{pos} \times M_{c \times p}; \forall i, w_i > 0$

$$\hat{u}_{ik} = \left[1 + \left(\frac{D_{ik}^2}{w_i} \right)^{\frac{1}{m-1}} \right]^{-1}$$

$$\hat{v}_i = \frac{\sum_{k=1}^{n} u_{ik}^m x_k}{\sum_{k=1}^{n} u_{ik}^m}; \quad 1 \le i \le c, 1 \le k \le n \quad (13)$$

The general scheme of a cluster procedure $\wp$ is ,

$t \leftarrow 0$

repeat

$t \leftarrow t+1$

$U_t \leftarrow F_{\wp}(V_{t-1})$

$V_t \leftarrow G_{\wp}(U_{t-1})$

$until(t = T or \|V_t - V_{t-1}\| \le \varepsilon)$

$(U,V) \leftarrow (U_t, V_t)$

where c is the given number of clusters, *T* is upper limit on the number of iterations, *m* is the weight parameter, $1 \le m < \infty$, C is the terminal condition, w is the system of weights $\forall i, w_i > 0$, $V_0 = (v_{1,0}, ..., v_{c,0}) \in M_{c \times p}$ is the initial system of centroids and $F_{\wp}$, $G_{\wp}$ are the updating functions.

4. PCA-based algorithm for extracting skeleton information

In the following a new learning by examples PCA-based algorithm for extracting skeleton information from data to assure both good recognition performances, and generalization capabilities, is developed. Here the generalization capabilities are viewed twofold, on one hand to identify the right class for new samples coming from one of the classes taken into account and, on the other hand, to identify the samples coming from a new class. The classes are represented in the measurement/feature space by continuous repartitions, that is the model is given by the family of density functions $(f_h)_{h \in H}$, where *H* stands for the finite set of hypothesis (classes).

The basis of the learning process is represented by samples of possible different sizes coming from these classes. The skeleton of each class is given by the principal components obtained for the corresponding sample. The recognition algorithm identifies the class whose skeleton is the "nearest" to the tested example, where the closeness degree is expressed in terms of the amount of disturbance determined by the decision of allotting it to the corresponding class. The model is presented as follows. Let $X_1, X_2, ..., X_N$ be a series of *n*-dimensional vectors coming from a certain class C. The sample covariance matrix is

$$\Sigma_N = \frac{1}{N-1}\sum_{i=1}^{N}(X_i - \mu_N)(X_i - \mu_N)^T \,, \tag{14}$$

where $\mu_N = \frac{1}{N}\sum_{i=1}^{N} X_i$.

We denote by $\lambda_1^N \geq \lambda_2^N \geq ... \geq \lambda_n^N$ the eigen values and by $\psi_1^N, ..., \psi_n^N$ a set of orthonormal eigen vectors of Σ_N .

If X_{N+1} is a new sample, then, for the series $X_1, X_2, ..., X_N, X_{N+1}$, we get

$$\Sigma_{N+1} = \Sigma_N + \frac{1}{N+1}(X_{N+1} - \mu_N)(X_{N+1} - \mu_N)^T - \frac{1}{N}\Sigma_N \tag{15}$$

The computation can be carried out as follows.

$$\mu_{N+1} = \frac{1}{N+1}\sum_{i=1}^{N+1} X_i = \frac{N}{N+1}\mu_N + \frac{1}{N+1}X_{N+1}$$

$$\Sigma_{N+1} = \frac{1}{N}\sum_{i=1}^{N+1}(X_i - \mu_{N+1})(X_i - \mu_{N+1})^T =$$

$$= \frac{1}{N}\sum_{i=1}^{N}(X_i - \mu_{N+1})(X_i - \mu_{N+1})^T + \frac{1}{N}(X_{N+1} - \mu_{N+1})(X_{N+1} - \mu_{N+1})^T$$

