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Contents

THE APPLICATION OF MIXTURE MODELING AND INFORMATION CRITERIA FOR DISCOVERING PATTERNS OF CORONARY HEART DISEASE

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Abstract: This paper's purpose is twofold: first it addresses the adequacy of some theoretical information criteria when using finite mixture modelling (unsupervised learning) on discovering patterns in continuous data; second, we aim to apply these models and BIC to discover patterns of coronary heart disease. In order to select among several information criteria, which may support the selection of the correct number of clusters, we conduct a simulation study, in order to determine which information criteria are more appropriate for mixture model selection when considering data sets with only continuous clustering base variables. As a result, the criterion BIC shows a better performance, that is, it indicates the correct number of the simulated cluster structures more often. When applied to discover patterns of Coronary Heart Disease, it performed well, discovering the known pattern of data.

Key words: Quantitative Methods; Unsupervised Learning; Finite Mixture Models; Patterns in Continuous Data; Theoretical Information Criteria; Simulation experiments; Coronary Heart Disease

1. Introduction

As a technique of intelligent data mining, Finite mixture models (FMM) has proven to be a powerful tools for clustering analysis, namely in the domain of social, human and behavioural science data, (Dias and Willekens 2005), and in particular in segmentation, (Punj and Stewart 1983), (Fonseca and Cardoso 2007b). There have been numerous proposals of information criteria for the selection of the number of clusters (model selection) of FMM.

The main goal of this research is to address the performance of specific theoretical information criteria for mixture modelling selection, when dealing with the *continuous* clustering base variables. A simulation study is conducted for this purpose which results may help to support future analysts' decisions concerning the choice of particular information criteria when dealing with specific clustering applications. Mainly, we want to know which criterion we should select in advance, knowing that clustering base variables are continuous.

This paper is organized as follows: in section 2, we define notation and review finite mixture models, and previous work on the EM algorithm for the estimation of mixture models; in section 3, we review several model selection criteria proposed to estimate the number of clusters of a mixture structure; in section 4, we present the proposed simulation based approach to compare the performance of eleven information criteria; in section 5 we report on simulation results, and finally, in section 6 we present some concluding remarks, about BIC and Coronary Heart Disease application.

2. Clustering via Mixture Models

For illustrating the use of mixture models in the field of cluster analysis, see for instance (McLachlan and Peel 2000), (McLachlan 1997), (Figueiredo and Jain 2002). FMM assume that parameters of a statistical model of interest differ across unobserved or latent clusters and they provide a useful means for clustering observations. In FMM, clustering base variables are assumed to be described by a different probability distribution in each latent cluster. These probability functions typically belong to the same family and differ in the corresponding parameters' values.

This approach to clustering offers some advantages when compared with other techniques: provides unbiased clusters memberships' estimates and consistent estimates for the distributional parameters, (Dillon and Kumar 1994); it provides means to select the number of clusters, (McLachlan and Peel 2000); it is able to deal with diverse types of data (different measurement levels), (Vermunt and Magidson 2002). In order to present FMM we give some notation below (Table 1).

The mixture model approach to clustering assumes that data are from a mixture of an unknown number S of clusters in some unknown proportions, $\lambda_1, \cdots, \lambda_S$. The data $\underline{y} = (\underline{y}_1, ..., \underline{y}_n)$ are assumed to be a p-dimensional sample of size *n*, from a probability distribution with density

$$f(\underline{y}_i \mid \underline{\psi}) = \sum_{s=1}^{S} \lambda_S \; f_S(\underline{y}_i \mid \underline{\theta}_S), \tag{1}$$

where the mixing probabilities satisfy

$$\lambda_S \geq 0 \text{, s = 1, ..., S, and } \sum_{s=1}^{S} \lambda_S = 1 \tag{2}$$

Table 1. Notation

n	sample size
S	number of (unknown) segments
$(Y_1, \cdots, Y_P)$	P segmentation base variables (random variables)
$(\underline{y}_1, \cdots, \underline{y}_n)$	measurements on variables $Y_1, \cdots, Y_p$
$\underline{y}_i$	measurements vector of individual *i* on variables $Y_1, \cdots, Y_p$
$\underline{z} = (\underline{z}_1, ..., \underline{z}_n)$	segments-label vectors
$\underline{z}_i = (z_{i1}, ..., z_{iS})$	binary vector indicating segment membership
$\underline{x} = (\underline{y}, \underline{z})$	complete data

p(d)f	probability (density) function
$\underline{\theta}_s$	vector of all unknown p(d)f parameters of the s^{th} segment
$\Theta = (\underline{\theta}_1 ... \underline{\theta}_S)$	vector of mixture model parameters, without weights
$\underline{\lambda} = (\lambda_1, \cdots, \lambda_{S-1})$	vector of weights (mixing proportions)
τ_{is}	probability that an individual i belongs to the $\underline{s}^{th}$ segment, given
$\underline{\psi} = (\underline{\lambda}, \Theta)$	vector of all unknown mixture model parameters
$\hat{\underline{\psi}} = (\hat{\underline{\lambda}}, \hat{\Theta})$	estimate of the vector of all unknown parameters
L	likelihood function, L(ψ)
LL	log-likelihood function, log L(ψ)
LL_c	complete-data log-likelihood function
n_ψ	number of mixture model parameters

The complete set of parameters we need to estimate, to specify the mixture model is

$$\underline{\psi} = \{\underline{\lambda}, \Theta\},\ \underline{\lambda} = \{\lambda_1, \cdots, \lambda_{S-1}\},\ \text{and}\ \ \Theta = \{\underline{\theta}_1, \cdots, \underline{\theta}_S\}.$$

The log-likelihood function for the parameters is

$$\log\ L(\underline{\psi}) = \sum_{i=1}^{n} \log \sum_{s=1}^{S} \lambda_S \quad f_S(\underline{y}_i \mid \underline{\theta}_S) \tag{3}$$

When dealing with Mixture Models for clustering purposes, we may define each *complete data* observation, $\underline{x}_i = (\underline{y}_i, \underline{z}_i)$, as having arise from one of the clusters of the mixture (1). Values of clustering base variables $\underline{y}_i$ are then regarded as being incomplete data, augmented by segment-label variables, z_{iS}, that is, $\underline{z}_i = (z_{i1}, ..., z_{iS})$ is the unobserved portion of the data; z_{iS} are binary indicator latent variables, so that $z_{iS} = (z_i)s$ is 1 or 0, according as to whether $\underline{y}_i$ belongs or does not belong to the s^{th} segment, for *i* = 1,…,n, and s = 1, …S.

Assuming that $\{\underline{Z}_i\}$ are independent and identically distributed, each one according to a multinomial distribution of S categories with probabilities $\lambda_1, \cdots, \lambda_S$, the complete-data log-likelihood to estimate ψ, if the complete data $\underline{x}_i = (\underline{y}_i, \underline{z}_i)$ was observed, (McLachlan and Krishnan 1997), is

$$\log L_c(\underline{\psi}) = \sum_{i=1}^{n} \sum_{s=1}^{S} z_{iS} \{\log f_S(\underline{y}_i \mid \underline{\theta}_S) + \log \lambda_S\} \tag{4}$$

With the maximum likelihood approach to the estimation of $\underline{\psi}$, an estimate is provided by a suitable root of the likelihood equation

$$\frac{\partial \log L(\underline{\psi})}{\partial \underline{\psi}} = \mathbf{O} \tag{5}$$

Fitting finite mixture models (1) provides a probabilistic clustering of the n entities in terms of their posterior probabilities of membership of the S clusters of the mixture of

distributions. Since the ML estimates of most of the latent segment model (1) cannot be found analytically, estimation of FMM iteratively computes the estimates of clusters posterior probabilities and updates the estimates of the distributional parameters and mixing probabilities, (Kim, Street, and Menezer 2002).

Expectation-maximization (EM) algorithm, (Dempster, Laird, and Rubin 1977), is a widely used class of iterative algorithms for ML estimation in the context of incomplete data, e.g. fitting mixture models to observed data.

Since, typically with mixture model approach, the likelihood surface is known to have many local maxima the selection of suitable starting values for the EM algorithm is crucial, (Biernacki, Celeux, and Govaert 2003) or (Karlis and Xekalaki 2003). Therefore, it is usual to obtain several values of the maximized log-likelihood for each of the different sets of initial values applied to the given sample, and then consider the maximum value as the solution. Also, in order to prevent boundary solutions, the EM implementation may recur to maximum a posteriori estimates.

3. Model selection

Selecting FMM structures may rely on multiple information criteria, like, for instance, BIC, ICOMP, AIC, which turns opportune the specific issue concerning the selection among several criteria themselves.

Table 2. Some information criteria for model selection on Latent Segment Models

Criteria	Definition	Author
AIC	$-2LL + 2n_{\underline{\psi}}$	(Akaike 1973)
AIC3	$-2LL + 3n_{\underline{\psi}}$	(Bozdogan 1994)
AICc	$AIC + (2n_{\underline{\psi}}(n_{\underline{\psi}}+1))/(n-n_{\underline{\psi}}-1)$	(Hurvich and Tsai 1989)
AICu	$AICc + n\log(n/(n-n_{\underline{\psi}}-1))$	(McQuarrie, Shumway, and Tsai 1997)
CAIC	$-2LL + n_{\underline{\psi}}(1+\log n)$	(Bozdogan 1987)
BIC/MDL	$-2LL + n_{\underline{\psi}}\log n$	(Schwarz 1978) / (Rissanen 1978)
CLC	$-2LL + 2EN(S)$	(Biernacki 1997)
ICL_BIC	$BIC + 2EN(S)$	(Biernacki, Celeux, and Govaert 2000)
NEC	$NEC(S) = EN(S)/(L(S)-L(1))$	(Biernacki, Celeux, and Govaert 1999)
AWE	$-2LL_c + 2n_{\underline{\psi}}(3/2+\log n)$	(Banfield and Raftery 1993)
L	$-LL + (n_{\underline{\psi}}/2)\sum\log(n\lambda_S/12) + S/2\log(n/12) + S(n_{\underline{\psi}}+1)/2$	(Figueiredo and Jain 2002)

On the other hand, applications are common in the clustering domain, which refer to clustering base variables; also the criterion selection could be based on convergence property. In the present study we propose an approach for evaluating several (see table 2) information criteria's performances, taking into account theirs relationship with continuous

clustering base variables. Information criteria all balance fitness, trying to maximize the likelihood function, and parsimony, by using penalties associated with measures of model complexity, trying to avoid overfit. The general form of information criteria is as follows

$$-2\log L(\hat{\psi}) + C, \tag{6}$$

where the first term is the negative logarithm of the maximum likelihood which decreases when the model complexity increases; the second term or penalty term penalizes too complex models, and increases with the model number of parameters. Thus, the selected FMM should evidence a good trade-off between good description of the data and the model number of parameters.

AIC (Akaike 1973) and AIC_3 (Bozdogan 1994) are measures of model complexity associated with some criteria (see table 2) that only depend on the number of parameters; some other measures depend on both the number of parameters and the sample size, as AICc (Hurvich and Tsai 1989), AICu (McQuarrie, Shumway, and Tsai 1997), CAIC (Bozdogan 1987), and BIC/MDL (Schwarz 1978) / (Rissanen 1978) ; others depend on entropy, as CLC (Biernacki 1997), and NEC (Biernacki, Celeux, and Govaert 1999); some of them depend on the number of parameters, sample size, and entropy, as ICL-BIC (Biernacki, Celeux, and Govaert 2000) , and AWE (Banfield and Raftery 1993) ; L (Figueiredo and Jain 2002) depends on the number of parameters, sample size and mixing proportions, λ_S .

4. Methodology

Several model selection criteria have been used in order to decide on the number of clusters that are present in data, when *a priori* knowledge does not exist, such as graphical techniques, likelihood ratio tests and theoretical information criteria. This work specifically refers to information criteria presented in table 2, which have been referred previously. This issue is in limelight, because there is no indication concerning the selection of the information criteria themselves, in a certain application, (Fonseca and Cardoso 2007). In this paper we try to establish a relationship between type of clustering variables - continuous - and the performance of information-based criteria. We also illustrate other factors that may influence the outcome, such as clusters' separation and sample size. When we have a mixture of normal components ($1 \le s \le S$), the probability (density) function of an observation $\underline{y}_i$, conditional on entity *i* belonging to segment *s*, is given by

$$f_s(\underline{y}_i \mid \underline{\psi}) = \frac{1}{(2\pi)^{p/2} \mid \Sigma_s \mid^{1/2}} \exp\left(-\frac{1}{2}(\underline{y}_i - \underline{\mu}_s)^{\mathrm{T}} \Sigma_s^{-1} (\underline{y}_i - \underline{\mu}_s)\right) \tag{7}$$

Here, $\underline{\psi} = \{\underline{\lambda}, \underline{\theta}_S\}$, with $\underline{\theta}_S = (\underline{\mu}_S, \Sigma_S)$, the elements of components means, $\underline{\mu}_S$, and the distinct elements of the segment-covariance matrices Σ_S, s = 1,...S. To evaluate the performance of the information criteria presented in Table 2 and robustness across experimental conditions, a simulation study is conducted. Because special care needs to be taken before arriving at conclusions based on simulations results, we performed some replications within each cell. The experimental design controls the number of variables, the number of clusters, the sample size, and the number of distributions; thus, data sets were simulated with two levels (*p* = 2 and *p* = 4) of clustering base variables, two levels of clusters (S = 2 and S = 4), three different distributions, and three levels of sample size (100,

500 and 2000); the simulation plan uses a $2^2 \times 3^2$ factorial design with 36 cells (see table 3). For S = 2, we fixed the missing proportions at $\lambda_1 = 0.3$ and $\lambda_2 = 0.7$; for S = 4 we fixed the missing proportions at $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0.25$. Within each cell 5 data sets were generated, so we work with 180 samples.

Table 3. Factorial design for continuous variables

Y_i	S	n	Number of Distributions	Factorial design
2; 4	2; 4	100; 500 2000	3	
2	2	3	3	2^2*3^2

In order to avoid local optima in the generated FMM estimation process, the EM algorithm is repeated 50 times with random starting centres, and the best solution for ML and model selection results are kept, with a tolerance level of 10^{-6} (the criterion for convergence of EM: difference between log-likelihood being smaller than 10^{-6}).

5. Results of simulated experiments

Table 4 shows the percentage of cases (simulated experiments) each criterion determines the original (*true*) number of segments (*fit*), across the used factors, the overall percentages *underfit* (percentage of times each criterion selects a model with a few number of segments), and *overfit* (percentage of times each criterion selects a model with a high number of segments).

The best performance goes to BIC (overall 93%), followed by AIC_3 (overall 89%) and AICu (overall 88%). AIC_3 also performs very well, yielding the best performances when sample size decreases (85% for n = 100, against BIC 80%) and when the segment's number and variables' number increases (87% for S = 4 and p = 4, against BIC's 80%). Moreover, BIC only *overfits* and *underfits* on 1% and 6% of the times, respectively. As we could expect, other criteria, such as ICL-BIC, NEC, L, and AWE, almost never overfit; instead, they underfit a lot of time.

Concerning sample size BIC (80%) is outperformed by AIC_3 (85%), only when n = 100.

Table 4. Simulation results for continuous experiments

		BIC	AIC	AIC3	AICc	AICu	CAIC	CLC	ICL-	NEC	L	AWE
Overall	*Fit*	**93**	63	89	71	88	85	67	74	56	75	64
	Underfit	6	1	5	3	8	14	15	24	43	24	36
	Overfit	**1**	36	6	26	4	1	18	2	1	1	0
Sample size	*100*	80	72	85	83	77	69	45	65	51	55	49
	500	100	61	99	67	99	99	83	79	57	75	69
	2000	87	63	81	60	87	83	76	71	52	84	71

Number of seg./variables	2 P=2	98	70	93	78	83	93	76	80	81	90	83
	2 P=4	100	53	98	67	100	100	78	98	93	100	93
	4 P=2	73	67	73	64	67	62	49	31	4	29	13
	4 P=4	80	40	87	58	73	76	42	76	18	49	44

As far as the number of segments and variables number is concerned, BIC (80%) is only outperformed by AIC_3 (87%). Nevertheless the number of variables and sample size, the simulation experiment results show that information criteria BIC is quite effective for FMM with continuous clustering base variables, in order to select the *true* model.

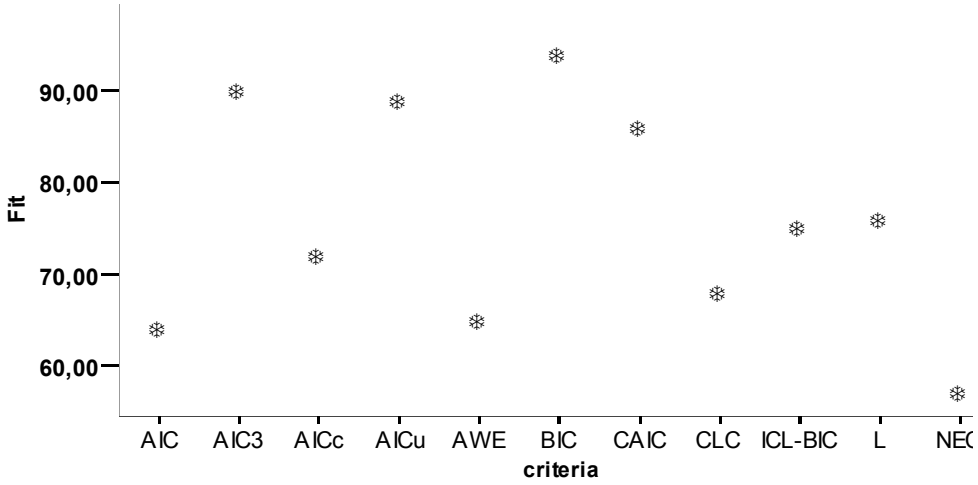

Figure 1. The true number of segments recovery (Fit), in percent

Figures 1, 2, and 3 show the percentage of cases (simulated experiments) each criterion determines the original (*true*) number of segments (*fit*), across the used factors, and also the overall percentages *overfit* ,and *underfit* respectively.

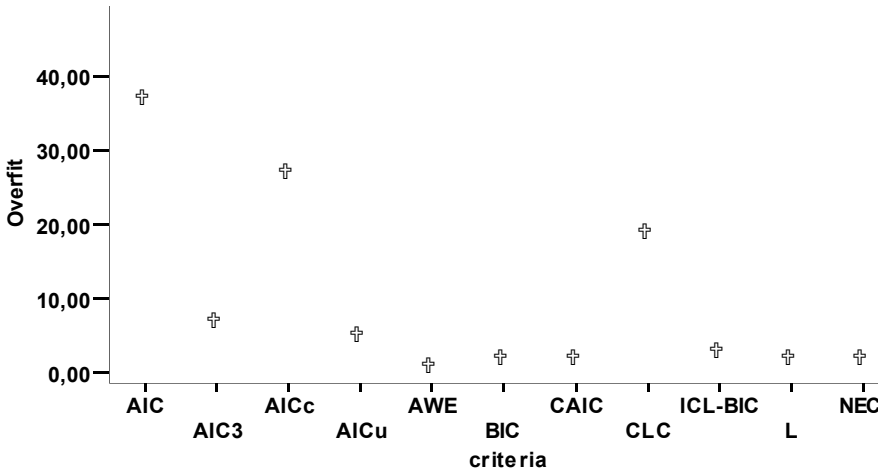

Figure 2. Criteria selecting models with more segments (overfit), in percent

As we can see from figure 2 (criteria select models with more segments, in %), AIC is the criterion which *overfits* more often, followed by AICc and CLC. Figure 3 (criteria select models with less segments, in %) shows that AIC almost never *underfits*; next, we have AIC_3, AICu and AICc; we also can see that BIC almost never *underfits* on normal multivariate models.

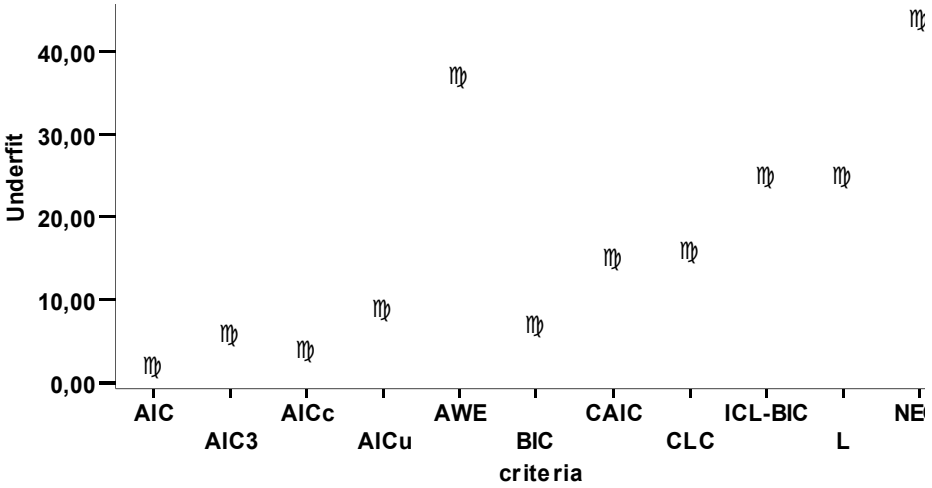

Figure 3. Criteria selecting models with less segments (underfit), in percent

6. Coronary Heart Disease Application

In order to see the performance of these models and information criterion BIC, we analyze a dataset (n = 231) with known diagnostic classification (normal, premature, serious and permanent), and five continuous variables: NAOHDLCC, CHOLESTEROL, LDLC, HDLC, TG.

In order to "guess" the diagnostic classification, we apply FMM approach, with information criterion BIC, and we display in table 5 the results for model selection. Because information criterion BIC presents an elbow for S = 4, we selected a model with four clusters, the true diagnostic classification, with relative sizes: 28, 23, 20, and 11 percent, respectively.

Thus, we can conclude that these models, finite mixture modeling, with information criterion BIC for model selection, are good for discovering patterns in continuous data, in particular for guessing true diagnostic classification for coronary heart disease.

Table 5. Model Selection (Information criterion BIC)

Model	LogL	BIC
1-Cluster	-5570,87	11196,08
2-Cluster	-5309,55	10733,21
3-Cluster	-5175,43	10524,74
4-Cluster	-5080,44	10394,53
5-Cluster	-5027,73	10348,89

As we can see from figure 4, the items NAOHDLCC, CHOLESTEROL, and LDLC are the most important ones, in order to discriminate between the four clusters.

