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## WEB SITE PROJECTS EVALUATION – A CASE STUDY OF ROMANIAN FACULTIES OF ECONOMICS WEB SITES

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**Abstract:** *In this paper, an evaluation of web sites regarded like projects is discussed. We give an overview of the Web Assessment Index (WAI), by presenting a web sites of Romanian Faculties of Economics case study. The WAI contains five categories: accessibility, access speed, navigability, content and reliability. We analyzed and presented a detailed report of the results coming out from this study. This study is important to understand the issues on which the faculties web sites are confronting.*

**Key words:** *web site; project; evaluation; Web Assessment Index (WAI)*

## 1. Introduction

Projects are temporary endeavors undertaken to create unique products or services. A project has settled start date, end date, milestones, scope and objectives; produces unique results and is characterized by a certain approach and a progressive elaboration

Nowadays, educational Web sites are considered as projects developed by Universities or other entities for their presentation, recruiting students and supplying different educational services. This is the reason why we have decided to evaluate the academic web sites of the most important Romanian Universities. For this assessment we need a flexible, engineering-based methodology that allows us to measure the degree of goal achievement of educational projects through the academic web sites.

In order to evaluate this kind of projects it is necessary to analyze them from different aspects, such as: the way they are managed, the costs/benefits report, the upgrade possibility, the potential risks, but most of all, in our opinion, we should pay a special attention to the quality feature.

Along with the web technology development, the education institutes have chosen for their presence on the Internet, by means of web sites. These ones are developed to offer general information about the universities, to support the education process or to carry on the distance education process over the Internet, exclusively.

Information technology has been successfully combined with the learning process, resulting the e-learning technology, which provides new learning opportunities with less restriction on time and space. Academic e-learning initiatives aim at designing, implementing and introducing an e-learning system in a higher education institution [Mendling, 2004].

The purpose of this paper is to develop a web site assessment index that can be employed to estimate the current usage of the Internet by the most famous Romanian universities for their educational process support and at the same time the satisfaction of specific requirements from user's viewpoint. Web sites, as essential component in modern academic educational projects, necessitate continuous evaluation for supervising the fulfillment of learning objectives stipulated in these projects.

The web site quality assessment is necessary because the web is an increasingly important source of information and there is no way to control the quality of published content.

## **2. Web sites assessment methods**

In order to achieve our goals, we have established the main necessary indicators for the web sites quality evaluation in education domain.

A review of the recent literature on web site reveals a lot of criteria for the web sites assessment. These elements are used in a quantitative evaluation, comparison, and ranking process [Pöllä, 2007; Shahin, 2004].

One of the most common method was proposed by Olsina et al. 1999 and can be considered as one of the main approaches. This method is the web site Quality Evaluation Method (QEM). There are four main factors analyzed in Olsina's study: functionality, usability, efficiency and site reliability [Olsina et al., 1999]. Currently, the results of the web sites evaluation are very subjective; thus, site evaluators should be given precise guidelines to rate every factor. In order to avoid this subjectivity problem, a Web Assessment Index (WAI) can be used. According to Evans and King, this index represents a web assessment tool and must have five main components: categories, factors, weights, ratings and total score [Evans and King, 1999].

In this paper, we have employed this assessment tool to compare the Internet usage from the five largest Romanian universities of the most famous

university centers of the province: Iași, Cluj-Napoca, Timișoara, Constanța, Brașov. Because of paper limited space, we have been reported only on Faculties of Economic Sciences of these universities (we mention that the Academy of Economic Sciences of Bucharest is constituted of 11 faculties and colleges, so we have not been reported on this one). The list below presents the faculties web sites of the first five Romanian universities.

**Table 1.** Classification of Romanian universities based on staff's scientific results with international relevance in 2006

University Centre	Faculty of Economic Sciences web site
"Al. I. Cuza" University of Iassy	<a href="http://www.feaa.uaic.ro">http://www.feaa.uaic.ro</a>
"Babes-Bolyai" University of Cluj-Napoca	<a href="http://www.econ.ubbcluj.ro">http://www.econ.ubbcluj.ro</a>
"West" University of Timisoara	<a href="http://www.fse.uvt.ro">http://www.fse.uvt.ro</a>
"Ovidius" University of Constanța	<a href="http://www.univ-ovidius.ro/stec">http://www.univ-ovidius.ro/stec</a>
"Transilvania" University of Brasov	<a href="http://econ.unitbv.ro/ed/default.aspx">http://econ.unitbv.ro/ed/default.aspx</a>

**Source:** Ad Astra Association, Topul universitatilor din Romania - Clasamentul general - 2006 (<http://www.ad-astra.ro/universitati/universities.php?year=2006>)

The WAI proposed by Miranda et al. (2006) employs four categories that are critical to web site effectiveness. These four categories are: accessibility, speed, navigability, and site content [Miranda, Cortés and Barriuso, 2006].