Obviously,

$$\frac{1}{N}(X_{N+1} - \mu_{N+1})(X_{N+1} - \mu_{N+1})^T = \frac{1}{N}\left(\frac{N}{N+1}\right)^2 (X_{N+1} - \mu_N)(X_{N+1} - \mu_N)^T$$

For each $1 \leq i \leq N$, we have

$$X_i - \mu_{N+1} = X_i - \frac{N}{N+1}\mu_N - \frac{1}{N+1}X_{N+1} = X_i - \mu_N + \frac{1}{N+1}\mu_N - \frac{1}{N+1}X_{N+1}$$

Hence, taking into account that $\sum_{i=1}^{N}(X_i - \mu_N) = 0$

$$\frac{1}{N}\sum_{i=1}^{N}(X_i - \mu_{N+1})(X_i - \mu_{N+1})^T = \frac{1}{N}\sum_{i=1}^{N}\left(X_i - \mu_N + \frac{1}{N+1}\mu_N - \frac{1}{N+1}X_{N+1}\right)\left(X_i - \mu_N + \frac{1}{N+1}\mu_N - \frac{1}{N+1}X_{N+1}\right)^T =$$

$$= \frac{N-1}{N}\Sigma_N + \frac{1}{N(N+1)}\sum_{i=1}^{N}(X_i - \mu_N)(\mu_N - X_{N+1})^T + \frac{1}{N(N+1)}\sum_{i=1}^{N}(\mu_N - X_{N+1})(X_i - \mu_N)^T +$$

$$+\left(\frac{1}{N+1}\right)^2(\mu_N - X_{N+1})(\mu_N - X_{N+1})^T = \frac{N-1}{N}\Sigma_N + \left(\frac{1}{N+1}\right)^2(\mu_N - X_{N+1})(\mu_N - X_{N+1})^T$$

Therefore, we finally obtain.

$$\Sigma_{N+1}=\frac{N-1}{N}\Sigma_N+\left(\frac{1}{N+1}\right)^2(\mu_N-X_{N+1})(\mu_N-X_{N+1})^T+\frac{1}{N}\left(\frac{N}{N+1}\right)^2(X_{N+1}-\mu_N)(X_{N+1}-\mu_N)^T=$$
$$=\frac{N-1}{N}\Sigma_N+\frac{1}{N+1}(X_{N+1}-\mu_N)(X_{N+1}-\mu_N)^T$$

Lemma. In case the eigen values of $\mathbf{\Sigma}_N$ are distinct, the following first order approximations hold, (State, Cocianu & al., 2006)

$$\lambda_i^{N+1}=\lambda_i^N+\left(\boldsymbol{\psi}_i^N\right)^T\Delta\mathbf{\Sigma}_N\boldsymbol{\psi}_i^N=\left(\boldsymbol{\psi}_i^N\right)^T\mathbf{\Sigma}_{N+1}\boldsymbol{\psi}_i^N \quad (16)$$

$$\boldsymbol{\psi}_i^{N+1}=\boldsymbol{\psi}_i^N+\sum_{\substack{j=1\\ j\neq i}}^{n}\frac{\left(\boldsymbol{\psi}_N^j\right)^T\Delta\mathbf{\Sigma}_N\boldsymbol{\psi}_i^N}{\lambda_i^N-\lambda_j^N}\boldsymbol{\psi}_j^N \quad (17)$$

The skeleton of C is represented by the set of estimated principal components $\psi_1^N,\dots,\psi_n^N$ .When the example X_{N+1} is included in C, then the new skeleton is $\psi_1^{N+1},\dots,\psi_n^{N+1}$. The skeleton disturbance induced by the decision that X_{N+1} has to be alloted to C is measured by

$$D=\frac{1}{n}\sum_{k=1}^{n}d\left(\psi_k^N,\psi_k^{N+\prime}\right) \quad (18)$$

where $d\left(\psi_k^N,\psi_k^{N+\prime}\right)=\left(\sum_{j=1}^{N}\left(\psi_{kj}^N-\psi_{kj}^{N+1}\right)^2\right)^{\frac{1}{2}}$