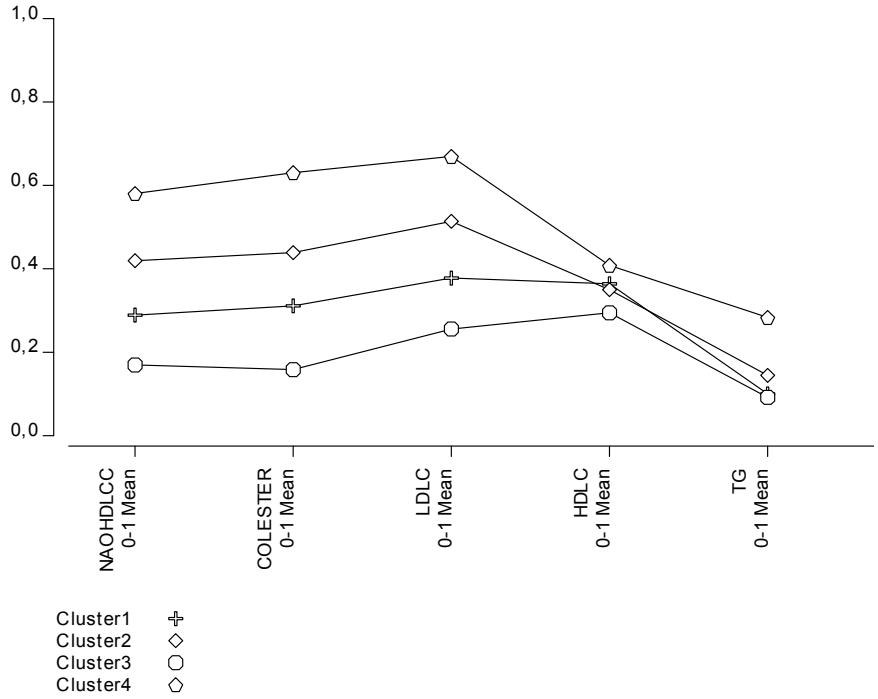

Figure 4. Conditional probabilities of four clusters

7. Conclusions

The results of this study help on developing a consistent way of selecting an appropriate information criterion for model selection when dealing with finite mixture modelling and continuous clustering base variables.

As a result of the simulation study, BIC and AIC3 (followed by AICu) are the best performing criteria when dealing with continuous segmentation base variables; moreover, BIC selects the right model in 93% of the time (Figure 1 and table 4). We also can see that BIC almost never *overfits* (Figure 2), and rarely *underfits* (Figure 3). Thus we conclude that BIC is a good criterion to select the best model and so to discover patterns in continuous data.

Finally, in order to compare the criteria performances, we run Friedman tests, because the data consist of *b* mutually independent k-variate random variables ($X_{i1},\ldots,X_{ik}$), called *b* blocks, $i=1,\ldots,b$; the random variable X_{ij} is in block *i* (the factors in analysis) and is associated with treatment *j* (the criteria we use).

Thus we run Friedman test for all the criteria in table 2, to test the null hypothesis that all the eleven means performances are identical. We reject the null hypothesis (Monte Carlo p-value of 0.000). Thus, we conclude that criteria performance was not identical for the eleven criteria in table 2, and we make multiple comparisons.

Criteria *i* and *j* are considered to have different performance if the inequality

$$|S_i - S_j| > t_{(b-1)(k-1);1-\frac{\alpha}{2}}\left[\frac{2b(F_1-F_2)}{(b-1)(k-1)}\right]^{\frac{1}{2}}$$

is satisfied, where $t_{(b-1)(k-1);1-\frac{\alpha}{2}}$ is the value of distribution *t* with (b-1)(k-1) degrees of freedom, and Rj, F_1 and F_2 are given by

$$F1 = \sum_{i=1}^{b}\sum_{j=1}^{k}\left[R(X_{ij})\right]^2 \text{ and } F_2 = \frac{1}{b}\sum_{j=1}^{k} R_j^2 \text{, with } R_j = \sum_{i=1}^{b} R(X_{ij}),$$

where $R(X_{ij})$ is the rank, from 1 to k, assigned to X_{ij} within block *i*.

Table 10 Matrix for multiple comparisons

Criteria		BIC	AIC	AIC3	AICc	AICu	CAIC	CLC	ICL-BIC	NEC	L	AWE
	R_i	82,5	26,5	74,5	38	68	62,5	31	44,5	17,5	50,5	30,5
BIC	82,5	0,0										
AIC	26,5	-56,0	0,0									
AIC3	74,5	-8,0	48,0	0,0								
AICc	38	-44,5	11,5	-36,5	0,0							
AICu	68	-14,5	41,5	-6,5	30,0	0,0						
CAIC	62,5	-20,0	36,0	-12,0	24,5	-5,5	0,0					
CLC	31	-51,5	4,5	-43,5	-7,0	-37,0	-31,5	0,0				
ICL-BIC	44,5	-38,0	18,0	-30,0	6,5	-23,5	-18,0	13,5	0,0			
NEC	17,5	-65,0	-9,0	-57,0	-20,5	-50,5	-45,0	-13,5	-27,0	0,0		
L	50,5	-32,0	24,0	-24,0	12,5	-17,5	-12,0	19,5	6,0	33,0	0,0	
AWE	30,5	-52,0	4,0	-44,0	-7,5	-37,5	-32,0	-0,5	-14,0	13,0	-20,0	0,0

$$(t_{(b-1)(k-1);1-\frac{\alpha}{2}}\left[\frac{2b(F_1-F_2)}{(b-1)(k-1)}\right]^{\frac{1}{2}} = 18.4)$$

Because we have

$$t_{(b-1)(k-1);1-\frac{\alpha}{2}}\left[\frac{2b(F_1-F_2)}{(b-1)(k-1)}\right]^{\frac{1}{2}} = 18.4,$$

as we can see, we have $|R_{BIC}-R_{AICu}| = 14.5$, $|R_{BIC}-R_{AIC3}| = .8$, and $|R_{AIC3}-R_{AICu}| = 6.5$, all less than 18.4; then, we can conclude that BIC, AIC_3 and AICu have similar performances. They differ from all the others information criteria with relation with performance.

To sum up, we conclude that for determining the number of segments, BIC, AIC_3 and AICu, with 93, 89 e 88 percent, respectively, perform very well when using FMM for discovering patterns in continuous data. Moreover, they perform well for several sample sizes and *true* number of segments, and they almost never overfit and underfit.

Then we apply this criterion, with mixture models, in order to discover the patterns *of coronary heart disease*, and the results are very good, because this approach selects a model with four clusters, which was the known pattern of data.

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JOURNAL OF APPLIED QUANTITATIVE METHODS

Quantitative Methods in Medical Sciences

APPLYING THE STATISTICAL SURVEY METHOD IN EVALUATING THE PUBLIC HEALTH CARE SYSTEM IN ROMANIA

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Abstract: *The reform of the public health care system is a complex and lengthy process, involving different types of people and institutions. The papers is revising the key issues that have to be taken into account when applying the reform process of the health care system and is analyzing some of the aspects of the reform process in the Romanian public health care system based on a survey that was conducted in 2007 among the medical doctors.*
The sampling plan had two steps and several primary and secondary variables were defined. Based on the 52 questions in the questionnaire, of which 49 have been closed, 177 primary questions were set, measured on a scale from 1 (low importance) to 5 (very high importance)
Two aspects are analyzed with statistical tools in this paper: the overall opinion of the medical personnel regarding the quality of the reform process in the public health care system and the opinion regarding the quality of the factors that concur to ensuring the quality of the medical services. Two aggregated variables were defined in both cases, each based on five primary variables. The results show significant differences in the opinions according to gender, age group and personnel category of the interviewed medical doctors.

Key words: statistical *survey; public health care system; tertiary education; Romania*

1. Introduction

In analyzing the reform process in the Romanian public health system, the paper takes into account the fact that the transformation of the healthcare system have focused mostly on the curative interventions, but the integrated network of preventive, curative and rehabilitative services[1]. For the entire period of the 90's the actions taken by past governments have sought more to solve current problems, rather than defining new and efficient ways of operating it. In these circumstances, the public health system has become expensive and sometimes not functional. Most of the times, at the whole system level, inefficient solutions were taken both from professional and economic point of view. At present, the networks of health services providers do not respond in most people's expectations.

In the last 18 years a series of measures were taken in order to decentralize the system and to privatize some of the medical services. However, presently, we are witnessing a fragmentation of the public health care system, underlining an uneven territorial distribution of medical personnel and showing a declining of the disadvantaged people's access to certain types of health services. It should be mentioned that the number of doctors per capita in the rural area represent only 20% of the urban area's average. Another major drawback of the system is linked to the financing system and its correlation with the decentralization strategy of public health care system. Several times the decentralization process was a way to place a part of the burden in charge of local administrations.

The difficulties of transition process in Romania as well the poor quality of the health services has led to a reduction in life expectancy by almost 3 years in the last decade. According to studies carried out by mixed teams of Romanian and foreign specialists, the reform process of the health care system should clearly focus on the following key issues:

- the development of services based more on health needs;
- redefining an efficient structure of health care services;
- redefining of improved quality standards;
- strengthening the universal right of access to basic health care services;
- defining of a coherent financing strategy that will lead to a better use of the system's resources

The main objectives for the next period aims mainly the following aspects[2]: to intensify the efforts to prevent diseases by increasing the awareness of the risk factors, to increase the transparency in using the public money; to speed up the restructuring process of hospitals; to close the gap between the health and demographic indicators from Romania and of the developed countries, while lowering the specific pathology for underdeveloped countries.

In reforming the public health care system in Romania, the existing diagnostic studies as well as current trends from the EU countries must be considered:

(1) *In the next 50 years is expected a 30% increase of expenditure in the health care sector (as percentage of GDP).*

Due to the increase in welfare in the developed as well developing countries, people will tend to spend more for health, which will cause a greater pressure on public health systems in these countries. Among the solutions proposed for public's protection is to increase the insurance policies and compensation limits.

One negative aspect of this measure is a possible reduction in the number of insured persons among those with low income and from disadvantaged areas.

(2) *Universal accessibility of medical service is guaranteed in all OECD countries, except in the United States.*

The principle of "appropriate treatment" is respected in all OECD countries in terms of treatment at a general practitioner, but a large part of the population can not afford medical services provided by specialists. This situation highlights an uneven distribution of medical care in favor of people with high incomes.

(3) *The notion of quality of a ' health product' is difficult to quantify in economic terms.*

OECD is in the stage of drafting a system of indicators to measure the quality of services provided in public health systems. Too long waiting times for a consultation or a non-uniform territorial distribution of hospitals are factors that will diminish the quality of the health in a country.

More than 60% of the EU countries are faced with increasing costs in the health care system. The only exceptions are Denmark, Spain and Luxembourg.

(4) *In most of the EU countries, the main problems encountered did not aim at the financial viability of the health system, but the effectiveness of medical care and universal accessibility of citizens to these services.*

Only in the Czech Republic, Slovenia, Slovakia and Poland the costs of health care are at a fairly high level, causing a matter of for concern. The universal accessibility of health care services is a problem in some countries due to unequal distribution of health facilities. For example, in these countries there are significant differences between urban centers and the rural ones.

(5) *Low wages of medical staff is another problem found in several EU countries.*

(6) *Outsourcing some of the services and abide them to the market rules is another solution adopted to increase the efficiency of medical services.*

Some of the specialized articles argue that the privatization of services represent an efficient solution to increase the profitability of the health sector[3].

(7) *Adopting of financing system is one of the important issues of reform processes of public health systems.*

(8) *Development of policies to increase citizens' trust in public health is another important component of a process of reform at European level.*

(9) *Creating an appropriate statistical system in the EU health care system and safety of the workplace.*

Thus, the new Regulation of the European Parliament and of the Council regarding the statistics on public health and safety at work will mainly follow the next aspects:

(i) statistics to be collected should include information required by the community activities in the field of public health care, to support national strategies for development of high quality, accessible and sustainable health care, as well the local community strategy for health and safety at work;

(ii) to provide data for sustainable structural development and indicators of community health, as well as other sets of indicators required in order to monitor the implementation of policy measures in the public health care system and health and safety at work;

(iii) the statistical sources could consist in existing or planned household surveys, similar surveys, as well as existing or planned national administrative sources;

(iv) The statistical methodologies and data collection, which will be developed for collecting data on public health care system and health and safety at work at European level will consider, whenever necessary, coordinated activities with international organizations in order to ensure international comparability of statistics and to prevent further work in parallel.

2. The research methology

In order to analyze some of the characteristics of the public reform process in the Romanian public health care system in 2007, a survey was conducted in 2007 among the medical doctors. The sampling plan had two steps. The first step included the medical units from Bucharest (hospitals, clinics, health centers). The second step was represented by the selection of medical doctors for each primary sampling unit. For Bucharest municipality the statistically representative sample size was established at 407 persons and it was chosen a 95% confidence in the result and a representativity error of ±5%.

The structure of the sample is presented in the following table:

Table 1. The structure of the sample

Category	Persons
Family doctors	75
Medical doctors form hospitals	279
Medical doctors from clinics and health centers	53

The data was gathered within three weeks (in July 2007). This way the comparability of the answers was insured given the fact that no major decisions were made at the time by the Romanian government.

The structure of the questionnaire according to the topics of interest taken into account is presented in the following table:

Table 2. The structure of the questionnaire, by area of research

Nr. Crt.	Area of research	Number of closed questions	Number of open questions	Number of variables
1.	General aspects of the public health system reform process	5	-	41
2.	The public policy framework defined by the MPH	5	-	18
3.	The general public's education related to health aspects	7	-	18
4.	The analysis of the improper behavior of some of the personnel from the public health institutions	7		24
5.	The research capacity of the public health system	5	1	24
6.	Current activities' characteristics of the public health institutions	2	-	6
7.	Personal identification data	12		32
8.	General data	6	2	14
	Total	**49**	**3**	**177**

The questionnaire was based mainly on closed questions, with predefined answers, but there were three open questions as well.

Based on the questions within the questionnaire primary variables have been defined. For each area of analysis specified in table 2 the number of primary variables. Based on the 52 questions in the questionnaire, of which 49 have been closed, 177 primary questions were set. The 177 data sets are used for the calculation of descriptive indicators, but also to calculate some aggregated variables based on which econometric models are defined in order to better understand certain aspects of the public health system.

To define the questions in a questionnaire that has the goal to identify the impact of the reforms in the public health care system, three major aspects have to be considered: the reform measures undertaken by the Ministry of Public Health, the models applied in the European Union for analyzing the performance of the public health system and the stakeholders that will contribute to an efficient implementation of the reform measures.

3. The quality of the reform process in the public health care system

In order to measure the overall opinion of the medical personnel regarding the quality of the reform process in the public health care system, an aggregated variable based on five primary characteristics was defined; the five primary variables refers to aspects of the financing of public health system, the reform process at the medical units level, procurement of medicines, the decentralization policy and employment and promotion of staff.

Starting from the questions of the questionnaire the following five primary variables have been defined: the quality of financing the public health care system (A1_1); the reform measures at the health care institution level (A1_2), the procurement system of medicines (A1_3), the process of decentralization in the health care system (A1_4), the opinion of medical personnel regarding the reform process based on the hiring and promotion policy of medical personnel with university degree and secondary education (RPS).

The five primary characteristics are measured on a measurement scale with five values, assigned as follows: 1 - if the reform of public health care system has a very weak impact on the item considered; 2 - where the impact of reform is poorly perceived in relation to the item considered; 3 - the impact is satisfactory; 4 - if the impact of the reform process is a good one 5 - to where the impact is very favorable.

The first-level aggregated variable (RSS) is calculated as an average of the primary variables defined directly on the recorded responses to questions from the questionnaire. In these circumstances, the aggregate variable is defined using the application below:

$$RSS : P \rightarrow [1, 4]$$

The values of the *RSS* variable are defined based on the average operator applied to the values of the primary variables:

$$RSS_i = E(A_i1\_1,..., A_i1\_4, RPS)$$

In the above relationship $E(\cdot)$ is the operator of the average values of the five primary variables defined on the basis of the five questions in the questionnaire. A high value of the variable indicates a favorable perception among medical personnel on the process of reform in the public health.

The main aspects of the reform process can be analyzed at first using the descriptive statistics measures.

Average indicators as well as indicators of variation and skeweness calculated for the five primary variables are presented in Table 3 (from Appendixes). Based on the five sets of data histogram was drawn (see Fig. 1 from Appendixes).

The values of the RSS variables can vary according to different characteristics of the respondents, such as age or gender. These differences are analyzed as follows, and for each case the descriptive indicators are presented to analyze the central tendency, variance and shape of the distribution.

In order to establish if there is a statistically significant difference between the averages calculated for each group (according to gender, age etc) the analysis of variance (ANOVA) method is use. For each case the value of the F statistics and the significance level are presented as well.

Table 6. Differences in opinions according to gender

Gender	Minimum	Maximum	Mean	Standard Deviation
M	0,00	3,83	2,204	0,666
F	0,00	3,83	2,086	0,664

The value of the F statistics, equal to 2.77, shows that for a level of significance equal to 0.09, there is a significant difference between the two genders. In other words, the male doctors have a better opinion on the reform process of public health care system compared to the female doctors. Should be noted that both groups of persons have quite a negative opinion on the process of reform in the public health system.

Table 7. Differences in opinions according to age

Age groups (years)	Mean	Standard deviation	Minimum	Maximum
Under 30	1.85	0,572	1.00	3.67
31-40	2.12	0,632	0.83	3.83
41-50	2.21	0,720	0.83	3.83
51-60	2.18	0,708	0.00	3.83
Above 61	2.24	0,518	1.50	3.33
Total	2,12	0,666	0,00	3,83

The value of F statistics, equal to 2.73, shows that the average level differs significantly between the age groups. The results are guaranteed for a significance level of 0.03. Moreover, the perception of the quality of reform process is more negative at young people. In all cases the average is well below three, meaning that, overall, there is a negative perception of the medical staff with higher education on the reform process of this system. Using a test of homogeneity of variance it results that there is no significant differences among the six age groups.

Table 8. Differences in opinions according to personnel category

Personnel category	Mean	Standard deviation	Minimum	Maximum
Managers	2.4143	0.69354	1.00	3.50
Specialists	2.0653	0.61543	0.00	3.83
Primary medical doctors	2.1975	0.69035	0.67	3.83
Residents	1.7939	0.52112	0.83	3.00
Other	2.2308	0.72181	1.33	3.83
Total	2.1237	0.66594	0.00	3.83

The value of F statistics, equal to 6.22, shows that for a significance level of 0.00 there are significant differences in the perception of the reform process in the different categories of medical doctors. In all cases the opinion is unfavorable, with two exceptions:

- doctors from management have a slightly more positive perception;
- resident doctorss have a totally negative perception of the reform process.

The homogeneity test (F = 2.14 and the level of significance is 0.08) shows that the degree of homogeneity between the five groups is significantly different between the groups. It should be noted that the most homogeneous group is the one of residents.

4. The analysis of the opinion regarding the quality of the factors that concur to ensuring the quality of the medical services

A quality medical service can be assured only if a minimal number of conditions are met, related to the facilities, training and motivation of medical staff, a performing management etc.

In this research, five important issues that ensure the quality of the medical services in the public health care institutions are vconsidered: the endowment with medical equipment (A7_1), provision of the necessary medicines (A7_2), the internal organization of the institution (A7_3), ensuring required staff with higher education (A7_4); ensuring required with staff medium education (nurses) (A7_5).

The five primary variables are measured on a scale from 1 to 5, values assigned as follows: 1 to where the doctors felt that the item is very poor in ensuring the quality of medical services; 2 for a poor situation; 3 - situation in which public opinion is acceptable; 4 – the interviewed person's opinion is good; 5 the interviewed person's opinion is a very good.

For an overall assessment of the opinion of the medical doctors regarding the factors that are contributing to ensure high quality medical services, a new aggregated variable (CF) is defined:

$$CF : P \to [1, 5]$$

Where the values are defined based on the following application:

$$CF_i = E(A_i 7\_1, \ldots, A_i 7\_5). \qquad [3]$$

For the calculation of average and variance indicators the answers from the questionnaire are taken into account. The total number of valid answers is equal to 393. The share of non-responses to each of the five characteristics are as follows: for A7_1 is 1% to

2% is A7_2 for A7_3 is 2.2% for A7_4 is 1.5% and for A7_5 is 1, 7%. The calculated descriptive measures for the five variables are presented in the table below.

Table 9. Descriptive indicators for the variables A7_1,...,A7_5

	Mean	Standard deviation	Coefficient of Skewness	Coefficient of Kurtosis
1. Medical endowment	2.63	1.038	0.287	-0.497
2. Assuring the required stock of medicines	2.60	1.023	0.272	-0.583
3. Internal organization of the institution	2.96	1.054	0.042	-0.371
4. Assuring highly qualified medical staff (with university degree)	3.37	1.059	-0.275	-0.619
5. Assuring medical staff (nurses)	2.92	1.084	-0.050	-0.897

After tabulating the data from the five primary variable, the following results are obtained for the first level aggregated variable:

- The histogram is presented in the following graph:

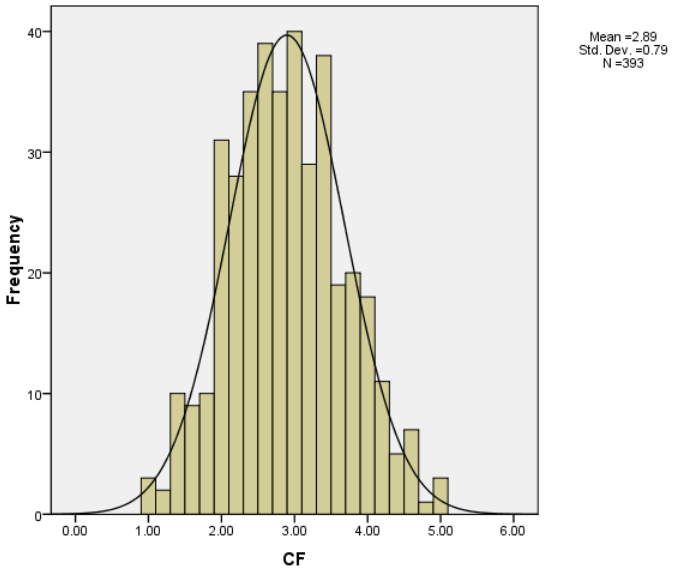

Figure 3. The histogram of the CF aggregated variable

  - The average level of the variable is 2.89 and the standard deviation is 0.79. The average value calculated for this variable differs significantly from three for a significance level of 0.01 (the Student t-statistics is equal to -2.66).

These results show that, overall, the quality of the factors that concur to the medical act is less than acceptable.

The contribution of the five factors considered is though different. Thus, there are three situations: the contribution is negative with respect to providing the necessary medicines and medical equipment; it is a relatively acceptable to the internal organization of medical institutions and the provision of medical staff with secondary education, the situation is relatively good in the report by providing medical staff with higher education.

There are differences of opinion in relation to the quality of the factors that concur to a quality of medical act at the level of medical units by age groups. For each age group in the table below is presented the average and standard deviation. From the table below it can be observed that there is a more favorable opinion in relation to the quality of the factors among the older doctors.

Table 10. The analysis according to age groups of the medical doctors' opinion regarding the quality of the factors

Total	Under 30	31-40	41-50	51-60	Over 61	F Statistics and significance level
2,89 (0,790)	2,54 (0,504)	2,93 (0,761)	2,87 (0,809)	3,01 (0,873)	3,16 (1,027)	2,57 (0,03)

The views are different as well for the groups defined for category of staff. In the next table are presented the results for each group, as well as the F statistics. The most favorable opinion is expressed by the staff in management positions within the health care institutions, which assess as acceptable the factors that contribute to ensuring quality medical service. The less favorable opinion is expressed by residents.

Table 11. The analysis according to staff category of the medical doctors' opinion regarding the quality of the factors

Total	Management staff	Specialists	Primary doctors	Residents	Other categories	F Statistics and significance level
2,89 (0,790)	3,13 (0,940)	3,00 (0,747)	2,87 (0,804)	2,52 (0,569)	3,11 (0,958)	4,52 (0,001)

According to staff category from the public health care system there are no significant differences in opinions regarding the quality of the factors that contribute to ensuring quality medical service.