In order to complete our empirical study, we have extended Miranda's proposed index at five categories: accessibility, speed, navigability, content, reliability. In our opinion, these five categories are essential for web sites assessment. For each category, we have chosen some factors which reflect the most important components and features of web sites from the user's viewpoint.

The first category in the WAI is *accessibility*. This criterion is an influence factor of the site quality; that is, the identification and access facility (from user's viewpoint) is in direct proportion with the quality. The web accessibility can be evaluated analyzing two factors: link popularity and search engines presence.

The accessibility of a web site is increased by the search engines ranking. In order to establish the search engines ranking of the five web sites, we have chosen Google search engine, this one being the most frequently used in our country and considered the best in the world. The higher search engine ranking is, the higher degree of accessibility is.

Link popularity is the number of external links to the assessed web site. This has been measured using Google for counting the link occurrences of the reviewed sites in other different sites.

A significant issue for sites visitors is access time. In our paper, we analyzed the *access speed* from time viewpoint. The access speed was measured using a chronometer [Miranda, Cortés and Barriuso, 2006]. In order to eliminate any disagreements in access speeds measuring of the five web sites, we carried the access speed tests at the same hour with the same computer (Intel PIV 2,66 GHz, 512MB of RAM, 64MB graphic card) which has a 1MB optic fiber connectivity. We

used Internet Explorer 6.0, Opera and Mozilla Firefox 2.0 browsers. The access speed was calculated as the average between the three time values, reported at the number of pages for each web site. This procedure was repeated on consecutive days so that the averaged speed of access to be more representative.

The *navigability* is a very important factor from user's viewpoint because it refers to user's ability to reach the desired location in very short time. In this category, we analyzed: the presence of a permanent menu which allows a fast access to the different sections (at least the presence of a Home button) and the presence of a site map button which allows us to see the structure of the web site. Also, a search function is a very important factor.

The *content* is the most important category, in our opinion, because the presented information is the attraction key factor. That is why we have focused on the assessment of this category. In order to evaluate the content of the five web sites, we decomposed the content in attributes, in lower levels of abstraction, so as to be able to effectuate the measurement. Thus, we considered the following levels of content: informational level, services level, scientific research level, communicational level and miscellaneous level.

The first level – information – has a general descriptive character therefore we have followed the decomposition for assessment process. We were interested in the presence of: general faculty information (departments, management); entrance, educational forms; university degree; syllabus, timetable; announcements; financial information.

The second level takes into account the services available on the web, especially in student's self-interest: digital library (download courses, on-line reading and other on-line resources); on-line support services (view of the results centralization, using a login form); scholarship; symposiums, magazines.

The scientific research level addresses to anyone who wants to participate at conferences, to publish scientific articles or to gain scholarships. Generally, the academic personnel are the target of this level.

The communicational level refers especially to contact information, such as: headquarters address; telephone/fax; e-mail/web; form-based feedback.

*Reliability* is an important category both for visitors and for faculties because it highly affects their site assessment. This category is evaluated using two factors: link errors and miscellaneous errors. Link errors can be hyperlinks which do not work from different reasons, invalid links that are not correctly implemented and unimplemented links that are not implemented at all (they are measured through the number of links that are invalid, respective unimplemented reported to the total number of links).

Miscellaneous errors consist of three factors: deficiencies or absent features due to different browsers, deficiencies or unexpected results (e.g. non-trapped search errors, frame problems, etc.) independent of browsers and inactive nodes (unexpectedly under construction or dead-end Web nodes).

### 3. Data analysis

In order to evaluate these web sites, for each category was assigned a weight, established on according to importance degree (from a total of 100 points). Every factor in every category has been rated (from the total of category).