The crisp classification procedure identifies for each example the closest cluster in terms of the measure (18). Let $H=\{C_1,C_2,\dots,C_M\}$. In order to protect against misclassifications of samples coming from new classes not belonging to *H*, a threshold *T*>0 is imposed, that is the example X_{N+1} is alloted to one of C_i for which

$$D=\frac{1}{n}\sum_{k=1}^{n}d\left(\psi_{k,j}^N,\psi_{k,j}^{N+1}\right)=\min_{1\le p\le M}\frac{1}{n}\sum_{k=1}^{n}d\left(\psi_{k,p}^N,\psi_{k,p}^{N+1}\right) \quad (19)$$

and *D*<*T*, where the skeleton of C_j is $\psi_{1,j}^N,\dots,\psi_{n,j}^N$.

The classification of samples for which the resulted value of *D* is larger than *T* is postponed and the samples are kept in a new possible class CR. The reclassification of elements of CR is then performed followed by the decision concerning to either reconfigure the class system or to add CR as a new class in *H*.

In case of fuzzy classification, the value of the membership degree of X_{N+1} to each cluster of $HT=H\cup\{CR\}$ is computed as follows. Let $d(X_{N+1},C_i)=\frac{1}{n}\sum_{k=1}^{n}d\left(\psi_{k,i}^N,\psi_{k,i}^{N+1}\right)$, $1\le i\le M$ and

$d(X_{N+1},CR)=\begin{cases}\frac{1}{n}\sum_{k=1}^{n}d\left(\psi_{k,R}^N,\psi_{k,R}^{N+1}\right), \text{if } CR\neq\varnothing\\ \infty, \text{otherwise}\end{cases}$, where the skeleton of *CR* is represented by the set of estimated principal components $\psi_{1,R}^N,\dots,\psi_{n,R}^N$.

$$\mu_{C_i}(X_{N+1})=1-\frac{d(X_{N+1},C_i)}{S},\ 1\le i\le M \quad (20)$$

$$\mu_{CR}(X_{N+1}) = \begin{cases} 1 - \dfrac{d(X_{N+1}, CR)}{S}, \text{ if } d(X_{N+1}, CR) \neq \infty \\ 0, \text{ otherwise} \end{cases} \quad (21)$$

where

$$S = \begin{cases} \sum_{C \in HT} d(X_{N+1}, C), \text{ if } d(X_{N+1}, CR) \neq \infty \\ \sum_{C \in H} d(X_{N+1}, C), \text{ if } d(X_{N+1}, CR) = \infty \end{cases} \quad (22)$$

5. Experimental results and concluding remarks

Several tests were performed on simulated data and they pointed out very successful performance of the proposed classification strategy.

A series of tests were performed on 4-dimensional simulated data coming from 5 clases each of them having 50 examples. Each class consists of Gaussian data (State, Cocianu &al., 2006)

The classification criterion is: allote X_{N+1} to C_{j_i} if

$$D = \min_{1 \le l \le t} \frac{1}{m_{j_l}} \sum_{k=1}^{m_{j_l}} d\left(\psi_{j_l}^{k}, \psi_{j_l, N+1}^{k}\right) \quad (23)$$

In order to evaluate the generalization capacities, 100 new examples were generated for each distribution. The results are presented in Table 1. (State, Cocianu &al., 2006)

The evaluation of the generalization capacities in case of examples coming from new classes was performed on 1000 samples generated from N(μ, Σ), where $\mu =$ [0 11 -9 -9.5] and

$$\Sigma = \begin{bmatrix} 8.2725 & 3.1080 & 1.7925 & 1.3680 \\ 3.1080 & 6.8986 & 1.8390 & 2.5561 \\ 1.7925 & 1.8390 & 6.0422 & 1.6410 \\ 1.3680 & 2.5561 & 1.6410 & 5.2261 \end{bmatrix}.$$