5. Conclusions

In order to measure the overall opinion of the medical personnel regarding the quality of the reform process in the public health care system, an aggregated variable based on five primary characteristics was defined; the five primary variables refers to aspects of the financing of public health system, the reform process at the medical units level, procurement of medicines, the decentralization policy and employment and promotion of staff.

The five primary characteristics are measured on a measurement scale with five values, from 1 corresponding to a very weak impact of the considered variable on the reform of public health care system up to 5 corresponding to a very high impact. The first aggregated variable was defined as the average values of the five primary variables. The results show a negative perception among medical personnel of the process of reform in the public health.

Moreover, there are significant differences in opinions by gender, age group and personnel category of the interviewed medical doctors.

Another aspect of the research concerned the opinion of the medical doctors regarding the factors that concur to ensuring the quality of the medical services. In this case five important issues that ensure the quality of the medical services in the public health care institutions were considered: the endowment with medical equipment, provision of the necessary medicines, the internal organization of the institution, ensuring required staff with higher education, ensuring required with staff medium education (nurses). Based on these five variables, an aggregated variable was defined.

The results of the analysis show that, overall, the quality of the factors that concur to the medical act are perceived as less than acceptable. There are significant differences between gender and age groups but no differences in opinions regarding the quality of the factors that contribute to ensuring quality medical services according to staff category.

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Appendixes

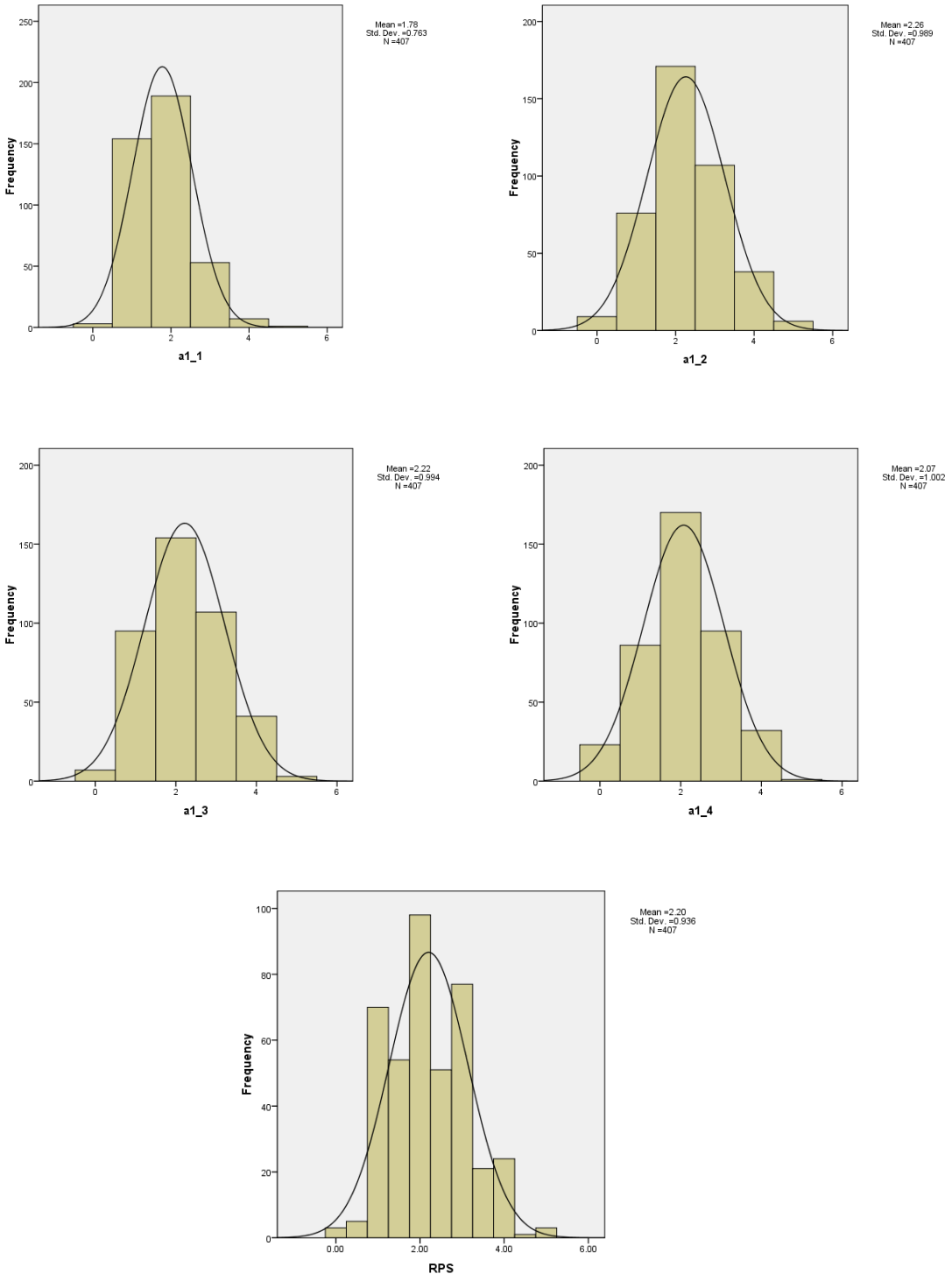

Figure 1. The distribution of answers reflecting the medical staff opinion regarding the characteristics of the reform process in the public health care system

Table 3. Descriptive indicators for primary variables used to characterized the reform process in the public health care system

	Financing of public health care system (A1_1)	Reform measures at institution level (A1_2)	Procurement system for medicines (A1_3)	Decentralization process in healthcare system (A1_4)	Hiring and promotion policy of medical personnel (RPS)
Mean	1.78	2.26	2.22	2.07	2.20
Median	2.00	2.00	2.00	2.00	2.00
Standard deviation	0.763	0.989	0.994	1.002	0.937
Coefficient of Skewness	0.664	0.268	0.245	0.043	0.313
Coefficient of Kurtosis	0.548	-0.028	-0.437	-0.238	-0.341

Table 4. Descriptive indicators of the RSS variable

	Minimum	Maximum	Mean	Standard Deviation	Coefficient of Skewness	Coefficient of Kurtosis
Total	0,00	3,83	2,124	0,666	0,401	-0,044

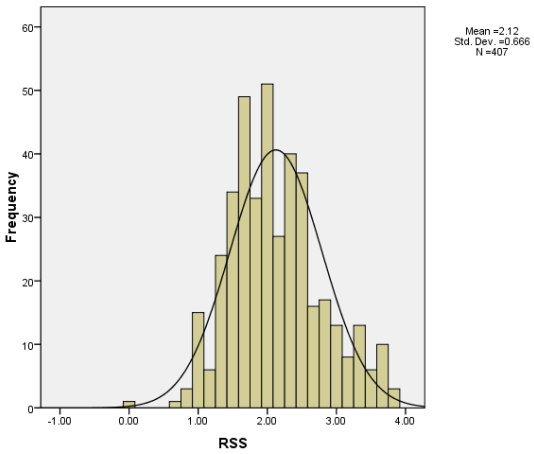

Figure 2. The distribution of the RSS variable

Table 5. The correlation matrix for the primary variables

	a1_1	a1_2	a1_3	a1_4	RPS
a1_1	1.000	0.345**	0.366**	0.276**	0.391**
a1_2	0.345**	1.000	0.310**	0.279**	0.403**
a1_3	0.366**	0.310**	1.000	0.396**	0.406**
a1_4	0.276**	0.279**	.396**	1.000	0.355**
RPS	0.391**	0.403**	0.406**	0.355**	1.000

Observation: ** the linear coefficient of correlation is significantly different from zero for $\alpha \leq 0{,}01$

[1] According to a study developed by the GRASP-USAID Program, 2004, Bucharest

[2] Pre-accession Economic Program – December 2005

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JOURNAL OF APPLIED QUANTITATIVE METHODS

Quantitative Methods in Medical Sciences

EPIDEMIOLOGICAL ASPECTS AND RISK FACTORS IN THE OUTCOME OF VARICEAL ESO-GASTRIC BLEEDING AT CIRRHOSIS PATIENTS

Motto:
"Ab uno disce omnes"
(From one sample, we judge the rest)
Publius Vergilius Maro

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Abstract: *The epidemiological aspects and risk factors in the outcome of upper gastrointestinal bleeding were analyzed in a prospective study of 268 patients with liver cirrhosis. The hemorrhagic episode has a negative prognostic in the immediate outcome, with 96 deaths (35.82%), p<0,01.*
In the acute phase of bleeding appeared 36 deaths (13.40 %); others were registered after recurrent hemorrhage (48 cases, 17.23%), or after sclerotherapy or surgical treatment of varices (12 cases, 4.47%).
Patients in advanced stage of cirrhosis – Child C stage – (n=124), registered the highest death toll (n=76, 61.29%, p<0.01).
High potential risk factors responsible for death included: altered general status (p<0.01), jaundice (p<0.01), increased seric level of total bilirubin (over 3 mg%, p<0.01), encephalopathy (p<0.05). Among these risk factors, the highest sensitivity belongs to jaundice (83.33%), and total highest positive predictive value belongs to seric and total bilirubin (over 3mg %), with 64.28% value.

Key words: *upper GI Bleeding; cirrhosis; esophageal varices; risk factors; epidemiology*

Introduction

One of the main public health problems with special epidemiological interest – both at the national and the international level – is liver cirrhosis.

Frequently caused by a hepatitis or chronic alcohol use, accompanied by portal hypertension and varices, the prevalence of cirrhosis is upscaling. Gastrointestinal bleeding from portal hypertension carries the highest mortality, ranging from 30 to 40 percent, and has an equally high rate of recurrence (1).

Cirrhosis is associated with a hyperdynamic circulatory state characterized by peripheral and splachnic vasodilatation, decreased mean arterial pressure and increased cardiac output (2).

Table 1. Risk factors for variceal hemorrhage (hepatic vein pressure gradient) (3,4,5,6)

	High		Low	
Portal pressure	HVPG > 12 mm Hg		HVPG < 12 mm Hg	
Varix size and location	Large esophageal varices		Isolated varices in fundus of stomach	
Variceal appearance on endoscopy ("red signs")	Red walemarks	Cherry spots	Hematocystic spots	Diffuse erithema
Degree of liver failure	Child Pugh class C cirrhosis			
Presence of ascites	Present		Absent	

Methods

In the prospective study of the 268 patients we examined different factors, regarding: *clinical data* (age, gender, presence of jaundice, ascites, encephalopathy and altered status), *antecedents* – former upper gastrointestinal bleeding, existence of toxic intake, *characteristic of bleeding* (hematemesis, melena, hematochezia, and associated signs). Hematochezia in the setting of upper GI hemorrhage implies that a minimum of 1000 ml of blood is entering the upper GI tract; red hematemesis with concomitant hematochezia are suggestive for massive brisk bleeding, in this case the mortality being around 30%.

1 *The origins of hemorrhage* – esophageal varices, gastric varices/ portal hypertensive gastropathy, gastric peptic ulcer).

2 *Evolution* – according to the type of treatment.

We used the Child-Pugh classification of patients, by means of 5 criteria: serum albumin, bilirubin, ascites, encephalopathy and protrombin time (each factor has values on a 1 to 3 scale representing the gravity; the final value is the sum of all values for that patient; Child-Pugh A = 5-6, Child-Pugh B = 7-9, Child-Pugh C = 10-15).

The management of hemorrhage comprised 4 main objectives:

1. rapid and effective resuscitation of the patient through i.v./central lines, transfusions of blood to insure an optimal hemodynamic;

2. definitive control of bleeding with medical therapy (hemostats), Sengstaken-Blackmore tube, endoscopic banding and sclerotherapy and the last resource – surgery. Sustaining the liver function and prevention and/or treatment of associated complications was don in the resuscitation unit, in order to fight-off the encephalopathy, cerebral edema,

infection and increase the immunity (7,8);

3. treatment of the cause;
4. prevention of rebleeding (recurrent hemorrhage).

The statistical analysis was made with χ^2 (chi square) test.

Results

In our paper, the most frequent cause of hemorrhage were ruptured esophageal varices (n=175, %). The clinical and laboratory findings pointed out that the Child-Pugh C stage was met in most cases (n=124).

With definitive hemostasis obtained only in 172 patients, there were 96 deaths (35.82%) registered.

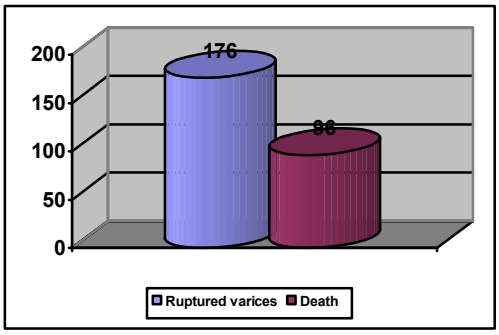

Figure 1. Deaths in esophageal varices
χ^2= 6.6
p<0.01

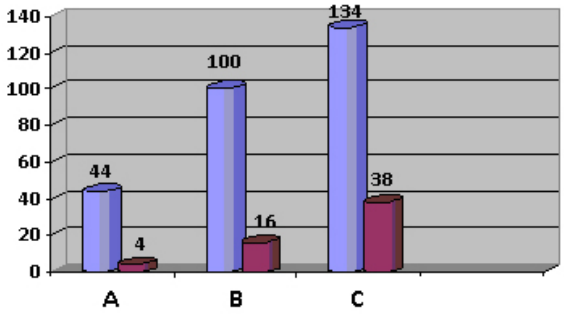

Figure 2. Deaths in Child-Pugh Classification
χ^2= 13.56
p<0.01

There were 88 deaths (p<0.01) due to the ruptured varices; off the total 96 deaths, 36 were registered the acute phase the disease, 48 after an recurrent hemorrhage and other 12 following local hemostasis.

Highest number of deaths was in C stage of cirrhosis (II), p<0.01 patients with altered general condition (figure 3, p<0.01), encephalopathy (figure 4, p<0.05) or jaundice (figure 5, p<0.01).

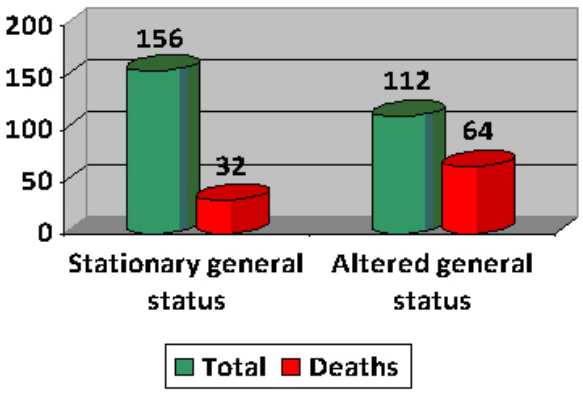

Figure 3. Deaths related to general condition
χ^2= 9.53
p<0.01

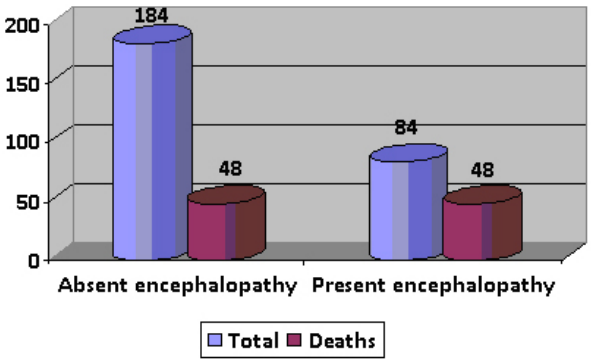

Figure 4. Deaths related to encephalopathy
χ^2= 6.05
p<0.05

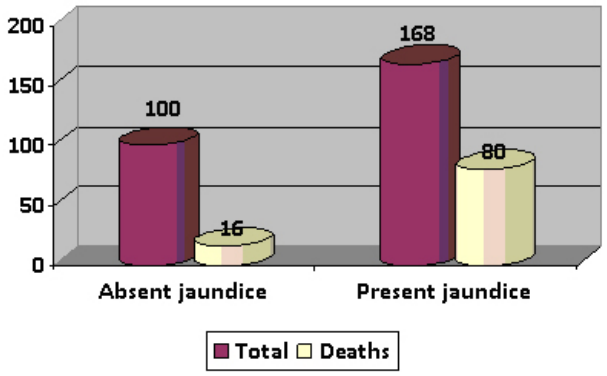

Figure 5. Deaths related to jaundice
$\chi^2 = 9.53$
$p<0.01$

As figured, the main cause of death remains the ruptured varix; upper GI hemorrhage remained the primordial aggravation for patients in Child-Pugh stage B, C, the ensuring hepatico-renal insufficiency being the lethal element.

Table 2. Generalities

Characteristics		Total	Deaths	χ^2
Gender	Female	76 (28.38%)	16 (21.05%)	2.51
	Male	192 (71.62%)	80 (41.66%)	
Age	< 60 years	184 (68.65%)	60 (32.60%)	0.65
	> 60 years	84 (31.35%)	36 (42.70%)	
Type of bleeding	Hematemesis	200 (74.62%)	72 (36%)	0.016
	Melena	44 (16.42%)	16 (36.36%)	
	Combined	24 (8.95%)	8 (33.33%)	
Arterial blood presure	Normal	184 (68.12%)	68 (36.95%)	1.79
	Decreasing	64 (23.83%)	20 (32.25%)	
	Under 80 mm Hg	20 (7.46%)	18 (90%)	
Bleeding cause	Varices	176 (65.62%)	88 (50%)	11.24 p<0.01
	Portal hypertension gastropathy	88 (32.83%)	8 (9.09%)	
	Others (peptic ulcer)	4 (1.4%)	0	
Treatment type	Medical (including Sengstaken-Blackmoore tube)	124 (46.24%)	27 (21.77%)	2.17
	In recurrent hemorrhage	48 (17.91%)	48 (100%)	
	Sclerotherapy	8 (5.97%)	2 (25%)	
	Surgery (resections, ligatures)	44 (16.42%)	4 (9.09%)	
Child-Pugh classification	A	44 (16.42%)	4 (9.99%)	13.56 p<0.02
	B	100 (37.31%)	16 (16%)	
	C	124 (46.27%)	76 (61.27%)	

Statistical significance was relevant for several risk factors, as early predictors, with key roles in triggering the deaths of cirrhosis patients with upper GI bleeding:

1. altered general status ($p<0.01$)
2. stage C of Child-Pugh classification of cirrhosis ($p<0.01$)
3. anatomical cause of hemorrhage ($p<0.01$)
4. serum bilirubin over 3 mg% ($p<0.001$)
5. encephalopathy ($p<0.05$).

The highest sensibility belonged to jaundice (83.33%), while the positive predictive value (<50%) belonged to serum bilirubin >3mg%.

Discussions

It is stated that approximately 1/3 of cirrhosis patients will develop in one stage of evolution an upper GI hemorrhage and in the vast majority of cases (approximately 80%) it will be due to variceal bleeding; auxiliary lesions may be present, like hypertensive portal gastropathy (30-40%) or peptic ulcer (7-10%) (9,10,11,12).

Similar percentages were obtained in our study (see table 2).

New varices develop in 5-15% patients with cirrhosis (each year), and enlarge by 4%-10% each year. Of the 30-40% patients who develop variceal bleeding, only 40 to 50 percent of actively bleeding varices will spontaneously stop bleeding (7,13,14).

This variability of phenomena requires attentive statistical analysis.

Regarding the risk of rupturing varices, the endoscopic data collected by NIEC (North Italian Endoscopic Club) established a predictability of the hemorrhage onset; varices with the size bigger than 5 mm, associated with "red dots" have a greater bleeding risk than small varices (70% opposed to 7%), $p<0.001$ (10,15,16,17,18). The stage of cirrhosis, with impairment of hemostasis, will directly influence the gravity of hemorrhage; the hepatic venous pressure higher than 12 mm Hg will induce the increase of the bleeding risk (9,19).

Table 3. Clinical and endoscopic findings

Characteristics		Total	Deaths	χ^2
Antecedents	Hemorrhage	Yes: 144 (53.73%)	52 (36.11%)	0.02
		No: 4 (46.27%)	44 (35.48%)	
	Ascites	Yes: 164 (61.19%)	48 (29.26%)	1.97
		No: 104 (38.81%)	48 (46.15%)	
	Use of aggressive drugs	Yes: 124 (83.58%)	76 (33.92%)	0.527
		No: 44 (16.42%)	20 (45.45%)	
Clinical exam	Altered general status	Yes: 112 (41.79%)	64 (57.14%)	9.53 p<0.01
		No: 156 (58.21%)	32 (20.51%)	
	Jaundice	Yes: 168 (62.68%)	80 (47.11%)	6.91 p<0.01
		No: 100 (37.32%)	16 (16%)	
	Ascites	Yes: 160 (59.47%)	60 (37.50%)	0.12
		No: 104 (40.63%)	36 (33.33%)	
	Encephalopathy	Yes: 84 (31.34%)	48 (57.14%)	6.045 p<0.05
		No: 184 (68.66%)	48 (26.08%)	
Endoscopical data	Ruptured varices	Yes: 176 (65.67%)	88 (50%)	6.6 p<0.01
		No: 92 (34.33%)	8 (8.69%)	

The 32 cirrhotic patients in our study, with fast decreasing blood pressure, registered a mortality of n=10 (31.25%), while the mortality scored to 90% (n=9), for the 10 patients hospitalized in hemorrhagic shock: international data acknowledges also high percentage mortality (approximately 20%) for the cirrhosis patients with severe upper GI bleeding (12).

The anemia, with low hematocrit value, and also maintaining the blood pressure only with saline i.v., can facilitate and increase the severity of bleeding (20). Likewise, in *table 4*, in our study, patients with hematocrit value under 25%, registered 88 deaths

(59.09%).

Table 4. Laboratory findings (data)

Characteristics		Total	Deaths	χ^2
Hematocrit value	>25%	180 (67.16%)	44 (45.83%)	0.20
	<25%	88 (32.89%)	52 (59.09%)	
Bilirubin	<3 mg/dl	156 (58.21%)	24 (15.38%)	16.98 p<0.001
	>3 mg/dl	112 (41.79%)	72 (64.27%)	
Prothrombin time	>40%	184 (69.42%)	64 (34.27%)	0.068
	<40%	84 (31.34%)	32 (38.09%)	
Albumin	>3g%	156 (58.21%)	44 (28.20%)	2.36
	<3g%	112 (41.79%)	52 (46.42%)	
Liver transaminases (ALT, AST)	<100 U/L	160 (59.76%)	52 (32.5%)	N
	>100 U/L	108 (40.29%)	44 (40.74%)	
Blood urea nitrogen	<60 mg%	164 (61.19%)	58 (35.36%)	N
	>60 mg%	104 (38.8%)	38 (38.46%)	
Sodium (Na^+)	>130 mEq/L	192 (71.64%)	64 (33.33%)	N
	>130 mEq/L	76 (28.35%)	32 (42.1%)	
Potassium (K^+)	>3 mEq/L	198 (73.83%)	72 (37.5%)	N
	<3mEq/L	70 (26.11%)	24 (34.28%)	

N – not significant

Directives are to use blood transfusions in upper GI bleeding at the cirrhotic patients with hematocrit value less than 25%, eventually frozen plasma.