**Table 2.** Web Assessment Index with the five category and their weights

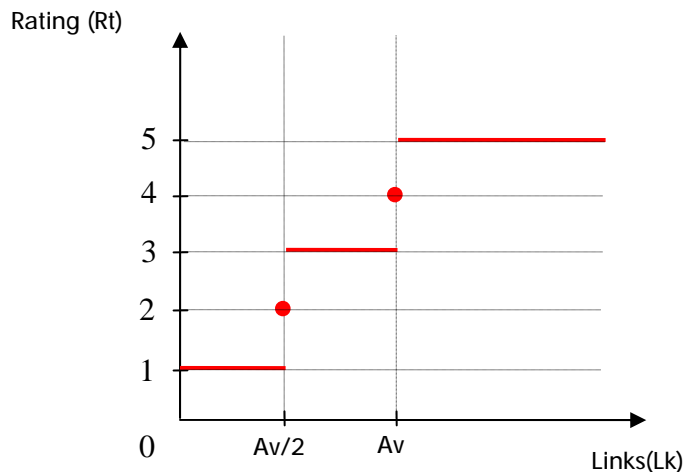
CATEGORIES	Weights	CATEGORIES	Weights
<b>Accessibility</b>	<b>10</b>	<b>Navigability</b>	<b>10</b>
Presence in search engine	5	Permanent menu	4
Link popularity	5	Site map	3
		Search function	3
<b>Speed</b>	<b>10</b>	<b>Reliability</b>	<b>10</b>
Access speed	10	Link errors	6
		Miscellaneous errors	4
<b>Content</b>	<b>60</b>		
Informational level	15	Services level	15
General faculty information	3	Digital library	6
Entrance, educational forms	3	Marks centralization	4
University degree	3	Scholarship	3
Syllabus, timetable	3	Symposium	1
Financial information	3	Magazines	1
Scientific research level	15	Communicational level	15
Conferences, symposiums	6	Address, telephone	4
Journals, magazines	6	E-mail	4
Scholarship	3	Form-based feedback	7
		<b>TOTAL</b>	<b>100</b>

For the first category, we have considered the *Position* attribute, which denotes the range number of the main site of the faculty (index) within results of Google *expression* search. The expression represents the faculty of each University, followed by the city name, such as: "facultatea de științe economice cluj-napoca" or "faculty of economic sciences cluj-napoca". The criterion function for determining the rating of the presence in search engine factor, is [Olsina, Rossi, 2000]:

case *Position* of  
 0:  $R_t = 0$ ; 1:  $R_t = 5$ ;  
 2:  $R_t = 4$ ; 3:  $R_t = 3$ ;  
 otherwise if ( $Position < = 10$ ) then  $R_t = 2$  else  $R_t = 1$ .

For the evaluation of link popularity, we have employed an advanced search option of Google search engine. For every web site we have counted sites that contain links to the faculty web site,  $Lk_i$  ( $1 \leq i \leq 6$ ), and we have calculated an average variable,  $Av$ . In order to establish the link popularity for each faculty site, we compared the  $Lk$  with the  $Av$  variable.

$$Av = (Lk_1 + Lk_2 + Lk_3 + Lk_4 + Lk_5 + Lk_6) / 6;$$



**Figure 1.** Popularity link assessment

If the web site structure includes a functional permanent menu available in every location which allows us to navigate in the whole web site, the permanent menu factor gets 4 points rating (by permanent menu we understand the principal menu, which is present by his buttons in every section of the web site, in top of the page). Otherwise, it gets 0 points rating (if the menu doesn't exist) or 2 points rating (if it exists but is not functional).

If there is a tree permanent menu, the factor gets only 3 points if it is functional, 1 point if it is not functional or 0 points if it is not permanent.

If there is no permanent menu, but there is a permanent Home button, the points are 3, 1 and 0, corresponding the three cases (exists and is functional, exists but is not functional, doesn't exist). In the same manner, we have rated the site map and intern search function with 3 points, 1 point or 0 points (corresponding the three cases presented above).