The admissibility criterion for allotting a sample to a certain class is given by the maximum value of D corresponding to correct classifications. The results showed that about 975 examples were classified in CR, that is the algorithm managed to detect the intruded examples. (State, Cocianu &al., 2006)

Table 1. Results on new simulated examples

Class	C_1	C_2	C_3	C_4	C_5
Number of correct classified examples	100	100	96	99	100
Number of missclassified examples	0	0	4 - allotted to C_2	1 – allotted to C_1	0
The mean value of D in case of correct classifications	0.08	0.05	0.75	0.21	0.14
The maximum value of D in case of correct classified examples	0.41	0.19	1.85	0.55	0.53

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Key words: fuzzy; choice functions; Irina GEORGESCU

Book Review on
"FUZZY CHOICE FUNCTIONS – A REVEALED PREFERENCE APPROACH"
by Irina GEORGESCU
Published in *"Studies in Fuzziness and Soft Computing"*, Springer, 2007

The monograph "Fuzzy Choice Functions – A Revealed Preference Approach", written by Dr. Irina Georgescu from the Academy of Economic Studies, Bucharest, Romania, and appeared in Studies in Fuzziness and Soft Computing, Vol. 214, 2007, Springer, ISBN 978-3-540-68997-3, started as a PhD thesis, supervised by Professor Christer Carlsson from Turku Centre for Computer Science, Institute for Advanced Management Systems Research, Abo Akademi University, Turku, Finland.

As mentioned in the Introduction, it has the following goals: to develop the main topics of revealed preference theory (rationality, revealed preference, congruence, consistency) for a large class of fuzzy choice functions, to explore new topics (degree of dominance, similarity, indicators of rationality) specific to a fuzzy approach to choice functions and to show the manner in which some problems of multicriterial decision making problems can find natural solutions in fuzzy revealed preference theory.

The book has eleven chapters: Introduction, Preliminaries, Classical Revealed Preference Theory, Fuzzy Preference Relations, Fuzzy Choice Functions, Fuzzy Revealed Preference and Consistency Conditions, General Results, Degree of Dominance, Similarity and Rationality Indicators for Fuzzy Choice Functions, Applications, Concluding Remarks and a rich bibliography of 120 titles.

As mentioned in Concluding Remarks, the contribution of the book consists in the following: (1) it is a theoretical framework for a fuzzy revealed preference theory different of that of Banerjee's; the author develops the fuzzy version of the direction Uzawa-Arrow-Sen. (2) The treatment, in this general framework, of the main topics of revealed preference theory such as rationality, revealed preference and congruence axioms, consistency conditions; the statement of various conditions and results, as well their proofs, is not a simple translation of the situations from the case of crisp choice functions; sometimes, a crisp property has many different fuzzy versions. (3) The definition of the degree of dominance of an alternative as a tool in obtaining the hierarchy of alternatives according to different criteria, where the criteria can be taken as the available sets of alternatives. (4) The definition of new concepts, as similarity and the indicators of fuzzy choice functions are introduced for obtaining a deeper insight on fuzzy revealed preference theory. (5) The analysis of the three applications of Chapter 8 describing concrete economic situations led to the conclusions that the mathematical modeling is done by formulating some fuzzy choice problems, where criteria are represented by fuzzy available sets of alternatives, and that the degree of dominance is the mathematical instrument on which the algorithms of multicriterial hierarchy are based.

The text is reasonably self-contained, but previous knowledge of revealed preference and fuzzy set theory is helpful for the reader.

The book is addressed to economists – social choice theorists- and to computer scientists, who can find in it a stimulating material for further research and concrete applications.

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The main publications in the last five years are:

Iorgulescu, A., **On BCK algebras - Part II: New algebras. The ordinal sum (product) of two bounded BCK algebras,** Soft Computing, 2007

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