The highest positive predictive value belongs to serum bilirubin levels higher than 3 mg% ($p<0.001$). One other predictive factor is recurrent hemorrhage which is present in 50% of the complicated cirrhosis (with anterior bleeding). Another issue is *infection*, with clear predictive role in the early recurrence of hemorrhage; infection is proved in 60-70% of cirrhosis patients and is caused by the lower immunity of these patients, the catheterization of body cavities, assisted ventilation. That was justification for the compulsory introduction of antibiotic protection in the therapeutic protocol.

The Baveno criteria were used to demarcate the recurrent hemorrhage: *zero time* is considered the full stop of bleeding, with no blood on nasogastric tube, no bleeding on endoscopy and stable vital signs for 24 hours. Early recurrent hemorrhage is considered premature bleeding after *zero time*; recurrent hemorrhage implies that after 10 days from *zero time*, there is hemorrhage that necessitates at least 2 units of blood at 6 hours interval, or hemostasis with red blood or endoscopy with bleeding stigmata (21,22).

With at least 30,000 deaths in USA, the hospitalization rate of 1/1000 and the 8-10% mortality, the upper GI bleeding remains in the focus of clinical teams of experts. In Europe, there is an incidence of 45-100 hospitalizations/100000 for upper GI bleed, with a case ratio of 3:2 males versus females; its incidence strongly correlates with increased age, 20 to 30 times higher in 70-80 year old patients compared with patients in the second decade of life. The lethality in Europe averages around 4-5% for less than 60 years old patients to more than 20% in patients over 80 years old. The mortality range for gastro-esophageal varices is 4-20% (22).

The remarkable issue is the unlowering curve of upper GI bleed mortality in the past 25-30 years, in disregard to the technical progresses – medical, endoscopical therapy that should have contributed to lessen the hemorrhage. The explanation dwells in the fact that the highest percentage of upper GI bleeding occurs in the elderly, with a rather sever

prognostic due to comorbidities, anticoagulant medication (over 45% of patients with upper GI bleed have over 60 years).

Varices frequently complicate end-stage liver disease, with more than 30% compensated cirrhotic patient and 60% decompensate cirrhotic having varices at the time of diagnostic.

Definitive hemostasis (n=124, 61.17%) used medical measures, endoscopy or surgical intervention (23).

The therapeutically protocol is represented in table 5.

Table 5. Therapeutical management stabilization

1. Stabilization with i.v. fluids, reverse coagulopathy.
2. Initiation with octreotide or vasopressin with nitrates.
3. Endoscopic evaluation with sclerotherapy or banding.
4. Multiple endoscopic sessions for variceal obliteration or TIPS/ surgical shunt/ angiographic shunt/ liver transplant.
5. Secondary prophylaxis with nonselective β-blockers ± nitrates.

During initial hemodynamic stabilization, the clinician must devise on orderly approach that will expedite diagnosis and treatment. Consulting a team of specialists that includes the internist, gastroenterologist, surgeon and interventional radiologist may provide the optimal management for the patient.

Conclusions

Upper GI bleeding is the most frequently met in cirrhosis patients with ruptured varices ($p<0.01$), the prognostic is not propitious in the immediate evolution of the hemorrhage ($p<0.01$), because of the high death toll (35.81%).

Most death were noted in the advanced stages (Child-Pugh stage C), $p<0.01$.

The risk factors in initiation of deaths were: encephalopathy ($p<0.05$), jaundice ($p<0.01$), altered general status ($p<0.01$), serum bilirubin level over 3 mg% ($p<0.001$).

The greatest sensibility belonged to jaundice (83.33%) and the highest positive predictive value belonged to serum bilirubin values over 3 mg% (64.28%).

Table 6. Risk factors in immediate evolution of hemorrhage of cirrhotic (24,25)

	Total	Deaths	Sensibility	Positive predictive value
Encephalopathy	84	48	50%	57.14%
Altered general status	112	64	66.66%	57.14%
Jaundice	168	80	83.33%	47.61%
Bilirubin >3 mg%	112	72	75%	64.28%
Child-Pugh C stage	124	76	79.16%	61.29%

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JOURNAL OF APPLIED QUANTITATIVE METHODS

Quantitative Methods in Medical Sciences

THE CLINICAL OUTCOME AND THE INCIDENCE OF PACEMAKER SYNDROME IN VVIR PACED PATIENTS

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Abstract: *Pacemaker therapy has become an important therapeutic option for patients with heart rhythm conditions worldwide. In Romania in the last decade pacing is playing an increasingly important role in the management of cardiac disease.*
A few years after the introduction of pacing therapies, the general practitioners and cardiologists realized that despite of the relief of life-threatening arrhythmias in paced patients, the changes in the hemodynamic and humor status may influence the clinical outcome, prognosis and the quality of life after cardio stimulation and be followed by a deterioration of the patients' condition.
This study evaluates the clinical outcome and the incidence and predictors of the pacemaker syndrome in 547 patients with ventricular-based (VVIR) pacing, implanted in "Sf. Ioan" Hospital, Bucharest, over a period of 7 years.

Key words: *right ventricular pacing; AV dyssynchrony syndrome; pacemaker syndrome; VVI = ventricular-based pacing; VVIR = rate modulated ventricular-based pacing*

1. Introduction

Numerous international multicenter studies, already published, or in progress, trie to compare the benefits of the two types of cardiac pacing devices – mono and bicameral - on life quality, incidence of complications and mortality.

Study	Nr. of pts.	Pacing mode tested
CTOPP[2]	2450	VVI(R) *versus* AAI(R) si DDD(R)
UKPACE[3]	2021	VVIR *versus* DDDR
MOST[4]	2010	VVI sau VVI(R) *versus* DDD

Pacemaker syndrome, or intolerance to VVIR pacing, consists of a number of cardiovascular signs and symptoms induced by the right ventricular pacing. Erbel was the first to name the pacemaker syndrome in 1979. He described a patient in whom ventricular pacing was associated with an episodic, highly symptomatic decline of peripheral arterial pressure when there was a loss of synchrony between atrial and ventricular contraction.

Since then the definition of the pacemaker syndrome has gone through several stages of evolution. The question of improvement in the quality of life by single chamber right ventricular pacing has not been thoroughly examined.

The expectation that the hemodynamic benefits of atrioventricular synchrony would lead to a reduction in cardiac mortality, a reduced risk of heart failure, and a better quality of life were not proven by all the clinical trials. The MOST study which followed for three years the cardiovascular mortality and morbidity in patients with DDDR cardio stimulation toward patients with VVIR cardio stimulation showed no statistical differences between the two groups. In exchange, concerning the heart failure episodes and the quality of life, the study proved the superiority of the DDDR stimulation.

Since heart failure is one of the most important complications after cardiostimulation and it is accompanied by high level of invalidity and mortality the aim of many clinical studies was to asses the real incidence of the pacemaker syndrome. According to statistical dates 70% of the men and 63% of the women which develop heart failure symptoms die in the first 6 years. The high morbidity and mortality due to this post implant complication justifies detailed clinical and fundamental research in order to accurate stratify the risk patients.

2. Methods

The study included 547 patients, men and women, who needed permanent pacing according to the guidelines ACC/AHA/NASPE 2002 (Guideline Update for Implantation of Cardiac Pacemakers anti arrhythmia devices).

Patients who refused to sign the written consent and those with serious (severe) coagulation disorders, chronic patients with dialysis or with cancer in terminal stages were excluded.

The follow up after the implant was made at 1 month, 3 month and 12 month.

Patients were evaluated before implant by a complete clinical examination. Cardiac risk factors, cardiac and associated non cardiac pathology were identified and concomitant medication was recorded.

For a proper evaluation of heart failure a special attention was given to include the patients in different NYHA classes according with their symptoms. The symptom screening, prior to the clinical examination and echocardiogram was made by the physician by asking the same questions in order to evaluate symptoms of heart failure.

The real effort capacity was estimated by standard 6 minutes walking test.

Before and after the implant, the end systolic and end diastolic volumes of the left ventricle and the ejection fraction (Simpson method in two and four chambers incidence) were measured.

Echocardiographic measurements were made in M mode and two-dimensional echocardiography (2DE). Measurements of left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), and EF were obtained using the software installed on

the ultrasound equipment, with LVEDV measurements at the time of mitral valve closure and LVESV measured on the image with the smallest LV cavity. The papillary muscles were excluded from the volumes. Biplane Simpson's rule volumes were obtained from the apical four- and two-chamber views.

Mode parameters were measured according to the American Society of Cardiology. The quality of life before and after the implant was also assessed by using CDC HRQOL-14 Module which included the *Healthy Days Core Module* (4 questions). *Activity Limitations Module* (5 questions) and the *Healthy Days Symptoms Module* (5 questions).

We also used the MLHFQ score, an 21 question test which was developed at the University of Minnesota, Minneapolis USA, as an independent scale for the outcome of the patients with heart failure. The questionnaire is scored by summating the responses to all 21 questions (score 105 meaning severe limitation and score 0 meaning no limitation).

We defined a pacemaker syndrome when a patient with single-chamber VVIR pacing developed after the implant either congestive signs and symptoms associated with retrograde conduction during VVIR pacing, or a ≥20 mm Hg reduction of systolic blood pressure during VVIR pacing, associated with reproducible symptoms of weakness, lightheadedness, or syncope.

3. Results

The study included 547 patients with ventricular-based (VVIR) pacing, implanted in "Sf. Ioan" Hospital, Bucharest, between 2000 and 2007. All includend patients did sign the informed consent. The male sex was preponderant (62,24%). The mean age was 73 ± 12 years, with 21,9% of the patients aged over 85 years.

The highest incidence between the risk factors was hypertension (63%) in the female group and history of smoking in the male group (66%). Other risk factors were equally prevalent in the male and female group. 24% of the female group and 44,1% of the male group had evidence of ischaemic heart disease. ($p<0,001$)

Regarding the follow up after the implant - at 1 month, 3 month and 12 month, at the end of the study only 29 (5,30%) patients were lost from the follow up.

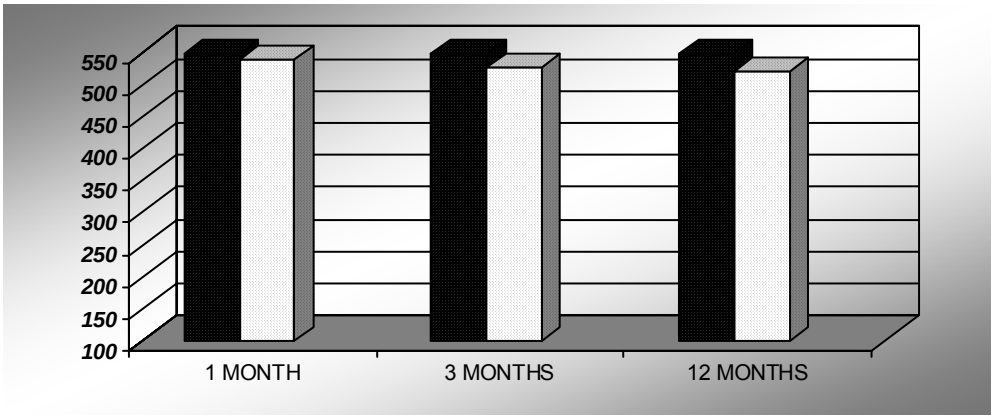

Figure 1. Patient's follow up

Prior to the clinical examination, at each follow up each patient was asked a number of questions in order to evaluate the symptoms.

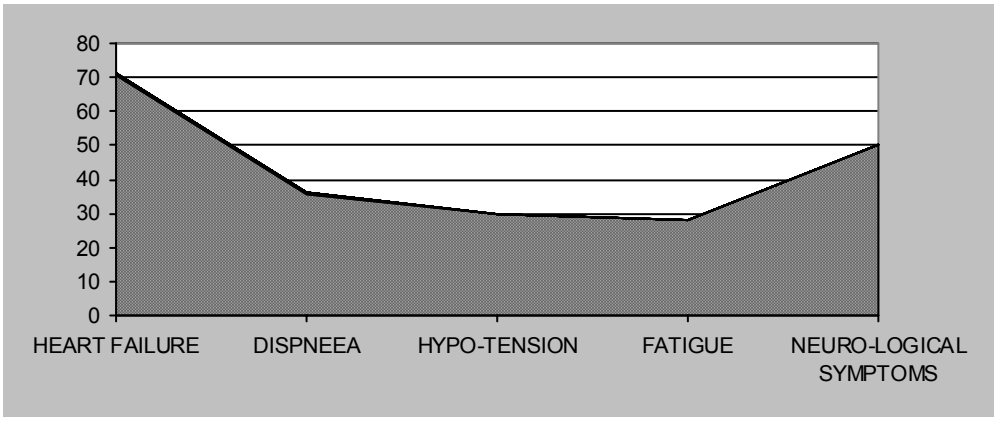

Figure 2. Symptom burden (%)

In order to assess the exercise capacity, a standardized six minutes walk test was performed. Patients which were noncompliant (5,11%), or incapable of performing the test due to immobility (3,47%) were excluded from the test.

The echocardiographic findings showed at baseline (before the pacemaker implant) that 455 patients (13,8%) of the patients had EF>50% and no symptoms of heart failure.

147 patients (16,8%) had symptoms correlated with NYHA class II – IV and a LVEF between 35 - 40% and 28 patients had the same symptoms but had a LVREF < 35%.

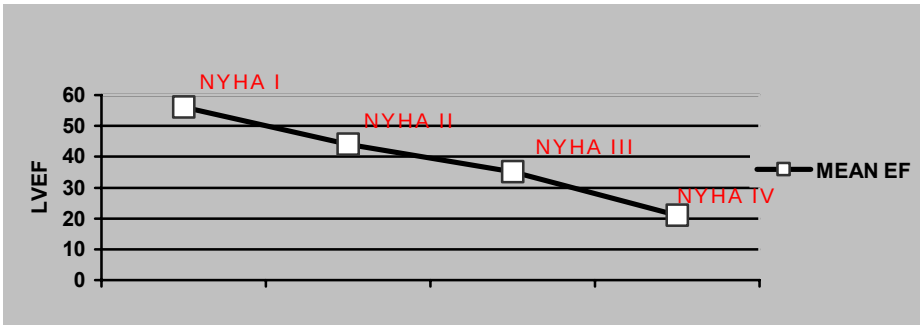

Figure 3. Mean LVEF for each NYHA class

Prevalence of heart failure showed to increase steeply with age in the patient group at baseline (prior to stimulation), so that while around 4% of the patients aged under 65 had heart failure, this increased to between 25 and 28% of those aged 75 to 84 and to 55,8% of those aged 85 and over.

AGE	Number of patients	Number with heart failure	Number without heart failure
≤ 65	25	2	23
65-74	220	55	165
75-84	182	51	131
≥ 85	120	67	53
Total	**547**	**175**	**372**

T

he incidence of atrial fibrillation was increasing during the study from 63,43% to 77,41%.

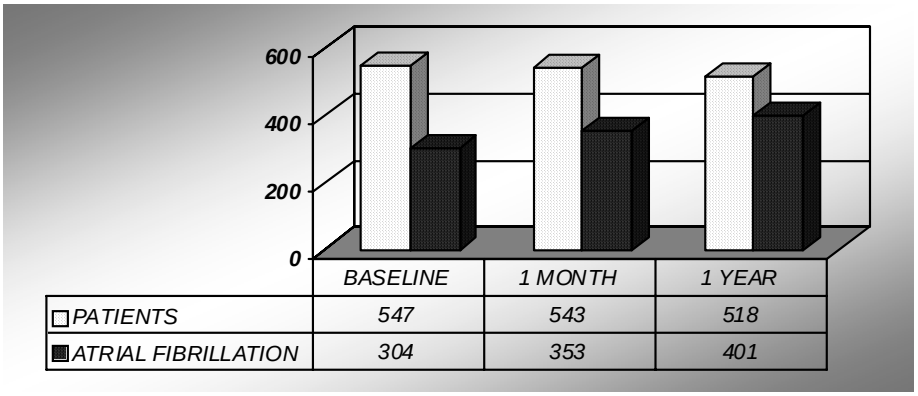

Figure 4. The incidence of atrial fibrillation

The scores on the specific activity scale varied as follows:

Score on Specific Activity Scale	BASELINE	1 MONTH	3 MONTHS
1 (best)	185	195	190
2	125	116	115
3	180	179	180
4 (worst)	10	10	15
P VALUE		0.71	0.22

MLHFQ	BASELINE	1 YEAR	P VALUE
	21,7 ± 2,5	18,7 ± 3,0	0,0284

After cardiostimulation the pacemaker syndrome as defined in our study occurred at 23 patients (4,2%).

4. Discussions and Conclusions

The global incidence of the pacemaker syndrome in our group of patients was lower (4,20%) than in the TRAVILL STUDY (20%), and much lower than in the HELDMAN STUDY (83%).

The incidence of the pacemaker syndrome was similar in the male group (4.9%) and the female group (4,06%) ($p<0,0001$).

The relation between VVIR pacing and the development of the pacemaker syndrome is likely to be complex. Age, comorbidity and haemodinamic status before pacing are factors that influence the appearance of the pacemaker syndrome.

The patient group over 85 years had a higher incidence of worsening heart failure than the other age groups.

The patients with EF> 40% before pacing had a better outcome than those with impaired left ventricular systolic function.

The data of our study show that VVIR pacing may not induce directly heart failure but may increase the risk of developing atrial fibrillation, an important precipitant of heart failure.

One limitation of the study is the fail to study the relationship paced beats/ nonpaced beats in our patients. It might be a direct relationship between the percentage of VVI paced beats and the occurrence of the pacemaker syndrome.

The echocardiographic measurement of the LVEF was a better predictor for developing heart failure than the 6 minutes walk test.

Pacemaker implantation resulted in substantial improvement in almost all QOL measures. Subjects 75 years or older experienced significantly less improvement in functional status and physical scores than did younger patients.

The aethiology of heart failure and of the pacemaker syndrome in VVIR paced patients is variate and may only partial be induced by the right ventricular pacing.

Further studies are required in order to evaluate the impact of VVIR on clinical outcome and its relationship with QOL coefficients.

Pacemaker syndrome incidence was much lower in our study, comparing to other clinical studies.

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Quantitative Methods Inquires

TEST POWER IN COMPARISON DIFFERENCE BETWEEN TWO INDEPENDENT PROPORTIONS

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Abstract: *In this study, the effect of population proportion difference (effect size) and the relation between sample sizes on test power in comparing two independent proportions were investigated. At the end of 50 000 simulation experiments it was observed that increasing in the sample size and population proportion difference increase the test power while the controversy decreases it. In the case of studies with equal sample sizes, sufficient test power level (80.0 %) was obtained by 60, 90, 150 and 350 observations when δ= 0.25, 0.20, 0.15 and 0.10, respectively. On the other hand, it is not available to obtain sufficient power level even for the extremely large sample size taken into consideration (500 observations) when δ=0.05. Results of this study showed that the inequality in sample size or relations between sample sizes (n2=r.n1 or n1=r.n2) affect the test power. However, total number of observations may be more effective on the test power rather than inequality in sample sizes.*

Key words: *Test power; sample size; simulation; comparing two proportions*

1. Introduction

The statistical method used in evaluating the observed values concluded from an experiment or research changes depending on the way of collecting the data, sample size, the shape of the distribution, the number of factors to be studied, the correlations between the variables, and whether the variances are homogenous or not (Ott, 1998; Mendeş, 2002). In practice, researchers mostly interested in with the difference of the proportions of observing a property taken from a population which has a binomial distribution (i.e has only types of two outcomes). That means, we are interested in testing the control hypothesis: $H_0 : p_1 = p_2$ against the alternative hypothesis stated as: $H_1 : p_1 \neq p_2$. In testing the

hypothesis given above, as known, Z-test is used given as $Z = \frac{P_1 - P_2}{\sigma_{\bar{d}}}$ (Winer et al., 1991; Zar, 1999; Sheskin, 2000). If Ho is rejected ($Z \geq 1.96$), the difference between two proportions is statistically significant. But especially lately, it is emphasized that only rejecting Ho hypothesis itself does not give enough information and there is a great deal of advantage to emphasize how a right decision is made by rejecting it. In other words, embodying the test power to the research has a great deal of importance of defining the probability of failure out coming from rejecting the Ho hypothesis.

Test power can be defined as, the probability of false rejecting of the null (Ho) hypothesis, and expressed as 1-β (Adcock, 1997; Mendeş, 2004a). The lower bound value of the test power is accepted as 80% in general (Cohen, 1988; Hoening ve Heisey, 2001; Wilcox, 2002; Mendeş, 2002; Ferron ve Sentovich, 2002). Calculating the test power enables the researcher, not only to get information about the hypothesis which should be rejected indeed but which concurrently will be rejected as a result of the analysis with how much probability, but also to determine an appropriate sample size (Lenth, 2001). As it is known, one of the topics that a researcher should have a difficulty on is to make a decision on the sample size used in the study (Adcock, 1997; Mendeş, 2005a).

Determining the appropriate sample size for an experiment or a research is a crucial component of the study design. Studying with appropriate sample size provides of the researcher to obtain reliable information about the study. However, it is not easy to determine adequate or optimum sample size. Since test power and sample size are related to each other, the calculation of test power gives at least an idea about whether the sample size of the experiment is enough or not. As a result of this procedure, the researcher may have an idea about the sample size which will be dealt with for the successive experiments. The smallest sample size when an enough test power value (80%) obtained, can be accepted as an appropriate or optimum sample size (Ferron and Sentovich, 2002; Mendeş, 2004b).

The major purpose of this study is to determine test power and appropriate sample size depending on the experimental conditions such as sample sizes and the population proportion difference or effect sizes.

2. Material and Method

The material of this study is composed of the random numbers which are generated from the IMSL library of Microsoft FORTRAN Developer studios (Anonymous, 1994). With this motivation, by the aim of RNBIN sub-function, different sizes of samples are taken from two binomially distributed populations. Random number are chosen for the probability of the selected property to be p1=0.75 for the first sample, and p2=0.50, 0.55, 0.60, 0.65 and .0.70 for the second sample respectively. Subsequently, aimed to estimate the test power, the difference between two population proportion is taken as (δ=p1-p2), so five difference-of-proportions (effect size) are formed as δ=p1-p2=0.05, 0.10, 0.15, 0.20 and 0.25. By this motivation, it is observed that how the power of the test changes, depending on the difference between two proportions. In the study, in order to determine how the differences of the two samples affect the power of the test, both the equal sample size (n1=n2) and the unequal sample size (n2/n1=1.5, n2/n1=2.0 ve n2/n1=2.5) cases were taken into consideration. Each experimental condition which has been taken into consideration is

repeated for 50,000 times (Mendeş, 2005b). Subsequently, the number of the H_0 hypothesis is determined which are false indeed and also found as false through analysis. Then, it is converted to the percentages makes estimations about the test power. The predetermined alpha level was 0.05 in all computations.