The content's factors ponderability has been made depending on some aspects, as follows:

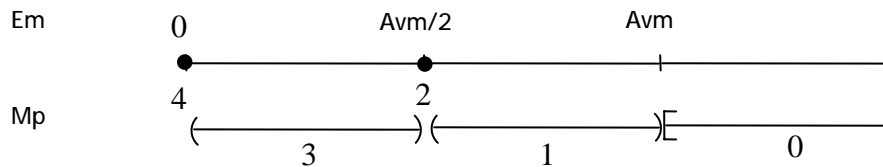
- for the first level – we have considered some aspects, regarding information, such as: quality, amount, enframming within page, last update;
- for the second level – we have focused on student services offer, especially on digital library service. We have rated these factors depending on the service complexity and functionality;
- for the scientific research level – we have analyzed the possibility of research activity development for the faculty's personnel and for others academics. We have rated this factor depending on amount of conferences symposiums, journals, magazines (like Acta Universitatis). We also consider very important (maybe more important than the amount characteristic) their bench mark (if there are international or national rated, if they are recognized by CNCSIS etc.).
- the feedback level (or the communicational level) implies the existence of contact information, such as address, telephone, e-mail. We have also

looked for the feed-back availability, meaning the presence of a form which allows the user to ask any questions about the faculty.

Link errors (*E*) have been measured through the number of links that are invalid, respective unimplemented (*L*) reported to the total number of links (*T*). In order to establish the points for this factor (*E<sub>p</sub>*), we have multiplied this coefficient *E* by 100 and we have truncated it to obtain natural numbers, named link errors index (*E<sub>li</sub>*), which have been compare using a scale from 0 to 10 (we have chosen the upper limit at 10, because the bigger natural number was 9).

$$\begin{aligned}
 E &= L / T; \\
 E_{li} &= \text{Trunc}(E * 100); \\
 \text{if } E_{li} = 0 &\text{ then } E_{pi} = 6 \\
 \text{else if } E_{li} \leq 2 &\text{ then } E_{pi} = 5 \\
 \text{else if } E_{li} \leq 4 &\text{ then } E_{pi} = 4 \\
 \text{else if } E_{li} \leq 6 &\text{ then } E_{pi} = 3 \\
 \text{else if } E_{li} \leq 8 &\text{ then } E_{pi} = 2 \\
 \text{else if } E_{li} \leq 10 &\text{ then } E_{pi} = 1.
 \end{aligned}$$

Miscellaneous errors (*E<sub>m</sub>*) have been measured through the number of specified attributes (*S<sub>a</sub>*) considering a scale. In order to find out miscellaneous errors, we tested the five web sites using two browsers: Internet Explorer and Opera. Then we have calculated an average variable, *A<sub>vm</sub>* (the average of the *S<sub>a</sub>* variables). The factor was rated with points (*M<sub>p</sub>*) from 0 to 4, comparing with the 0, *A<sub>vm</sub>*/2 and *A<sub>vm</sub>* values.



**Figure 2.** Miscellaneous errors assessment

After the settlement of these assessment criteria, we have started the evaluation of the five web sites – projects based on empirical case study. Using the above criteria, we calculated for each factor and each category, the rating and the weight, respectively. We present a table containing the five categories and their weights:

**Table 3.** Romanian Faculties of Economics Web Sites Assessment Index

Categories / Universities	Al.I.Cuza Iasi	Babes-Bolyai Cluj-Napoca	West University Timisoara	Ovidius Constanta	Transilvania Brasov
<b>Accessibility</b>	6	10	6	2	6
Presence in search engines	5	5	5	1	5
Popularity	1	5	1	1	1
<b>Speed</b>	10	10	10	10	10
Access speed	10	10	10	10	10