2.1. Calculating the power of the test analytically with regard to the difference between proportions

The Z-test expressed as $Z = \frac{P_1 - P_2}{\sigma_{\bar{d}}}$ is exploited to test $H_0 : p_1 = p_2$ hypothesis with a probability of specific error (α), against $H_1 : p_1 \neq p_2$ using samples sizes n1 and n2 taken from the populations which have the probability of being or proposed to be p1 and p2. Where, $\sigma_{\bar{d}} = \sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}$. The estimation of the test power while comparing the differences between two independent proportions, is made by Eq.(1) (Agresti, 1990; Zar, 1999).

$$1-\beta = P\left[Z \leq \frac{-Z_{\alpha/2}\sqrt{\bar{p}\bar{q}/n_1 + \bar{p}\bar{q}/n_2} - (p_1 - p_2)}{\sqrt{p_1 q_1/n_1 + p_2 q_2/n_2}} \right] + P\left[Z \geq \frac{-Z_{\alpha/2}\sqrt{\bar{p}\bar{q}/n_1 + \bar{p}\bar{q}/n_2} - (p_1 - p_2)}{\sqrt{p_1 q_1/n_1 + p_2 q_2/n_2}} \right] \quad (1)$$

where, $\bar{p} = \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}$, $q_1 = 1 - p_1$, $q_2 = 1 - p_2$ and $\bar{q} = 1 - \bar{p}$

3. Results and Discussion

3.1. Estimations of the power of the test when n1=n2

When both samples have the same sample size (n1=n2), the test power depending on the difference between the proportion, are given in Table 1. According to Table 1, it can be seen that, the sample size affects the test power very much, regardless of the difference between the proportions. That effect is more evident in case of the difference of the proportion is ~~too~~ quite small (δ=p1-p2≤0.10). For instance, when δ=p1-p2=0.25 and n1=n2=5, the power of the test is estimated as 12.1%. But, when the difference between the proportion is δ=0.20, the test power decreases to 9.6%, when δ=0.15 it decreases to 7.7%, when δ=0.10, it decreases to 6.3% and when δ=0.05, it decreases to 5.3%. In case the sample size increased to 15, the test power values are 28.6%, 20.4%, 13.8%, 9.3% and 6.5% respectively depending on the difference between the proportions taken into consideration, when the sample size increased to 30, the values are to be 51.7%, 37.3%, 24.3%, 13.5% and 7.8% respectively, when the sample size increased to 60, the values are 82.1%, 64.3%, 41.8%, 22.4% and 10.3% respectively.

In case the sample size is increased to 500 respected as an extreme value in practice, the test power values resulted as 100.0%, 99.9%, 99.9%, 93.7% and 42.7%. As it

can be noticed, similar to the decrease in the difference between the proportions, the test power decreases. When the difference between the proportions is δ=0.05, even if the sample sizes are 500 (even if the sample sizes are totally 1000), the test power just increases to 42.7%. That is, even if when δ=0.05 while dealing with samples sizing of 500 each, it can be concluded that just 42.7% of the hypothesis given as $H_0 : p_1 = p_2$ and false indeed, are false also as a result of the analysis of hypothesis. Reviewing the Table-1; when δ=0.25, studying with the sample size of 60 for each (total of 120 observations), results to obtain enough power values (82.1%); and when δ=0.20, obtaining enough power values (81.1%) requires a sample size of for 90 for each. As δ decreased to 0.15, obtaining enough power values (80.1) requires a sample size of 150 for each (total of 300 observations); but as δ decreased to 0.10 obtaining enough power values (83.0%) requires a sample size of almost 350 for each (total of 700 observations). These findings support the results of the studies of Berry and Hurdato (1994) and Schlotzhauer (1996). On the other hand, as δ decreased to δ=0.05, enough power values can not be obtained even if the sample size is 500. As it is mentioned before, calculating the test power can also be used as criteria for obtaining information about the adequacy of the sample size. As a result, the appropriate sample size is proposed as 60 when δ=0.25, as 90 when δ=0.15, as 150 when δ=0.15 and as 350 when δ=0.10. But when δ=0.05, since the 80.0 % of a power value may not be obtained in any valuable experiment, it is almost impossible to declare an idea about the sample size.

3.2. Estimation of the power values of the test when n2=r.n1 and n1=r.n2

Among the sample sizes taken into consideration in the study, when relation is n2=r.n1 or n1=r.n2 between the sample sizes, that is, as the samples sizes are r times of each other (r=1.5, 2.0, 2.5), the test power values are given in Table-2, depending on the differences between the proportions. The resultant power values when the second sample size is 1.5 times greater than the first one (n2=(1.5).n1), and when the first sample size is 1.5 times greater than the second one, it can be seen that they are very close to each other (Table-3) except the sample size combination of (6:9). This result is valid for all the differences between the proportions taken into account (δ=0.25, 0.20, 0.15, 0.10, 0.05). Same situation can generally said to be valid for the case that one sample size is 2 or 2.5 times greater than the former one. But one of the most important point that should be highlighted for that experiment conditions is, the increase in the ratio of the sample sizes, in other words increase in the imbalance between the observations, causes the resultant power values a little bit higher when n1=r.n2, than those of when n2=r.n1. In this experimental conditions, just like in the conditions when n1=n2, the smallest power values are obtained when δ=0.05.

Existing a relationship between the sample sizes as n1=n2, n2=r.n1 or n1=r.n2, causes a differentiation on the strength of the test power values. In general, obtained power values are higher when the sample size is large. Anyway, it is recommended for the researchers deal with the same or nearly the same sample size in their studies or researches (Zar, 1999; Mendeş, 2005a). But in practice, due to the different reasons, it is not always possible to deal with the same sample sizes. In such conditions, the answer is very crucial to the question of "what kind of a relationship must be exist between the sample sizes depending on the experimental conditions taken into consideration". It is recommended to the researchers aiming to find the answer to this question that they can deal with the sample

sizes as n1,n2=(60,90), (90,60), (60,120), (120,60), (40,100) or (100,40) which provides approximately the same power conditions, in case when δ=0.25 and as the smallest sample size combination condition being n1=n2=60 can not be provided. When δ=0.20, as it is impossible to deal with the smallest sample size combination being n1=n2=90 which can not provide enough power values, it can be suggested that dealing with the sample sizes of n1, n2=(100,150), (150,100), (100,200), (200,100), (80,200) or (200,80). When δ=0.15, as it is impossible again to deal with the combination being n1=n2=150 which again can not provide enough power values, it can be suggested that dealing with the sample sizes of n1,n2=(200,300) or (300,200).

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Appendixes

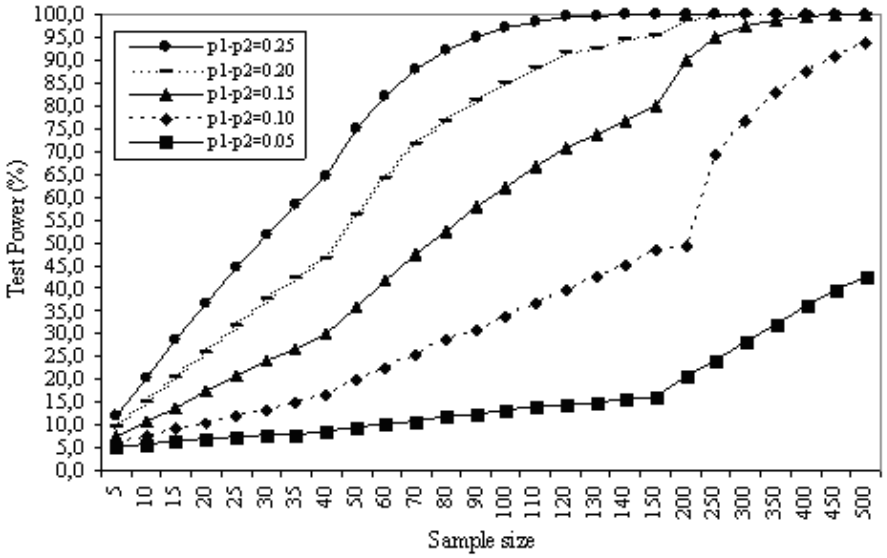

Figure 1 : The power values (%) when sample sizes were equal

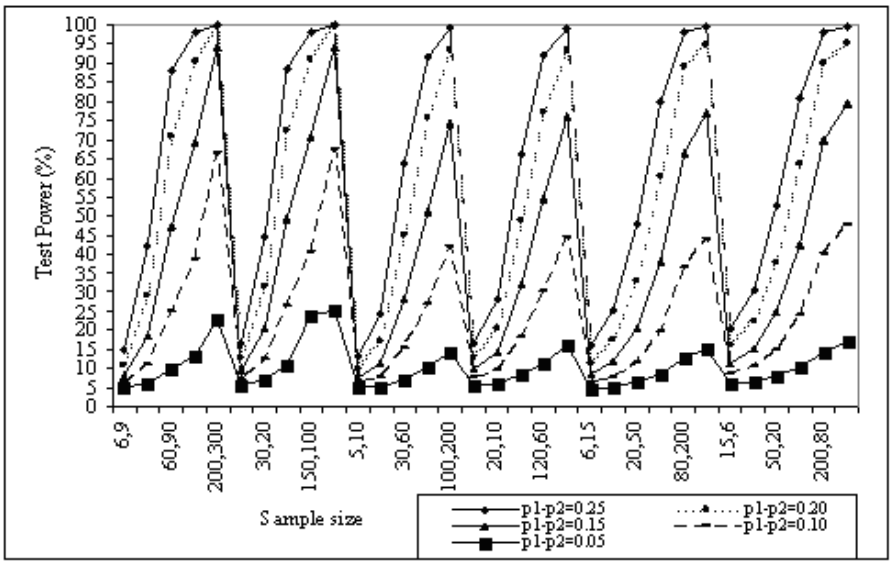

Figure 2 : The power values (%) when sample sizes were unequal

Table 1. The power values (%), obtained depending on the differences between proportions, in case of dealing with the same sample sizes

	δ=0.25	δ=0.20	δ=0.15	δ=0.10	δ=0.05
n1=n2	1-β	1-β	1-β	1-β	1-β
5	12.1	9.6	7.7	6.3	5.3
10	20.3	15.1	11.0	7.6	5.8
15	28.6	20.4	13.8	9.3	6.5
20	36.8	26.0	17.3	10.5	6.9
25	44.5	31.8	20.8	11.9	7.3
30	51.7	37.3	24.3	13.5	7.8
35	58.2	42.0	26.5	15.2	8.0
40	64.7	46.8	30.1	16.7	8.7
50	74.9	56.2	35.8	19.8	9.4
60	**82.1**	64.3	41.8	22.4	10.3
70	87.8	71.8	47.4	25.5	11.0
80	92.1	76.5	52.7	28.6	11.9
90	95.2	**81.1**	57.8	31.0	12.6
100	97.1	85.2	62.2	33.8	13.5
110	98.3	88.3	66.5	36.7	14.2
120	99.5	91.6	70.8	39.7	14.6
130	99.7	92.7	73.6	42.4	15.0
140	99.9	94.5	76.7	44.9	15.7
150	99.9	95.6	**80.1**	48.2	16.4
200	99.9	98.8	90.2	49.2	20.8
250	99.9	99.7	95.1	69.1	24.3
300	100.0	99.9	97.7	76.5	28.2
350	100.0	99.9	98.9	**83.0**	32.1
400	100.0	99.9	99.5	87.3	36.1
450	100.0	99.9	99.8	90.8	39.4
500	100.0	99.9	99.9	93.7	42.7

Table 2. The power values (%), obtained depending on the differences between proportions, in case of dealing with different sample sizes

n2=(1.5)n1	δ=0.25	δ=0.20	δ=0.15	δ=0.10	δ=0.05
N1	1-β	1-β	1-β	1-β	1-β
6:9	14.7	11.2	8.3	6.4	5.2
20:30	42.1	29.1	18.6	11.0	6.4
60:90	88.2	71.0	47.6	25.1	9.9
100:150	98.3	90.6	69.5	38.6	13.5
200:300	99.9	99.7	94.1	66.4	22.8
n1=(1.5)n2					
9:6	16.7	12.9	9.8	7.4	5.8
30:20	44.3	31.5	20.6	12.5	7.1
90:60	88.4	72.2	49.5	26.5	10.8
150:100	**98.3**	90.8	70.8	40.8	24.1
300:200	99.9	99.7	94.3	67.3	25.3
n2=(2)n1					
5:10	13.3	10.0	7.6	6.1	5.1
10:20	24.3	17.1	11.5	7.7	5.5
30:60	63.8	45.2	28.1	15.2	7.4
60:120	91.6	75.4	51.2	26.8	10.3
100:200	99.0	93.3	74.0	42.0	14.3
N1=(2)n2					
10:5	16.6	13.0	10.0	7.6	5.9
20:10	28.1	20.5	14.5	9.5	6.4
60:30	65.8	48.6	32.0	18.1	8.5
120:60	91.8	77.1	54.5	30.0	11.5
200:100	99.1	93.5	76.1	44.5	16.1

n2=(2.5)n1					
6:15	16.2	11.6	8.4	6.3	5.0
10:25	25.3	17.6	11.8	7.7	5.5
20:50	48.0	33.1	20.5	11.6	6.5
40:100	80.0	60.1	38.1	19.8	8.5
80:200	98.1	89.2	66.7	36.5	13.1
100:250	99.5	94.8	76.8	44.1	15.2
n1=(2.5)n2					
15:6	20.6	16.2	11.6	8.5	6.2
25:10	30.7	22.3	15.4	10.3	6.9
50:20	52.5	38.0	25.1	14.6	8.0
100:40	80.9	63.5	42.8	23.8	10.3
200:80	98.2	89.8	70.0	40.2	14.5
250:100	99.4	95.0	79.2	47.8	17.2

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TIME-COST OPTIMIZATION MODEL FOR DETERMINISTIC NETWORK PROJECTS[1]

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Abstract: *A deterministic PERT activity-on-arc network $G(N,A)$ with logical operation "AND" at the event's receiver and "MUST FOLLOW" at the event's emitter, is considered. Each activity $(i,j)\in A$ entering the model can be operated within several deterministic durations t_{ij} depending on the corresponding budgets c_{ij} assigned to that activity. The problem centers on determining optimal budget values c_{ij} to be assigned to each activity $(i,j)\in A$ in order to minimize the network's critical path subject to the restricted pregiven budget C assigned to the whole project $G(N,A)$.*

Key words: *Deterministic PERT project; Restricted pregiven budget assigned to the project Optimal local budgets assigned to project's activities; Heuristic iterative algorithm; Critical path's minimization*

1. Introduction

A variety of publications (see Arisawa and Elmaghraby [1][7], Arsham [2], Ben-Yair [3], Deckro and Herbert [4], Golenko-Ginzburg [6-8], Howard [9], Kelley [10], Laslo [11-12], Panagiotakopoulas [13], Siemens [14], etc.) is related to stochastic network projects (in the form of a graph $G(N,A)$ comprising nodes $i \in N$ and activities $(i,j) \subset A$ leaving node i and entering node j) with random activity durations. For any activity (i,j) entering the network project $G(N,A)$, it is assumed that:

- the corresponding activity duration t_{ij} depends parametrically on the budget c_{ij} assigned to that activity, and
- the budget value c_{ij} satisfies

$$c_{ij\ min} \le c_{ij} \le c_{ij\ max},$$

where $c_{ij\ min}$ stands for the minimal budget capable of operating activity (i,j), and $c_{ij\ max}$ is the maximal budget required to operate activity (i,j). Both values $c_{ij\ min}$ and $c_{ij\ max}$ are pregiven beforehand.

Note that in case $c_{ij} > c_{ij\ max}$ additional value $c_{ij} - c_{ij\ max}$ is redundant. Thus, function $t_{ij} = f_{ij}(c_{ij})$ can be implemented for any $(i,j) \in A \subset G(N,A)$. The main objective of the time – cost trade-off procedure is to consider the relationship between the project duration and the total project costs.

The main purpose of the time – cost trade-off can be stated as the development of the procedure to determine activity cost assignments to reduce as much as possible the project duration time under restricted total project's costs (usually pregiven). The classical time – cost model is as follows:

Given a PERT graph $G(N,A)$ together with functions $t_{ij} = f_{ij}(c_{ij})$, $(i,j) \in G(N,A)$, and values $c_{ij\ min}$ and $c_{ij\ max}$, determine:

- the minimal total project direct costs C,

$$Min\ C, \quad \text{and} \tag{1}$$

- the optimal assigned budget values c_{ij}^{opt}, subject to

$$T_{cr}\left\{t_{ij} = f_{ij}\left(c_{ij}^{opt}\right)\right\} \le D, \tag{2}$$

$$\sum_{\{i,j\}} c_{ij}^{opt} = C, \tag{3}$$

$$c_{ij\ min} \le c_{ij}^{opt} \le c_{ij\ max}, \tag{4}$$

where D stands for a pregiven due date.

Problem (1-4) is usually solved [4] by means of heuristic methods. In cases of non-linear f_{ij} the problem becomes too difficult to be solved analytically [1].

In [3, 7] the trade-off model minimizes the allocated budget under given time chance constraint. The extension of problem (1-4) for a random activity duration t_{ij} is as follows:

Given the PERT-COST project $G(N,A)$ with random activity durations t_{ij}, $(i,j) \in G(N,A)$, where for each activity (i,j) its probability density function (p.d.f.) $p_{ij}(t)$ depends parametrically on the budget c_{ij} assigned to that activity: the problem is to minimize the project's budget C

$$Min\ C, \tag{5}$$

as well as to determine the optimal budget volumes c_{ij}^{opt} assigned to each activity $(i,j) \in G(N,A)$ subject to

$$Pr\left\{ T\left[t_{ij} / c_{ij}^{opt}\right] \le D \right\} \ge p, \tag{6}$$

$$\sum c_{ij}^{opt} \le C, \tag{7}$$

$$c_{ij\ min} \le c_{ij}^{opt} \le c_{ij\ max}. \tag{8}$$

Here:

- $T\left[t_{ij} / c_{ij}^{opt}\right]$ stands for the project's random duration on condition that all the activity's durations are random values with p.d.f. $p_{ij}\left(t / c_{ij}\right)$. Value $T\left[t_{ij} / c_{ij}^{opt}\right]$ can be determined either via simulation, or by means of approximate analytical methods;
- D designates the pregiven due date;

- p is the minimal value of the chance constraint (pregiven by the project management as well).

Problem (5-8) is a very complicated problem which even for medium-scale projects cannot be solved analytically. It requires therefore heuristic solutions that are widely used nowadays in various design offices [7].

It can be well-recognized that even nowadays there do not exist both simple and effective time – cost optimization procedures. Moreover, even for most simplified deterministic activity-on-arc PERT networks where each activity can be operated with several rates by assigning several corresponding cost values for each activity, classical time – cost problems have not found as yet their solution. This refers both to minimizing the project's critical path duration by optimal allocation of the restricted project's budget among the activities, or to minimizing project's budget subject to the restricted critical path duration.

In this study we suggest a simple heuristic procedure which enables to solve both of the outlined above problems. An activity-on-arc network with logical operation "AND" at the event's receiver and "MUST FOLLOW" at the event's emitter, is considered. Each activity $(i, j) \in A$ entering the network can be operated by n_{ij} different rates, i.e., within n_{ij} different deterministic durations t_{ij} depending on n_{ij} corresponding budget values c_{ij} assigned to that activity. Both the direct and dual problems center on determining the optimal budget assignment c_{ij} among all activities (i, j) in order either to minimize the critical path duration subject to restricted project's total budget (direct problem), or to minimize the total budget subject to restricted (from below) critical path length.

The problems are solved by means of a simple heuristic procedure based on numerous critical path length calculations together with determining the so-called critical activity rates for each activity entering the project. The general idea is to diminish as much as possible the budget values assigned to activities with law critical rates, and to transfer the released budget for activities with high critical rates.

A numerical example is presented.

2. Definitions

In order to proceed we require the following definitions:

Definition 1. Call a PERT type deterministic network model properly enumerated if for any activity (i, j) entering the network relation $i < j$ holds.

Definition 2. Call a list of activities entering a properly enumerated network a lexicographically ordered list if *any* two different activities (i_1, j_1), (i_2, j_2) are placed in the list according to the following rules:

- if $i_1 < i_2$, (i_1, j_1) is placed before (i_2, j_2);
- if $i_1 = i_2$, and $j_1 < j_2$, (i_1, j_1) is placed before (i_2, j_2);
- in all other cases (i_1, j_1) is placed after (i_2, j_2).

Definition 3. For each activity (i, j) entering a PERT type deterministic network model, its critical activity rate CAR_{ij} can be calculated as follows [6]:

$$CAR_{ij} = 1 - \frac{T^l_{(j)} - T^e_{(i)} - t_{ij}}{T_{cr} - T^*\left[L_{cr}, L(i,j)_{\max}\right]}, \quad (9)$$

where:

- $T^l_{(j)}$ is the latest possible moment for event j to occur;
- $T^e_{(i)}$ is the earliest possible moment for event i to occur;
- $T\left[L(i,j)_{\max}\right]$ is the duration of the longest path connecting the source and the sink nodes and comprising activity (i, j);
- T_{cr} is the duration of the critical path L_{cr};
- $T^*\left[L_{cr}, L(i,j)_{\max}\right]$ is the duration of the part of $L(i,j)_{\max}$ which belongs to the critical path as well.

Note that for all activities (i, j) belonging to the critical path, relation $CAR_{ij} = 1$ holds.

3. Notation

Let us introduce the following terms:

$G(N, A)$ - deterministic PERT type network project;

$(i, j) \in A$ - activity leaving node i and entering node j;

M - number of activities entering the project;

$t_{ij}(c_{ij})$ - deterministic activity duration depending on the budget value c_{ij} assigned to (i, j);

n_{ij} - number of different budget values which can be assigned to (i, j);

c_{ijk} - k-th budget value which can be assigned to (i, j), $1 \le k \le n_{ij}$ (pregiven); values c_{ijk} are given in ascending order;

t_{ijk} - deterministic activity duration corresponding to value c_{ijk} (pregiven); it can be well-recognized that values t_{ijk} are given in descending order);

L_{cr} - critical path of network $G(N, A)$;

$L(i,j)_{\max}$ - the longest path connecting the source and the sink nodes and comprising activity (i, j);

$T_{cr}/\{c_{ij}\}$ - critical path length obtained on the basis of duration $t_{ij}(c_{ij})$;

$T^l_{(j)}$ - the latest possible moment for event $j \in N \subset G(N,A)$ to occur;

$T^e_{(i)}$ - the earliest possible moment for event $i \in N \subset G(N,A)$ to occur;

$T^*[L_{cr}, L(i,j)_{\max}]$ - duration of the intersection between L_{cr} and $L(i,j)_{\max}$.

ΔC - cost value step (pregiven);

δT - relative accuracy value to obtain a quasi-optimal solution (pregiven);

ω - iterative relative change;

C - total budget value assigned to project $G(N,A)$ (pregiven).

Note that relation

$$\sum_{\{i,j\}} c_{ij1} \le C \tag{10}$$

holds, otherwise the problem has no solution.

In case

$$\sum_{\{i,j\}} c_{ijn_{ij}} \le C \tag{11}$$

the problem obtains a trivial solution $\{c_{ijn_{ij}}\}$.

4. The problem

The problem is to determine for each activity (i,j) entering the project, quasi-optimal values $c_{ij\varepsilon_{ij}}$, $1 \le \varepsilon_{ij} \le n_{ij}$, in order to minimize the project's critical path length subject to the pregiven project's budget:

$$\underset{\{c_{ij\varepsilon_{ij}}\}}{Min} \left\{ T_{cr}/\{c_{ij\varepsilon_{ij}}\} \right\} \tag{12}$$

subject to

$$\sum_{\{i,j\}} c_{ij\varepsilon_{ij}} \le C\,. \tag{13}$$

Note that to determine an optimal combination of values $c_{ij\varepsilon_{ij}}$ by means of an analytical lookover algorithm leads even for small- and medium-size projects ($M < 15 \div 20$, $n_{ij} \approx 3 \div 5$) to enormous computational efforts. This is why preference has to be given to more attractive and at the same time more realistic heuristic algorithms. The latter result in obtaining quasi-optimal values which usually meet most practical requirements.

5. Heuristic algorithm

We will apply a newly modified version of the model outlined in [4, 7]. The step-wise procedure of the algorithm is as follows:

Step 1. Enumerate properly all the activities entering the project.

Step 2. Order lexicographically the list of activities.

It can be well-recognized that *Steps 1-2* appear in most textbooks on project management, e.g. in [6].

Step 3. By any means reassign budget C among the project's activities $(i, j) \in A \subset G(N, A)$ subject to

$$\sum_{\{i,j\}} c_{ij} = C \tag{14}$$

to obtain a feasible solution of the problem. One may suggest a variety of different methods to carry out *Step 3* on the basis of (10), e.g. first to set c_{ij1} for each activity (i, j), and afterwards to reallocate the remainder $C - \sum_{\{i,j\}} c_{ij1} = \Re$ among the activities. This can be carried out by consecutively adding value ΔC to all activities (being arranged in an lexicographical order) by honouring their maximal possible values $c_{ijn_{ij}}$, until the remainder $\Re$ will be totally exhausted.

Step 4. Calculate the project's critical path length T_{cr} for values c_{ij} and durations t_{ij} obtained on *Step 3*. Call the obtained value $T_{cr}^{(1)}$.

Step 5. Calculate by means of (9) the activities' CAR_{ij} values.

Step 6. Reorder the project's activities in descending order of their CAR_{ij} values. For (i, j) with similar CAR values place first activities with smaller lexicographical numbers.

Step 7. Choose the activity with the minimal CAR_{ij} value (i.e., in the right part of the list), on condition that its budget value c_{ij} may be decreased by value $\Delta_1 = c_{ij} - c_{ij1} \geq \Delta C$ in order not to exceed the threshold level c_{ij1}. Call that activity (i_η, j_η).

Step 8. Choose the activity with the maximal CAR_{ij} value (in the left part of the list), on condition that its budget value c_{ij} may be increased by value $\Delta_2 = c_{ijn_{ij}} - c_{ij} \geq \Delta C$ in order not to exceed limit $c_{ijn_{ij}}$. Call that activity (i_γ, j_γ).

Step 9. Transfer cost value $Z = \min(\Delta_1, \Delta_2)$ from (i_η, j_η) to (i_γ, j_γ). Calculate

$C_{i_\eta j_\eta} - Z \Rightarrow C_{i_\eta j_\eta}$,

$C_{i_\gamma j_\gamma} + Z \Rightarrow C_{i_\gamma j_\gamma}$.

Step 10. Check inequality $C_{i_\eta j_\eta} > C_{i_\eta j_\eta 1}$. If inequality holds, calculate $C_{i_\eta j_\eta} - C_{i_\eta j_\eta 1} = \Delta_1$ and go to *Step 8*. In case $C_{i_\eta j_\eta} = C_{i_\eta j_\eta 1}$, i.e., $\Delta_1 = 0$, apply the next step.

Step 11. Calculate new values t_{ij} for all activities entering the project.

Step 12. Calculate value T_{cr} on the basis of *Step 11*. Call this value $T_{cr}^{(2)}$.

Step 13. Calculate the iterative change

$$\omega = \frac{T_{cr}^{(1)} - T_{cr}^{(2)}}{T_{cr}^{(1)}} \qquad (15)$$

to compare the latter with the relative accuracy δT.

Step 14. If $\omega > \delta T$, apply the next step. Otherwise go to *Step 16*.

Step 15. Set $T_{cr}^{(2)} \Rightarrow T_{cr}^{(1)}$. Go to *Step 5*.

Step 16. The heuristic algorithm terminates. Value $T_{cr}^{(2)}$ obtained at *Step 12*, set $\{c_{ij}\}$ determined at *Step 9* as well as values $\{t_{ij}\}$ calculated at *Step 11* are taken as quasi-optimal values of the problem's solution.

It can be well-recognized that the general idea of *Steps 7-10* is to diminish the assigned budget for activity (i_η, j_η) with the minimal CAR to its minimal value $C_{i_\eta j_\eta 1}$ in order to reassign the gained reserve value Δ_1 among activities with higher CAR values. Note that the number of those activities may be more than one.

In certain cases *Step 9* may be simplified by substituting value Z for value ΔC. Although such a substitution increases the number of iterations, it simplifies the solution procedure and refines the algorithm's accuracy.

The outlined above algorithm solves the direct time-cost optimization problem (12-13). As to the dual time-cost problem with pregiven project duration D

$$Min\ C \tag{16}$$

subject to

$$T_{cr}\Big/\left\{c_{ij\varepsilon_{ij}}\right\} \le D, \tag{17}$$

$$\sum_{\{i,j\}} c_{ijn_{ij}} \le C, \tag{18}$$

it can be easily solved by consecutive increasing C by ΔC and later on solving the direct problem (12-13). Increasing value C proceeds until relation (17) starts to hold.

6. Numerical example

We will consider a small-scale PERT-COST type project comprising 12 activities with deterministic activity durations. The project's initial data is presented in *Table 1*. The project's budget $C = 111$, cost value step $\Delta C = 1$, relative accuracy $\delta T = 0.01$.

By implementing *Step 3* of the heuristic algorithm (see *Section 5*) the trivial feasible budget reassignment among activities is as follows: $C_{12} = 9$, $C_{13} = 13$, $C_{14} = 14$, $C_{23} = 10$, $C_{25} = 14$, $C_{26} = 7$, $C_{34} = 5$, $C_{35} = 10$, $C_{36} = 15$, $C_{45} = 7$, $C_{46} = 5$, $C_{56} = 2$.

Table 1. The project's initial data

i, j	C_{ij}	t_{ij}
1, 2	6, 7, 8, 9	10, 8, 6, 5
1, 3	10, 11, 12, 13, 14	28, 26, 24, 20, 18
1, 4	10, 11, 12, 13, 14, 15	18, 17, 16, 14, 12, 10
2, 3	9, 10 ,11	15, 13, 11
2, 5	12, 13, 14, 15	12, 11, 10, 8
2, 6	6, 7, 8	22, 18, 14
3, 4	2, 3, 4, 5, 6	18, 17, 16, 15, 12
3, 5	8, 9, 10 ,11	12, 10, 8, 6
3, 6	14, 15, 16	10, 8, 6
4, 5	5, 6, 7, 8	12, 11, 10, 9
4, 6	4, 5, 6	20, 16, 12
5, 6	1, 2, 3	15, 10, 6

The computational process of the algorithm is represented in *Table 2*:

Table 2. Iterative computational process of budget reassignment

(i, j)	C_{ij}	t_{ij}	CAR_{ij}	C_{ij}	t_{ij}	CAR_{ij}	C_{ij}	t_{ij}	CAR_{ij}	C_{ij}	t_{ij}	CAR_{ij}	C_{ij}	t_{ij}	CAR_{ij}	C_{ij}	t_{ij}	
1, 2	9	5	0.9	9	5	1	9	5	0.89	9	5	0.89	9	5	0.89	9	5	
1, 3	13	20	1	14	18	1	14	18	1	14	18	1	14	18	1	14	18	
1, 4	14	12	0.34	14	12	0.36	14	12	0.4	14	12	0.4	10	18	0.6	13	14	
2, 3	10	13	0.9	10	13	1	11	11	0.89	11	11	0.89	11	11	0.89	11	11	
2, 5	14	10	0.33	14	10	0.25	12	12	0.425	12	12	0.5	12	12	0.436	12	12	
2, 6	7	18	0.42	7	18	0.375	7	18	0.46	7	18	0.5	7	18	0.51	7	18	
3, 4	5	15	1	5	15	1	6	12	1	6	12	1	6	12	1	6	12	
3, 5	10	8	0.32	10	8	0.32	10	8	0.36	8	12	0.64	11	6	0.286	8	12	
3, 6	15	8	0.24	14	10	0.28	14	10	0.3125	14	10	0.357	14	10	0.37	14	10	
4, 5	7	10	1	7	10	1	7	10	1	8	9	0.9375	8	9	1	8	9	
4, 6	5	16	0.8	5	16	0.8	5	16	0.8	5	16	1	6	12	0.8	6	12	
5, 6	2	10	1	2	10	1	2	10	1	3	6	0.9375	3	6	1	3	6	
T_{cr}	55			53			50			46			45			45		
Iteration No.	Feasible solution			1			2			3			4			5		
Iterative change ω				0.036			0.056			0.08			0.022			0		

The iterative process terminates

It can be well-recognized that the iterative quasi-optimization process took only 4 iterations in order to reduce the critical path length from $T_{cr} = 55$ (trivial feasible solution) to $T_{cr} = 45$ (the quasi-optimal solution). Thus, the iterative procedure proves to be efficient. Unfortunately, we have not proved the convergence of the heuristic algorithm.

The quasi-optimal solution is as follows:

$C_{12} = 9$, $C_{13} = 14$, $C_{14} = 10$, $C_{23} = 11$, $C_{25} = 12$, $C_{26} = 7$, $C_{34} = 6$, $C_{35} = 11$, $C_{36} = 14$, $C_{45} = 8$, $C_{46} = 6$, $C_{56} = 3$ (quasi-optimal *Version A*), or

$C_{12}=9$, $C_{13}=14$, $C_{14}=13$, $C_{23}=11$, $C_{25}=12$, $C_{26}=7$, $C_{34}=6$, $C_{35}=8$, $C_{36}=14$, $C_{45}=8$, $C_{46}=6$, $C_{56}=3$ (quasi-optimal *Version B*).

Both versions yield in the same result.

7. Conclusions

1. The newly developed algorithm is easy in usage and effective in practice. Its implementation requires mostly no more than 3÷5 iteration.

2. The algorithm has been widely used both for medium- and large-scale projects with the number of activities exceeding 50÷100. In all cases the algorithm performed well and the number of iterations did not exceed 5.

3. The algorithm can be realized on the basis of classical algorithms which are widely used in network planning and are described in many textbooks on project management.

4. The model suggested in this paper is open for various modifications: e.g., instead CAR values other terms defining the closeness of activities to the critical area and, thus, the level of their influence on the project's duration, may be implemented. However, those modifications are not essential from the principal point of view.

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JOURNAL OF APPLIED QUANTITATIVE METHODS

ECONOMIC MODEL COST-SATISFACTION IN INCLUSIVE EDUCATION. BASED ON RESEARCH MADE IN GEORGIA

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Abstract: *This research comprises a brief analysis of the economic model design, projected for poor countries, where complex assessments of the health status, education outcomes and motivation for children with disabilities are impossible to be done; is possible to be applied on a national scale in Georgia, if the actual government has the necessary resources, or, in other countries, having a similar lack of expertise in special education and disabled children assessment. The National Curriculum Assessment Centre from Georgia is envisaging such development, and finding the best ways to identify various needs for teacher training, auditing and report procedures and funding this future development, and to identify alternative sources for finance.*

We consider the aim and the objectives of the research, reflected in this paper, as leading to appropriate actions to satisfy the needs of disabled children, enough general to afford the opportunity of replication at a broader scale. The lack of skilled and dedicated human resources – expertise, counselling, care for children for special needs could be in a measure cushioned, if this model is applied on national scale.

Key words: *economic model; cost-satisfaction; inclusive education; Georgia*

1. Executive summary

This research comprises a brief analysis of the Inclusive Education Pilot, started in 2004 with Norwegian support and expertise. The report is offering tools for auditing, reporting and economic analysis for inclusive education, with the view to help the extension of the inclusive education pilot to whole country, valuing experience and structures created by the pilot. The National Curriculum Assessment Centre is envisaging such development,

and finding the best ways to identify various needs for teacher training, auditing and report procedures and funding this future development, and to identify alternative sources for finance.

1. The pilot accomplished its broad mission, and the effects produced by the project will continue to be seen in the future. In addition, I see a great opportunity for the pilot outcomes to generate the growth of a new educational approach within the broad picture of the Georgian educational system. A number of possible developments are needed such as the creation of links between the subsystems of the public education, more accountability and coherence between resources means and aims. The most important development is the transformation of the audacious political approach towards the Georgian school autonomy into a motor of the broader social and economical development.

2. The rapid pace of changes introduced by the laws in force (Education Law, Finance Law) and policies implemented (decentralization, school autonomy, broad management freedom for the school boards and principals) created a series of problems that will be reported in detail in the second chapter: **"A brief analysis of risk factors at systemic, school and students' level"**. The pilot schools experience a series of problems due to insufficient funds from the vouchers, on the one hand, and lack of effective procedures for decision making and general financial management, on the other hand. These matters will be detailed in the paragraph dedicated to inclusive pilot budget and finance aspects.

3. The decentralization process in administration, with the focus on financial issues pertaining to education, went back and forth, starting with a strong move to devolve all local government (oblast and rayons). The funds for schools managed at local level were not accompanied by a clear decision making criteria for allocation of funds to individual schools. The lack of a clear procedure for fund distribution resulted into conflicting auditing and financial reporting procedures (double reporting from rayon offices, both to elected local councils bodies and to higher levels in the Ministry of Education and Science).

Starting from 2003, connected with the anti-corruption fight, a reform was initiated in all levels of government but also specific to the education sector. The leader in the education reform was the minister Melikidze. The measures implemented under his authority are characteristic of crisis management, being based on recentralizing decision making and budget and going up to the redefinition of the MoES hierarchical structures.

4. The most common forms of corruption in schools were at that time the private payments into the public schools and the misappropriation of funds earmarked for schools at the local government level. Special classes still exist in the inclusive pilot schools. These classes focus on educational services demanded and desired by the parents (art classes, sports, foreign languages, etc). For example in one of the visits of the pilot I found out that no evidence, tracking records, contracts or other legal forms, completed or signed by the parties, could be produced. This is a major weakness of the actual auditing and reporting system, and the recommendations section of this report will address it together with suggestions on improvement measures.

5. One of the major issues is the lack of correlation between the principles adopted for financing schools (the voucher system), the project aim and objectives, and the level of professional training and skills for the school principals and school teachers. However, the project has had the potential to instill changes in the professional behavior and trigger a

process of transforming the mental models of the people on which the Norwegian project, and then, the new project led by the Ministry focused.

2. General statements about the inclusive pilot

1. International and national legal and paradigm context. The Ministry of Education and Science of Georgia and the organizations participating in the project prioritize the development and introduction of new methodologies and approaches in order to give the appropriate level of educational rights for disabled children.

Georgia joins and recognizes international documentation concerning the rights of disabled people, such as the Universal Declaration of Human Rights, the Convention on the Rights of a Child, the "UN Declaration on the Rights of Mentally Retarded Persons"(1971), the "Declaration on the Rights of Disabled Persons"(1975), the "Standard Rules on the Equalization of Opportunities for Persons with Disabilities"(1993). In addition, Georgia assumes the responsibility of coming to effective resolutions concerning the issues that appear in the field in question.

On February 13, 2004, the Parliament of Georgia approved the "Main Trends of Social Policy of Protection of Rights of Disabled Children". Based on the above document, the government was assigned to develop concrete implementation strategies.

2. Cooperation. In the past years, the foreign and local non-governmental organizations working in Georgia implemented several projects and initiatives for popularization, maintenance and introduction of inclusive and integrated education.

3. Documentation. The Ministry of Education and Science of Georgia and the organizations participating in the project attribute greater importance to compiling, updating and complex testing of accumulated information, taking into account the results in the process of elaboration of development program of inclusion of disabled children in the general and special educational institutions.

4. Leadership. The lead of the inclusive education pilot project was first undertaken by the Child Care Division. However later it was decided to be exercised by the NCAC, which the Ministry officials considered more fitted for the purpose of strategic approach, together with the overall process of issuing education standards and implementing a national system of quality assurance.

5. Cooperation with MoES departments, synergy. The Child Care Division is assessing, coordinating and monitoring cooperation with NGO's in developing and implementing child-care governmental and ministerial programmes.

6. Related projects. There is another ongoing special education project dealing with educational, attitudinal and social issues of disabled children. The donor from Norway and the division are implementing this project. The project will take place between 2009 and 2011, and consists in policy implementation. The strategic issues are coordinated by Ana Lagidze, special consultant for concept development. Ana Lagidze formed a special working group for this purpose.

7**. Inclusive education project objectives.** From the inclusive project document, the aim and objectives were extracted and discussed. We consider them to be appropriate, consistent and realistic. The aim of the multidisciplinary team created by the project is "to provide assistance to administration and teaching staff of selected schools in practical realization of inclusive education."

8. Implementation. For this purpose, specialized staff has been selected by the MoES , the Multidisciplinary Team, trained to coordinate, to implement and to issue operational documents for the inclusive pilot. The areas of qualification are:

No.	Position/function	No of persons employed
1	Special needs education consultant, as team coordinator	1
2	Physiologist	2
3	Speech therapist	1
4	Occupation therapist	2
5	Neurologist	1

The project objectives, as stated in the project document, are:

1. Obtaining and analyzing information on children with disabilities;
2. Contributing to inclusion of children with disabilities into educational process;
3. Evaluating children with disabilities (newly enrolled and already in schools) and defining of their abilities and individual needs;
4. Developing of recommendations for individual educational plans (IEP);
5. Monitoring of the processes at schools;
6. Analyzing of the problem and defining of the ways for their overcoming.

9. Opportunities for replication and further development. We consider the aim and the objectives of the inclusive pilot as leading to appropriate actions to satisfy the needs of disabled children, the system of objectives is coherent and complete, enough general to afford the opportunity of replication at a broader scale. The project contains in embryo a high potential for enlargement and system building at national scale for Georgia inclusive education, as well, the impact of the pilot is to be measured, after consuming most of its effects at all levels: student, teacher, school, broader public education administration. The budget is clear, task oriented and easy to understand, however, some performance indicators stated in the project document and a clear approach to standards in special education is lacking. In order to overcome these shortcomings in the near future, a system of provisory standards for inclusive education should be issued. This system should allow costing and forecasting to be used as economic tools; also it should allow performance indicators to assess the progress and to make corrections.

10. Multidisciplinary team. The MoEs is issuing inclusive education plans. There are some specialists in the project, working on a part time base, because there is not enough time in specialist's time, although the needs identified by them, on a non-formal, but professional basis, seem to ask more human resources for doing this activity in a better way. The lack of skilled and dedicated human resources – expertise, counselling, care for children for special

needs could be in a measure cushioned, if enough financial resources are allocated (by the Ministry, or other donors) the buy, on a market base, such time for expertise and care.

11. The group for concept and strategic issues about inclusive education is dealing with overall notional and theoretic issues, including legislation, strategic and planning issues. In addition, they will elaborate the project document. The project document will propose different acceptable ways in order for authorities and schools to be able to choose the best alternative and to extend the experience of the multidisciplinary group.

3. Costing methodology for inclusive education

Conclusions and practical issues, based on the economic model:

1. To select schools and local governments together, based on good cooperation and on an written agreement between schol and local council, to support some negociated parts of the school needs (as proposed in the policy recommendation chapter)
2. To involve local communities in consultations with inclusive education schools, on administrative, curriclar and financ aspects
3. To be tranparent about school development plans, budget and school outcomes. Therefore, a series of indicators should be calculated and made public.

I. Socio-economic background and educational considerations

The process of costing for inclusive education should use not only usual economic tools, but alos, a more detailed and insightfull view on socio-economic aspects, some psichological considerations and medical ones too. Focusing on different target groups of persons, institutions and on relationships established or wanting to be established among them, we should, first of all strengthen the idea that disbility is very often associated with poverty of parents, children's families, social close environment in general of the most frequent cases of disabled.

In this respect, some important considerations about risk factors should be made:

1. Poverty of parents creates a high level of stress and, in many cases, poor living conditions, crowded houses and rooms creates the conditions for home violence, sexual abuse. Competing demands of their lives affects responsiveness to children, level of priority afforded by parents to education and conntacs with the school. In many cases, low expectation about children's level of education and schooling outcomes are encountered.

2. Endemic and epidemic diseases affecting children and adults are more frequent than the average.

3. Children are affected by illnesses often encountered disrupted schooling, lack of access to educational, cultural and other goods, lack of space and quiet places for homework and study, lack of support from parents for homework, advice, moral suppport**.**

4. Schools, teachers and educators in general, often have low expectations for disabled, lack of responsiveness to various problems that children are facing, have negative

stereotypes about them and their families (sometimes, stigma and religious views are associated), poor school parents relationships.

5. **Communities could have poor neighbourhoods** with limited local services and facilities (transportation, leisure and sports, health services); this is associated with anti-school peer group attitudes, lack of confidence of education and schooling for success in life, role models
6. **Negative outcomes for children, resulted from the associated risk factors action:** low self esteem, low capacity of work and learning, high incidence of exclusion, low educational, schooling and life attainments.

Of course, not all these problems should be addressed; it would be unrealistic and ineffective. We will focus on school based ressources, but, all the time, we will keep into consideration the following:

- an institutional safety network should be in place, to create a variety of support systems, with various levels of intensity and types of support for disabled
- mentalities and stereotypes about disabled, at all levels, even on higher decision making or political levels, create new risks
- a step by step strategy, realistic and well defined, with clearly defined stages, with all instruments- performance indicators, educational, environmental and cost standards should be put in place, and work effectively, otherwise, no impact measurement, progress or assessment could be done.
-there are big cultural, economic and cultural differences between countries, education systems and general conditions between countries, therefore, all foreign models, even successful ones in their country of origin, should be carefully considered, about their appropriateness and adequacy for Georgia.

II. Costing process

All costing processes start with a careful evaluation of the actual system, conditions and results. A series of theoretical approaches could be done, but, most of them have in common some steps, that are to be described.

1. At the expert level, making a list of all needs that disabled children could have. The list comprises a number of items, using a typology of needs; for this report operational purpose, could be used, on a provisory base, the Pyramid of the needs, of Abraham Maslow, even if arguable. It is simple, robust and many specialists know it. The items of this hierarchy are: physiological, security – shelter, love/belonging, esteem, self-actualization. We will focus only on the first two categories, the others being, mostly, satisfied through social interaction, and not with materials. Some of the social nteractions are, although, offered by the specialized personnel, work environment, school organization, etc.

   Security, shelter – That means children and students (I will use the only word children, because is more comprehensive, and we deal with all their needs)

   This could be splitted into a) **Regular (normal needs) for common children and b) for the disabled** (separately).

   We will deal only with the needs of disabled children. These needs could be splitted again, into security needs:

- **At home** - for the moment, is not the case, but very important; because of the short term of this small research, we will deal with this issue indirectly, just focusing the parents and educators.

- In school

- *hygiene and sanitation rules respected* (according to the Laws and regulations in force)[3]

The content of the **Instrument no 1** - expert and school estimation (Tables 1-6) and also of the **Instrument no 2** – survey to identify needs, satisfaction about school resources and activities and willingness to support the school are presented in appendixes.

For this report, specialists from the Multidisciplinary Group realized a series of interviews with teachers and parents of disabled children; the questions were only about material needs, in order to prioritize these needs, because, regular or special teaching are regulated by the Ministry (Laws, regulations). The interviews have been realized by the specialists, in the inclusive pilot schools.

Some descriptive outcomes of the interviews

Schools			
Participant N			17
Participant gender			F
Participants occupation			- Parent – 3 architect, economist, physics - Teacher – 8 - Special teacher –3 - Psychologist – 1
Participant age range			25 – 70 mean – 47
Student age range			8 – 17 mean - 10
Participant contribution		***yes***	7
		no	10
		don't know	0
Area of contribution		***money***	- 30 LARI per month 1 [parent]
		other	- To draw visualization 1 - To coordinate the process 1 - Provide with education materials 1 - To work additionally on the lesson 1 - To work as teacher 3
		care	- as nurse 1 - To pay attention to the children in the corridor 1
	no	***I know***	5
		I can teach	2
		I'm specialist	3
		other	"I know but I'll appreciate new knowledge" "It's already late to re-train me"

4. Economic model to establish priorities in purchasing goods and services for disabled and to estimate the increased satisfaction

Both satisfaction expressed by the children, and the expert opinion of the teachers, psychologists are to be considered when establishing priorities for purchasing, and when realizing budget planning for a longer period, let's say, a year. Increased satisfaction of consumer is an indicator of increased quality, and, in the simplified but pragmatic model we offer hereby, will be the only way to estimate quality.

Another criterion to be used when making budget planning are the legal requirements – many times, unfortunately, the legal requirement are related to environment conditions, hygiene and sanitation, and the expenditures are quite big, conflicting with other simple purchasing, i.e., goods, games, books or other cheaper materials. Again, to avoid these decisions to conflict, upper programmes for investment for disabled, to meet legal requirements, would be better led from upper level than schools (socialised divisions of the MoES, project managers).

In a simple and pragmatic model, we will operate with the identified needs of the students, a series like: N_1 , N_2 ,N_3 …., N_k.

Children's satisfaction, S, is as well a series, with different number of terms, S_1 , S_2 ,S_3 …., S_p.

If needs, regularly, are expressed in terms of objects or services, or activities to be done, the satisfaction is more complex, and is expressed, usually, in terms of outcomes, results, intentions, or final stages of actions. Therefore, for a single satisfaction S_i

, there a re at least one ore nore needs who contribute to that satisfaction.

A distribution of this kind is shown in the next table:

Needs	Satisfaction	Level of satisfaction subsample 1	Level of satisfaction subsample 2	Cost of consumption to acquire items (need) (GEL), moment T	Cost of consumption to acquire items (need) (GEL), moment T′
N_1	S_1	1	3	C_1	C_1'
N_2	S_2	3	2	C_2	C_2'
N_3	S_3	4	5	C_3	$C_{3'}$
N_4	..			C_4	$C_{4'}$
…	..				
N_k	…	2	1	C_k	$C_{k'}$
	S_p	1	1		

The arrows shows which satisfaction S is acquired using one ore more needs satisfied: for example, learning chess needs an instructor (service), some kit for the game (item) and a room to play (use of assets).

There are **three possibilities** to find out which is the cost per unit of increased satisfaction, meaning the difference between different levels of satisfaction, acquired by different individual, having satisfied the same need

Method 1

The theoretical supposition is the quasi-identity of the individuals, their needs and perception of satisfaction, which is available if the sample is big enough, to smoothen the variations.

Comparing different parts of the sample, if the number of subjects answering the questions is quite large, is possible to see different degrees of satisfaction, for the same item, for the same category of children. For a level of satisfaction, let's say, of 3, S=3, are consumed some resources, which means the cost of satisfying the associated needs, until the given moment. The comparison between average levels of satisfaction will give differences, as seen in Formula 1:

$$\Delta S_1 = S_1^2 - S_1^1 \quad (1)$$

Method 2

If the sample is small (less than hundreds of individuals), the variation between individuals would appear, making the method inaccurate. A more accurate method for small samples is to make determinations of satisfaction at different moments of time, on the same individuals, using the same instrument, in the conditions of modifying the level of satisfaction by adding some resource consumption, to satisfy the same needs.

$$\Delta S_1 = S_1^{T2} - S_1^{T1} \quad (2)$$

Method 3

This method produces accurate results then the consumption of a single unit of good is producing saturation, for example: a single ramp for disabled built at the entrance of the school is enough, a single pencil or chess kit used is producing saturation, etc.

In this case, the consumption of a single unit is producing maximum of satisfaction, on a scale from 1 to 5, meaning S_5 and the lack of consumption is producing the minimum satisfaction, S_1 .

$$\Delta C = 5 - 0 = 5 \quad (3)$$

The increase is 5 satisfaction units and the cost is ΔC

The cost to obtain an unit increased satisfaction, in all cases and in all three simplified models, is obtained dividing the variation of cost to number of units of increased satisfaction.

$$\frac{\Delta C}{\Delta S} = \frac{C_p - C_r}{S_p - S_r} = CPU(\cos t\_per\_unit\_satisfaction\_increase) \quad (4)$$

5. Final discussion and conclusion

No matter the method to obtain the cost per unit of increased satisfaction, satisfaction increase is an indicator of increased quality, satisfaction decrease is an indicator for diminished quality; the satisfaction variation is a tool to manage decision in decision-making bodies, meaning, all conditions being equal, a rational decision making body will opt for a decision to increase at maximum the aggregated satisfaction for all disabled children in the school, and at larger scale, in a Resource Centre, rayon, region and national. This kind of analysis could be used to issue policies in investments, in purchasing goods or services on a scale programmes or to opt for some personnel policies (recommendation to work extra hours, to buy teaching, expert or tuition time from the market, to select providers who produce or deliver packages of goods or service, to compare policies, providers, decision, to adopt unique provider for some goods etc.)

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Appendixes

Instrument no 1 - expert and school estimation (Tables 1-6)

Table 1. Security, shelter needs

No	Item	Actual situation in the school	Assessed need	Estimated difference between existing and needed (physical units)	Estimated difference between existing and needed (monetary units)
1	Transportation to and from the school	Description, explanatory	Description, explanatory		
2	Materials for mobility/accessibility**:** transport, ramps, lifts, mobility aids (wheelchairs, walkers, etc) -				

3	free meals	Etc.			
4	special meals (for diseased children)				
5	adapted kitchen utensils (anti-slip, shaped plate, spoon/fork/knife with thickened handles, plastic caps)				
6	Materials for self-maintenance in school: adapted toilets, etc				
7	permanent or partial care taking (for severe disabilities)				
8	other therapies (specialist opinion)				
9	heating, cooling, environment				
10	special assets: access, space, bedrooms, restrooms, individual study rooms etc.				
11	regular and or special furniture: adapted furniture, special chairs and tables				
12	regular or and special learning facilities, premises				
13	special books or manuals, reading materials for children (Braille, audio, etc, special devices for communication in different ways.)				
14	Technical equipment				
15	Stationary				
16	Adapted equipment: key boards, scissors, pans etc.				
17	**Material for recreation** - games, toys, films, music etc.				
18	Materials for particular child (unique, difficult to predict)				
19	***Others, to be detailed***				

Table 2. Learning needs

No	Item	Actual situation in the school	Assessed need	Estimated difference between existing and needed (physical units)	Estimated difference between existing and needed (monetary units)
1	regular teachers with special training in				

	disabled children				
2	other types of training for special needs: dislexic, ADHD, other forms of special pedagogy needed, for regular subjects teachers				
3	in service training, school based and financed (or by different donors)				
4	Inclusive/ disabled, education specialists, Therapists, etc.				
5	***Others, to be detailed***				

Because teaching activities, special therapies, care taking, counseling and guidance are the most important the biggest part of the educational budget, they will be treated separately:

Table 3. Staff

Type of activity	Type of staff (staff means teaching and non-teaching, sanitary, or special aid, care takers, janitors, etc.) needed (To be named the positions and specialties according to the law, when is the case)	Number of hours needed to be worked, by each type of staff	Number of children needing this staff	Actual situation of staff (number of hours they work effectively during a week)	*Salaries and other payments, per week, for each staff category*

Table 4. Entertainment, extracurricular activities, sports, leisure

No	**Item (activity)**	**Actual situation in the school**	**Assessed need**	**Estimated difference between existing and needed (physical units)**	**Estimated difference between existing and needed (monetary units)**
1	Excursions				
	Other entertainment – movies, spectacles				
	Artistic and sporting activities				
	Social activities – community, helping others				
	Others, to be detailed				

Table 5. Activities with the parents and disabled children's families

No	Item (activity)	Actual situation in the school	Assessed need	Estimated difference between existing and needed (physical units)	Estimated difference between existing and needed (monetary units)
1	Regular communication with parents				
2	Special and emergency communication (indiscipline, violence, sickness, etc.)				
3	Parents' education and counselling				
4	Special training for parents having diseased or children with special needs				
5	***Others, to be detailed***				

Table 6. Synthetic table to establish priorities in materials and facilities, using satisfaction survey; the most simple is to ask teachers or parents about their opinion

Materials, facilities, other items	Existing	Number of children using the materials or facilities	Subjective satisfaction using the materials or facilities, on a scale from one to five: 1-very low, 2-low, 3-medium, 4-high, 5-very high	Number of children actually enrolled, that need to use the materials or facilities	Needed, for a subjective estimated, to produce for children average and high expected satisfaction (two figures, one for ave., one for high)	*Estimated costs of purchasing or investment (related to market prices)*

Instrument no 2 – survey to identify needs, satisfaction about school resources and activities and willingness to support the school

Questionnaire

1	*Which is the thing you are the most satified, about material conditions from the schools that your child uses?*	*Name at least three… …..1… …..2…… ….3…….*
	Make a list of three things (materials, facilities) that you think are useful in high measure for your children in school:	*1… 2… 3….*
3	*If the school or other donor are concerned about procurement or investment of the things you want more (materials, facilities), how could you help, from your part, for things to happen?*	*1.Contribution in money……..estimate…… 2.Contribution in kind……..estimate (work, other materials donated,*

		etc.)…… *3.Contribution in dedicated child care, on a voluntary basis* YES NO I DON'T KNOW
IF the answer is YES, which area of dedicated work do you prefer?		
4	*Area of work……* *How many hours……* *Are you commited to learn how to do the work?*	*YES NO I KNOW ALREADY* *I CAN TEACH THE OTHERS, BEING A SPECIALIST*
5	*Age of the child……* *Profession of yours……*	*Your age……* *Sex……*
THANK YOU VERY MUCH FOR ANSWERING THE QUESTIONS		

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[2] Nino Rukhadze is occupational therapist, psychologist and lecturer at Tblilisi State University, Dean Assistant, and have participated in many international projects, had inputs in seminars for disabled children, and special education programmes. One of the most important for our research is The Inclusive Education Project, that produced important decisions at Ministry of Education level, about enlarging, at national scale, the inclusive education concept.

[3] We have been told that, in many cases, these regulations are not observed, and the health security inspection works quite not well in assessing the sanitation and hygiene legal provisions. The legal provision comprises standards about physical and environmental conditions, and measurement methodologies. Using these standards for the inclusive pilot needs, and with the advisory help of a specialist, a non-formal estimation could be made by a team from school or other persons, assessing the real situation; a self assessment form could be issued for this purpose. The level of differences, both in physical terms and making a monetary estimation, using the legal criteria and a simple assessment methodology, that we previously discussed, could be made by headteachers o/and the trustee board of the school, using current market prices for goods and services, for salaries and other supplies.

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FACTORS OF THE EARNING FUNCTIONS AND THEIR INFLUENCE ON THE INTELLECTUAL CAPITAL OF AN ORGANIZATION

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Abstract: *This paper tries to consider some earning function as "start point" for the construction of indicators for intellectual capital measure. The analyze combines concepts from Mincer's and Becker theories and intellectual capital definitions currently in use. The correlation, significance and relation between elements are shown using three econometric models.*

Key words: *Intellectual capital; human capital; econometric model; earning function; education; experience; IT*

A. Introduction

A1. Intellectual Capital sense and components.

Intellectual capital was considered in many studies as a no financial value which drives the value of an enterprise.

There are two approaches to define intellectual capital. The first one considers the intellectual capital the sum of three dimensions: **human capital**, structural capital and relational capital.

Many definitions were considered in the analysis of term. For example:

Tom Stewart, in June 1991, article Brain Power - How Intellectual Capital Is Becoming America's Most Valuable Asset, brings IC firmly on to the management agenda.

He defines IC in his article as: „the sum of everything everybody in your company knows that gives you a competitive edge in the market place."

Stewart (1994) defined intellectual capital as the total stocks of the collective knowledge, information, technologies, intellectual property rights, experience, organization learning and competence, team communication systems, customer relations, and brands that are able to create values for a firm.

The first use of the term is thus to describe the dynamic effects of **individuals´** intellect. Tom Stewart makes IC the attribute of an **organization.** Leif Edvinsson, Skandia, and Pat Sullivan define it in European Management Journal (1996 vol 14) as: **„Knowledge that can be converted into value".** And in Laurence Prusak´s, Ernst & Young (later IBM Consulting), definition IC becomes even more "packaged". He defines it in Klein & Prusak 1994, Characterizing Intellectual Capital, as: **„Intellectual material that has been formalized, captured and leveraged to produce a higher-valued asset**"

According to Edvinsson and Malone (1997, p. 3), intellectual capital is **„information, knowledge applied to work to create value"**.

Haanes and Lowendahl (1997) claim that the knowledge within an organization exists at both the individual and the organizational level. On the individual level, **intellectual capital includes knowledge, skills and aptitudes. On the organizational level, intellectual capital includes client specific databases, technology, routines, methods, procedures and organizational culture.**

Sveiby (1997, p. 10) defines human capital as "the capacity to act in a wide variety of situations to create both tangible and intangible assets"; structural capital as "patents, concepts, models, and computer and administrative systems"; and relational capital as "relationships with customers and suppliers". The sum of these three elements is Intellectual Capital of the company.

Also, Klein defined, in 1998, intellectual capital as „**knowledge, experiences, expertise and associated soft assets", rather then the physical and financial capital.**

Mouritsen (1998, p. 462) says that intellectual capital **is a matter of „broad organisational knowledge, unique to a firm, which allows it constantly to adapt to changing conditions".**

Bontis, Crossan, and Hulland (2002) noted conceptual confusion between intellectual capital and organizational learning. They state. **Intellectual capital represents „the stock of knowledge that exists in an organization at a particular point in time".** On the other hand, organizational learning broadens the discussion to incorporate behaviors as well as knowledge and provides a means to understand how the stock changes over time" (p. 440).

In the first part of research period regarding Intellectual Capital the attributes like „knowledge, experience, expertise, information, skills and attitudes etc. where attached to Human Capital Term. Later The Human Capital was extended to Intellectual Capital by including some aspects of relation and organizational skills in and between business participants.

The second approach is exemplified by Saint-Onge (1996) and Knight (1999) who defines the basic dimensions of intellectual capital but do not propose indices to measure them. It is not our goal to develop this approach.

A2. Earning Functions

A big part of human capital literature, with two great pioneers, Becker and Mincer, analyze the earnings function fpr the study of the effects of investments. Willis, in 1986, defined the earning function like „any regression of individual wage rates or earnings on a vector of personal, market and environmental variables thought to influence the wage".

Many studies were focused on the function $y = f(s, A, z) + \varepsilon$ where

y represented by income, earning or wage, s is a measuring of school (years completed usually), z is a set of other variables assumed to affect the dependent variable and to be different for each case *i*. The "z" variable could be represented by : years of experience, post school investments, family pattern(parent education), health, satisfaction etc. "u" variable is the measure of residual factors. Residual factors are considered those factors non-mentioned in the model and independent of the z's and also independent of A and s. A is an unobservable variable referring the individual ability, skill of case *i* (used as A_i) .

Other types of functions were proposed by Mincer. For example $y = h(s, x) + \varepsilon$ where:

$s =$ years of schooling

$t =$ age

x represent the experience and it is determined as $t - s - b$ where b is the age of person at first year of school.

In 1974 using as a start point the schooling model $\ln y_x = \beta_0 + \beta_1 s + \varepsilon$. After the development of this model with $y = h(s, x) + \varepsilon$ we had $\ln y_x = \beta_0 + \beta_1 s + \beta_2 x + \beta_3 x^2 + \varepsilon$

Where y_x is the "net earning" after x years of experience. The net earning was calculated as gross earning minus the resources that the person devotes in furthering his jobs skills and acquiring job-related information).

Willis (1985) considers that the model $\ln y_x = \beta_0 + \beta_1 s + \beta_2 x + \beta_3 x^2 + \varepsilon$ "represents a pragmatic method of incorporating some of the major implication of the optimal human capital models into a simple econometric framework, which can be applied to the limited information available data". He offered an alternative of the previous function:

$$\ln y_x = \beta_0 + \beta_1 s + \beta_2 s^2 + \beta_3 x + \beta_4 x^2 + \beta_5 xs + \varepsilon$$

with x and s mentioned before.

Our purpose is to connect these earning function with some variable near *t(age), s(years of schooling)* and *x (experience)* which may also contribute to the evaluation of the intellectual capital.

B. Purpose, data file and variable description

Our purpose is to connect these earning functions with some variable near *t, s* and *x* which may also contribute to the evaluation of the intellectual capital.

Database was published by Open Society Foundation in 2006. The values were all registered from a sample of 1200 respondents with ages between 18 and 80 from Romania and these data have as reference period may 2006. Because of multiple cumulated non-answers (missing or out of range) we decided to delete unavailable cases. Finally the database contains 588 valid cases.

B1. Short description of the variables

Income(in billions lei). In the questionnaire was met the following question: "What was your income in the last month". We had values between 0 and 4,000 lei/month, with an average of 650 lei. Even they have education or other personal skills we had some persons without income. We may consider that those persons were temporarily unemployed and they possibly had no income in the last month.

Education. Information about this variable were obtained analyzing the following question from the research: "Which is your total number of years of education graduated?". The values obtained were between 0 and 22 years of school. There were few persons with low education, less than 2% from total sample. The maximum of 22 years of school graduated represents the "label" for the persons which graduated long PhD courses, perhaps in domain like medicine, engineering and others. The average of numbers of years graduated is close to 12 which has a practical signification. The persons from the sample have in mean a high school graduated.

Experience. This variable was not collected by owner of the study. We determined their values using the following relation. $Experience = Age - Years\,of\ School - 6$. Using this approach we have made some assumption like:

a) The age of beginning school is 6.(In Romania this value is between 6 and 7)

b) We had considered that each person was hired in a short time after he has finished the studies. We "lose" here the experience of the persons who worked during studies. For the future it is recommended to ask if the person worked during the studies and how much. "Age" represents the age in years of the respondent.

Sex. There were selected, using criteria above mentioned, 52% males and 48% females.

Info_TV. This variable was not measured directly in the mentioned study and it was computed using other variables. There were asked in the questionnaire the following questions:

-"How often do you (how interested are you for…) listen radio for education, for personal learning?"

-"How often do you watch TV for education, for personal learning?"

-"How often do read newspapers, magazines for education, for learning?"

The possible answers were represented on a 1 to 5 scale with 1=very less interested, 5 very interested. These qualitative variables are very hard to be exactly quantified in an econometric model. We choused to sum the three variables from the questionnaire with the following signification: The greater is the value of "info_TV" the more informal education (gained from media sources) has the respondent.

Language. In the study was not computed a variable to measure the quality of language knew. The question was: "Which language do you know except your mother tongue?". Each respondent mentioned the languages knew. We summed this answers in a

variable named "language". For example if the respondent mentioned he speaks English, French and Russian then the value for "language" variable was 3.

Health. Self appreciation of the respondents regarding their health. Their answers should be done on a 1 to 4 scale where 1=not at all satisfied and 4 very satisfied.

IT. This is a binary variable which measures computer literacy. The respondents were asked to answer at the following questions: "Do you know to use computer?". Possible answers 1= Yes 2= No. There are some weaknesses of this variable like:

a) it is a raw method to measure the computer literacy
b) it is not standardized because of "self appreciation"
c) should be detailed for the future

Medium. The earnings are strongly influenced by the place of live of the respondent. Most of the persons are working close to their place of live but of course there are exception. Here perhaps it is good to study in a future study the dependence medium, income and other factors by region of development in Romania.

C. Results

Using the database already mentioned we proposed the following models:

I

$$income = a_0 + a_1 INFO\_TV + a_2 IT + a_3 LANGUAGE + a_4 MEDIU + a_5 SEX + a_6 HEALTH + \\ + a_7 EXPERIENCE + a_8 EDUCATION + \varepsilon$$

II

$$\lg(income) = a_0 + a_1 INFO\_TV + a_2 IT + a_3 LANGUAGE + a_4 MEDIU + a_5 SEX + a_6 HEALTH + \\ + a_7 EXPERIENCE + a_8 EDUCATION + \varepsilon$$

III

$$\sqrt{(income)} = a_0 + a_1 INFO\_TV + a_2 IT + a_3 LANGUAGE + a_4 MEDIU + a_5 SEX + a_6 HEALTH + \\ + a_7 EXPERIENCE + a_8 EDUCATION + \varepsilon$$

After a quick econometric analysis we observe that all the coefficients of the factor variables are statistically significant at levels lower than 0,05 with a single exception in the 3rd model.(Please see the Appendixes).

The models include factors from different categories:

- education factors (formal and informal education) like LANGUAGE, INFO_TV and EDUCATION
- discriminant factors like gender (SEX)
- experience like (EXPERIENCE)
- the medium of location (MEDIU)

and one mixed factor IT which referes to computer literacy as we mentioned before. The analysis shows that the income is a complex "mixture" of many factors. Analyzing all the models we can also see that not only a simple linear model describes best the connection between variables.

From all these variables we'll chose to analyze the third model considered as "the best" model according to econometric criteria presented in the following table:

Table 1.

Model	Performance and validity indicators			
	R^2	*F statistic and significance*	*Inofrmation criteria AIC*	largest level of factor coefficients significance α_{max}
I	0,34	37,43 (0,000)	5,86	0,046
II	0,39	42,75 (0,000)	1,58	0,1383
III	0,41	50,62 (0,000)	2,48	0,0579

The third model already described has the following general form

$$\sqrt{(income)} = a_0 + a_1 INFO\_TV + a_2 IT + a_3 LANGUAGE + a_4 MEDIU + a_5 SEX + \\ + a_6 HEALTH + a_7 EXPERIENCE + a_8 EDUCATION$$

after parameters estimation we have the following results:

$$\sqrt{(income)} = 0,144 + 0,043 * INFO\_TV - 0,256 * IT + 0,125 * LANGUAGE + 0,466 * MEDIU + \\ + 0,132 * SEX + 0,198 * HEALTH + 0,011 * EXPERIENCE + 0,123 * EDUCATION$$

In this study we are less interested about strong test about OLS hypotheses. We are mostly interested in coefficients statistical and practical signification, model in ensemble.

The a_0 term which is 0,144 billions lei shows that in mean a person without any qualification, without experience or other knowledge/skills mentioned in the model will receive an income of 144.000 lei (approximately 4 eur./month). In this case if we considered only the persons involved in some activities in the last month we may consider that this income is specific for a peasant which has an income only from their own activity. Could be this category that one which works only few days. Moreover we have to consider that this person is at beginning of work (no experience no school). Practically this category is very isolated and it is represented by a very small number of persons.

The a_1 term, equal with 0,043, allows us to say that an increase of informal education index with 1 unit will increase in mean the income with 0,043 billions lei. This relation is normal. Even if most researcher proved that preferences of the free time spent is dependent of income we may consider that technical information got from specific t.v. programs, book, reviews or other information consist an added value of the human capital in particular and of the intellectual capital of the person and his organization in the extended mode.

Coefficient for ***IT*** factor has a negative value. This value implies that a person without any IT knowledge has in mean an income with 0,256 billions lower than a person with few knowledge. Practically we are in the era of technology and communication and this result mentioned is normal for current state of life. Personal IT literacy competence doesn't not represent only a personal skill. This skill is a base on the whole IT management structure of the company. Many organization invested in IT development and for their employees training. The results were successfully. The productivity grew, the organization progressed the results were seen also in the personal income. As many studies consider IT development

capital as part of Intellectual capital of an organization[2] then every person even if it is client, employee or in other relation becomes a part of this complex system.

Coefficient of ***LANGUAGE*** factor shows also a positive relation. An increase of this Index increase the income of languages owner. This indicator is very important in relational capital side of any organization. Now, when there is no limit in communication possibilities the gaps are done by languages and IT channels. A better trained (as quality and number of qualification) person with languages a better results will be achieved.

Two variable used as discriminate variable are **medium** and **sex**. Gender discrimination was met in all the domains. It looks in our research like in others that women have a lower income than mans have. In our case in mean a mean has an monthly income greater than a women with 0,132 billions lei. This result already knew is an important indicator for Brand Image of an organization. If there is a discrimination with a high gap, this will affect the image of the organization and this implies a lower value of intellectual capital.

The medium variable is also important for the companies. The possibilities to relocate or to give externalization in the rural areas with a goal of cost minimization also contributes to brand expansion, stronger relation etc. As negative thing in general we get less skilled persons from rural area.

Experience, Health and Education are the most important factors of human capital even if his considered as part of intellectual capital or not. Better skilled employees, more experienced and healthier better results will be achieved. The results are seen first in company values and after that in the income value as we can saw in the three models analyzed.

We analyzed also the impact "life satisfaction" but this indicator is strongly correlated with "health satisfaction" and we renounced at it. In general in Romania if a person is healthy than the overall satisfaction (except the influence of income) of that person has a good value.

These factors mentioned are not only the factors of the human capital of a company. Because of multiple connections made by employees their skills considered as "raw human capital" contributes directly to the organizational, structural and relational capital.

D. Conclusions

As we can see in Table 1. those mentioned factors explains only 41% of total income variation. This complex of factors could be completed with many others. Even if they are correlated each other we can add factors like : climate of enterprise, organizational management, type of activity, concurrency, and other personal skills like (experience in domain, management skill, natural skills or talent, not only the quantity of education but quality etc.). Also there are some macroeconomics factors which are not measured in the earning function like (GDP, current economy power and sustainability, dummy variable like crisis or not etc).

We mentioned these variables because as they are reflected in a model of an earning function in the same manner this variables affect the intellectual capital measure of an organization.

These variables mentioned are all strongly recommended to be used as factor in index or indicator developed for intellectual measure. The importance shown in the models should help to split and combine variables with type of each element of intellectual capital of an organization. As we mentioned for example experience is not only a human capital factor it is also a source of relational capital, of development and innovational capital if experience is combined with other factors like education, IT, management skills etc.

In the end, we consider that personal income and their factor of influence should be balanced with intellectual capital and his components.

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Appendixes

Dependent Variable: INCOME, **model I**				
Method: Least Squares				
Sample: 1 588				
Included observations: 588				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFO_TV	0.162728	0.067108	2.424871	0.0156
IT	-1.402811	0.479175	-2.927552	0.0036
LANGUAGE	0.824294	0.317146	2.599098	0.0096
MEDIU	1.526773	0.436609	3.496887	0.0005
SEX	1.096454	0.379913	2.886069	0.0040
HEALTH	0.836789	0.419089	1.996685	0.0463

EXPERIENCE	0.077850	0.018649	4.174441	0.0000
EDUCATION	0.603783	0.077055	7.835761	0.0000
C	-3.841138	1.517058	-2.531965	0.0116
R-squared	0.340915	Mean dependent var		6.496190
Adjusted R-squared	0.331809	S.D. dependent var		5.523969
S.E. of regression	4.515455	Akaike info criterion		5.868077
Sum squared resid	11805.43	Schwarz criterion		5.935068
Log likelihood	-1716.215	F-statistic		37.43640
Durbin-Watson stat	1.746429	Prob(F-statistic)		0.000000

Dependent Variable: LOG(INCOME), **model II**				
Method: Least Squares				
Sample: 1 588				
Included observations: 541				
Excluded observations: 47				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EDUCATION	0.080806	0.009663	8.362464	0.0000
EXPERIENCE	0.010859	0.002339	4.642949	0.0000
INFO_TV	0.022406	0.008338	2.687396	0.0074
LANGUAGE	0.055830	0.037609	1.484476	0.1383
MEDIU	0.245732	0.054520	4.507181	0.0000
SEX	0.145123	0.046558	3.117020	0.0019
HEALTH	0.135176	0.051528	2.623370	0.0090
IT	-0.228832	0.057839	-3.956324	0.0001
C	0.343209	0.188173	1.823900	0.0687
R-squared	0.391345	Mean dependent var		1.729132
Adjusted R-squared	0.382192	S.D. dependent var		0.676081
S.E. of regression	0.531404	Akaike info criterion		1.589909
Sum squared resid	150.2318	Schwarz criterion		1.661334
Log likelihood	-421.0704	F-statistic		42.75730
Durbin-Watson stat	1.570052	Prob(F-statistic)		0.000000

Dependent Variable: SQR(INCOME), **model III**				
Method: Least Squares				
Sample: 1 588				
Included observations: 588				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFO_TV	0.042847	0.012353	3.468462	0.0006
IT	-0.256123	0.088206	-2.903688	0.0038
LANGUAGE	0.125281	0.058380	2.145957	0.0323
MEDIU	0.466660	0.080371	5.806352	0.0000
SEX	0.132892	0.069934	1.900251	0.0579
HEALTH	0.198389	0.077146	2.571624	0.0104
EXPERIENCE	0.011093	0.003433	3.231414	0.0013
EDUCATION	0.123068	0.014184	8.676429	0.0000
C	0.144812	0.279259	0.518560	0.6043
R-squared	0.411563	Mean dependent var		2.310853
Adjusted R-squared	0.403432	S.D. dependent var		1.076159
S.E. of regression	0.831201	Akaike info criterion		2.483298
Sum squared resid	400.0286	Schwarz criterion		2.550289
Log likelihood	-721.0897	F-statistic		50.62027
Durbin-Watson stat	1.583584	Prob(F-statistic)		0.000000

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[2] See Skandia Navigator for Example

SOME EPISTEMOLOGICAL CONSIDERATIONS CONCERNING QUANTITATIVE ANALYSIS[1]

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Ladies and Gentlemen,

I am honored by this award for many reasons. The mission assumed by the Journal of Applied Quantitative Methods is generous, and its profile fascinating. From the very first editions, the publication has complied with the high scientific standards. I am also pleased by the fact that the award addresses to my life-time passion. Bringing to my attention the jury's decision, Professor Alexandru Isaic-Maniu suggested that, on this occasion, I reveal some thoughts inspired from my experience in research, teaching and practice.

My contact with the fabulous universe of Economics has indeed given rise to many reflections, and I will share with you some of them that refer to three theses that question the gnoseological and operational efficiency of quantitative methods in the social domain.

1. The first refers to the symbolical analysis, where the connections between different

qualitative categories are transposed into equation systems, including different types of inequalities or existence conditions. The essence of this thesis is the following: "the utility of the mathematical operations depends on the correctness of the initial non-mathematical premises, whereas the mathematical deduction can never reveal an error made in the initial statements". With this assertion the utilisation of mathematics in socio-economic theories, that has considerably developed since the end of the 19th century, is discredited.

I don't deny the fact that along this road abuses were committed; Nicholas Georgescu-Roegen, among others, magisterially incriminated such cases. But he also admitted that, and I quote: "Perhaps the most obvious merit of an arithmomorphical model is the one recognized by most of the mathematical economics critics: the merit of bringing to light important errors in the papers of literate economists that had dialectic reasoning." ("The Entropy Law and Economic Process", Harvard University Press, 1971; Romanian version Editura Politică, 1979, p. 540).

1.1. Relevant in this regard was the dispute generated by the so-called "transformation problem" that preoccupied the economic thinking for a long period. I wish to remind you its main moments.

- The English classical school (Adam Smith, David Ricardo) committed some inconsistencies in the price theories, sometimes granting the role of bench-mark exclusively to direct labour, while other times not only to direct labour but also the entire invested capital.
- In "The Capital", Karl Marx supported the first principle in volume I and the second in volume III, thus accrediting "the static compatibility" of the two types of economic measurement.
- His proposal generated acute controversies. Around 1895, Eugen von Böhm -Bawerk considered that "The theory of average profit and production price cannot be reconciled with the theory of value" (Böhm-Bawerk: "Zum Abschluss des Marxschen System", 1896, p.218, quoted by N. N. Constantinescu: "The theory of the labor value in contemporary world", Bucharest, Editura Politică, 1984, p. 73). Brilliant minds have then been involved but, due to ambiguities, the polemic seemed to be enveloped in mystery.

It was the contribution of Ladislaus von Bortkiewicz – at the beginning of the 20-th century – that defined the problem using the rigorous terms of inter-branches relations and thus revealing the vulnerability of the Marxian construction. The problem was that Marx's table was based on an incongruent mix, in which the input prices complied with the principle of value, but the output prices, with the market prices principle. The translation of the literary-descriptive statements into matrix-language has undoubtedly solved this incoherence. It was later proved that "the transformation issue" can be solved logically, but only by dynamic models. (E. Dobrescu: "Again about "The transformation problem", Romanian Economic Review, Tome 33, No.2, 1989, p205-232).

1.2. I shall mention another famous case. I think there is no economist or at all educated person that didn't hear about Adam Smith's miraculous "invisible hand". What the author meant was that, under perfect competition conditions, free markets lead to an efficient distribution of resources, articulating around it the economic equilibria. But everything was given as a metaphor, uncorroborated with the unanimously or at least widely accepted by the scientific community assumptions. Getting over the road from the intuitive statement to the authentic theorem required efforts that increasingly resorted to the mathematical apparatus. I mainly refer to the contribution of Alfred Marshall and the Austrian School, that focused on the producers' and consumers' behavioural typology, and then to the unparalleled walrasian formalization of the general equilibrium.

The progress was huge, but still insufficient to elucidate Smith's collocation. From the equality between the number of equations and the number of endogenous variables did not automatically result – as Leon Walras and his disciples thought - that the system has a solution. Later laborious investigations – sustained by new, important acquisitions of the modern mathematics – made possible the settlement of the debate through the superb Arrow-Debreu model. About the first thesis against quantitative analysis, I stop here.

2. The second one already refers to the empirical research. Of course, social sciences as well as natural sciences have to face multiple difficulties of the inductive inference, pointed out by David Hume, and thoroughly analyzed before First World War by the Vienna Circle

and afterwards by Hans Hahn, Hans Reichenbach, Otto Neurath, Rudolf Carnap, Ludwig Wittgenstein, Bertrand Russel, Carl Gustav Hempel, Alfred North Whitehead, Nelson Goodman, Karl Popper and others. What we can make appeal to in order to support the quantitative analysis in the social domain is its extraordinary availability, especially in the last decades, of using the probabilistic fundamentals of induction, with all its afferent arsenal of significance tests, confidence intervals, sampling methods, estimation algorithms. The available nowadays econometric software is eloquent. But the thesis we discuss does not refer to this matter.

2.1. It invokes mainly the "impossibility of discovering – similar to natural sciences – some universally valid empirical constants" **(**Ludwig von Mises Institute: "Epistemological Problems of Economics - Sociology and History", http://mises.org/epofe/c2sec8.asp). The observation cannot however be denied. In what concerns the Economics for example, all attempts to identify generally applicable parameters, have failed – starting from the duration of various cycle types to the Phillips curve slope or the Okun relation. But, the social-economic research has understood that, in order to remain relevant, it must explicitly remain circumscribed in a strict perimeter delimited in space and time. While in our domain the appearance of scientific products similar to the laws of Physics and Chemistry is not to be expected, conceptual schemes and sets of recommendations, perfectly viable for the reference conditions, as varied as they may be, can be substantiated. This was the starting point for Milton Friedman, when he structured his vision upon positive economy. Stanford Encyclopedia of Philosophy states: "The great advantage of induction is not that it can be justified or validated, as can deduction, but that it can, with care and some luck, correct itself, as other methods do not" (Stanford Encyclopedia of Philisophy-The Problem of Induction, http://plato.stanford.edu/entries/induction-problem/).

2.2. Referring exactly to the diversity of the research object, the quantitative analysis is questioned also from the perspective of the passage from primary data concerning the elements of a collectivity to the parameters characterizing it as a whole. The impossibility of aggregation theorem, associated to the Arrow paradox, is often brought to support such an approach. What can we say in this case?

- It would be superfluous for me to try to convince you that aggregation is indispensable to any scientific process of classifying direct information, that it takes part in all the functional processes of mankind. Let's at least think about the fact that we understand each other by using languages that abound in cumulative terms. After all, what withdraws itself from taxonomy in our social existence? Almost nothing.

- Besides, neither Kenneth Arrow, nor the Romanian mathematicians that worked on this issue, did not present this incriminated paradox as imminent, but only as possible. This is more justified in Economics, where aggregated indicators usually have a double dimension – an accounting one and a behavioural one. The first one, based on algebraic operations, involves by definition the compensation effect. Even the presence of the second one does not seem suspicious if the systems are relatively stable from the structural point of view. The problems start when the object of the analysis is made of variable structures. For example, if we would use the GDP per capita as one of the possible expressions of the productive potential of some communities, the in-between comparisons will not be vitiated by aggregation operations. However, if we would seek to configure the wealth differences

through the same indicator, ignoring the income distribution, we will fell under the incidence of the discussed theorem. Even in this situation, the respective indicator remains useful if it is completed with appropriate structural parameters.

3. The third thesis, that I wish to comment, refers to the skepticism concerning the predictive capacity of the quantitative analysis. It has been manifested in radical forms, such as the Austrian School and the doctrinaire current dominated by Ludwig von Mises, as well as in mitigated forms, occasioned by the errors of some punctual socio-economic prognoses.

3.1. What is the problem? Concerning the human actions – because after all, they are the subject – two attributes are essential.

- On one hand, psychology certifies the presence in the past and present economic behaviour, of some ingredients that modify in a relatively narrow range. If we accept the assertion, we do not have logical background to reject the hypothesis of also finding them in a future human actions. Identifying them, by studying historical data series, can thus be a solid predictive bench-mark. Usually, the forecasting models are based on this kind of premise. Even the more elaborated and complicated ones, that do not limit to trends but also involve endogenous discontinuities – from shocks or cycles to stochastic perturbations or the simulation of the "time memory" – are built on the examination, systematization and interpretation of the previous economic evolutions. In modelling, we already operate commonly with evaluations regarding the expectations and bounded rationality, with perceived economic parameters. The utility functions have also been considerably diversified. Other sciences came to help – fuzzy sets, mathematics of chaos and in general of complexity, experimental psychology.

However, we cannot deny the fact that no matter how far we go down this road, the decisions of people – endowed with conscience and will – will always have an imponderable subtext. These conditions do not invalidate the predictive modelling, but disqualifies the possible side-slips from its legitimate cognitive frame. All scientific disciplines obey this type of restriction.

3.2. The quantitative analysis was blamed also in the context of the recent global crisis. In my opinion, some were justified, some not.

What is it about? Although it has sometimes been strongly denied, the world economy – with its traditional locomotive (USA) – faced a descendent trend of the Kondratieff macro cycle, after the oil-shocks of the '70s. Naturally, the real business cycles (of shorter duration) continued to function, but they grafted on this trend, sometimes transparently, other times, not. Essentially, we refer to the fact that the economic pattern – based on an oversized private and public consumption, on the excessive use of primary resources and on the alarming pollution of the environment – had generally exhausted its progress potencies. Of course, many positive technological reactions appeared, but they proved to be insufficient. In this regard, one can hardly impute something to the quantitative analysis, which – through the studies made around bio-economics and durable development – insistently emphasized the historical dilemma we are headed to.

Why did the necessary corrections get to be so postponed? This was mainly accomplished through the artificial stimulation of demand, considerably accompanied and facilitated by the sophistication of the payment instruments. According to some sources, the

ratio between the world financial assets and the world GDP increased from approximately 1 in 1980, to almost 2 in 1993 and to over 3.1 at the end of 2005 [http://bulatlat.com/main/2008/09/21/the -global-financial-crisis-and-its-implications-for-workers-of-the-world/].

Here at least two problems appear, that already concern the quantitative analysis.

- The models for the potential output were conceived and econometrically specified mainly in relation to the equilibrium, especially inflation. The CPI however, as well as other price indices in USA and other developed countries did not send alarming signals, FED practicing for a long period of time small interests in the monetary policy. Nonetheless, in reality, the internal disequilibrium was beclouded by the external one. The USA covers 65% of its total oil consumption through imports [http://www.blgould.net/NAC_RevA.html]. At the same time, directly or indirectly the external labour resources were used (through immigration as well as the cheap import of labour intensive products). These valves narrowed step by step through both the growing relative prices for some resources (as fuels) and the improvement of the life standard in China, India and other countries, implying the increase of labour costs in these areas. Thus, it became more and more difficult for the domestic disequilibrium to be absorbed by the external one. If the potential output models would have incorporated the implications of the external balance of payments, perhaps the appearance of the crisis would have been more accurately anticipated.
- Some comments are also required regarding the monetary phenomenon itself.

Although not shared by some colleagues, my opinion remains that, one way or another, behind the avalanche of financial derivatives in the past few years, was also a monetary creation parallel to the circuit controlled by the central bank. This kind of innovations in themselves cannot however be blamed. Their forerunners, during history, made the money supply to evolve from M0 to M1 and M2 and so on. What matters is that the process must not be fraudulently distorted and that it must not become unpredictable for the emission authorities. The macroeconomic models however, did not adequately follow this phenomenon in due time.

I hope that my message did not cause sadness; after all, it is an optimistic one. The socio-economic research is in front of a major challenges that I am confident can be overcome. The most reliable ally in such a process is represented by the amplification of quantitative analyses, their refinement to the highest professional level.

Finally, I wish to express my gratitude to the editorial college of the Journal of Applied Quantitative Methods, to Professors Isaic-Maniu and Ivan, to the jury that awarded me this distinction, and to all of you present here today. I am also grateful to the National Institute of Statistics and the Academy of Economic Studies, especially to Professors Voineagu and Rosca. The statisticians who know me – and they are not few – know also that I always enjoyed being among them. Thank you!

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[1] Address at the 2007 JAQM prize awarding festivity. The festivity was included in the opening of 4th International Conference on Applied Statistics, November 22, 2008, Bucharest, Romania.

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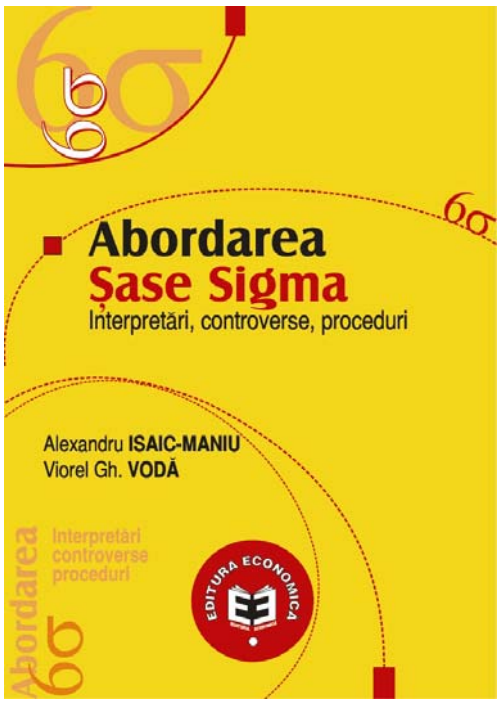
Key words: *Six sigma, quality control, statistics, Isaic-Maniu, Voda*

SIX SIGMA APPROACH – Interpretation, Controversies, Proceedings ("Abordarea Sase Sigma. Interpretari, controverse, proceduri") by Alexandru ISAIC-MANIU,Viorel Gh. VODĂ Editura Economica, Bucharest, 2008



The "Six Sigma" concept in quality control has been widely extended and encouraged in the last few years. A simple Google search gives almost 6 million results. However, in Romanian, the same search gives much fewer results (little over 3000); among the first listed results, we can find references about the two authors of this volume, which reveals the preoccupations that Viorel Gh. Voda (doctor in mathematics since 1977) as well as Alexandru Isaic-Maniu (doctor in economics since 1977) constantly and systematically have been having along their entire careers in the research of quality.

Without abusing the thoroughgoing study of the theoretical aspects that the "Six Sigma" approach is based on, and in the same time, also highlighting the inherent practical aspects in using this methodology, the present volume offers an analytic presentation, in a logical and coherent manner, of the multiple aspects and angles this new approach is involving. The case studies, themselves being of excellent guidance, the application as well as the rigorous theoretical foundation, recommend this volume to any person interested in assuming and using the newest methodologies in the domain. Consequently, students, students in master's and PhD programs on one hand, researchers and practitioners in the domain of quality on the other hand, have at their disposal a valuable instrument that will remain as referential in specialty literature.

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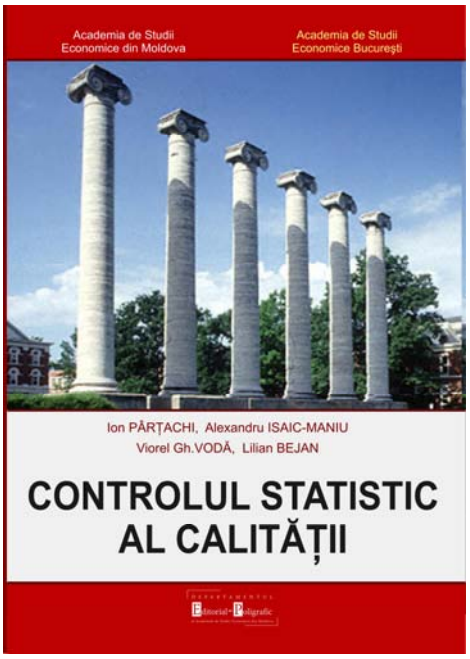
STATISTIC QUALITY CONTROL ("CONTROLUL STATISTIC AL CALITATII")
by Ion PARTACHI, Alexandru ISAIC-MANIU, Viorel Gh. VODĂ and Lilian BEJAN
Departamentul Editorial Poligrafic al Academiei de Studii Economice din Moldova, Kishinev, Moldova



A transnational group of scholars, with a solid reputation in the area of quantitative methods in general, as well as in the area of implementing the statistical procedures methods in quality and viability, brought to light a new volume in the research of quality.

The authors, with various backgrounds – in Mathematics and/or Cybernetics (Ion Partachi and Viorel Gh. Voda) and Economics (Alexandru Isaic-Maniu and Lilian Bejan) – give a highly academic outlook to the preoccupations they have in the domain of quality statistics.

In this regard, the present paper constitutes an important mark for interested students in master and PhD programs and, in the same time, offers practical and interesting solutions for other specialists confronting with aspects related to quality control in the business or research environments.

Without ignoring the classical procedures in quality control statistics, the present volume also reveals the latest innovations in the methodology validated by the international scientific community.