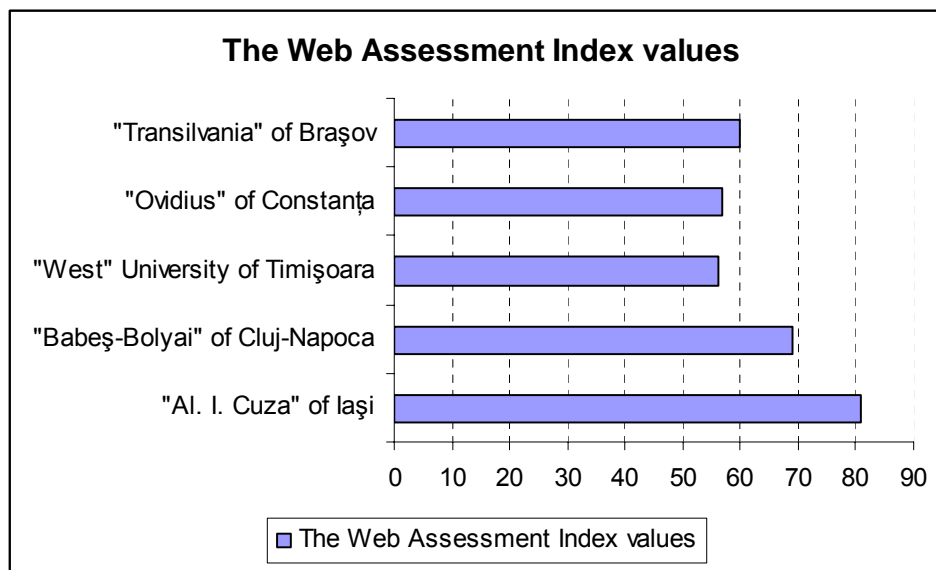


Categories / Universities	Al.I.Cuza Iasi	Babes-Bolyai Cluj-Napoca	West University Timisoara	Ovidius Constanta	Transilvania Brasov
<b>Navigability</b>	<b>10</b>	<b>4</b>	<b>7</b>	<b>7</b>	<b>3</b>
Permanent menu	4	4	4	4	3
Site map	3	0	0	0	0
Search function	3	0	3	3	0
<b>Content</b>	<b>51</b>	<b>36</b>	<b>32</b>	<b>28</b>	<b>32</b>
Informational level	14	13	9	11	12
Services level	9	6	3	8	7
Scientific level	13	9	12	3	9
Feedback level	15	8	8	6	4
<b>Reliability</b>	<b>4</b>	<b>9</b>	<b>1</b>	<b>10</b>	<b>9</b>
Link errors	4	5	1	6	6
Miscellaneous errors	0	4	0	4	3
<b>TOTAL</b>	<b>81</b>	<b>69</b>	<b>56</b>	<b>57</b>	<b>60</b>

#### 4. Results analysis

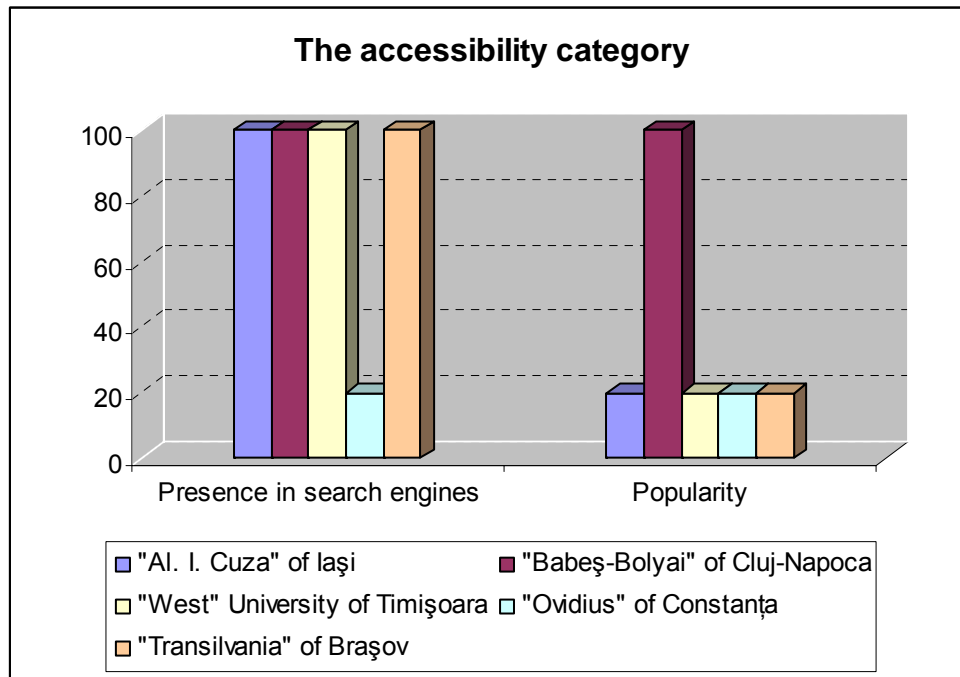
Although we have synthesized the results of our work in a graphic which presents the best web sites according to the WAI, we are not interested on identifying the best web sites, but on analyze how each faculty web site is compared to related sites and how can they be improved for their educational goals achievement.

According to the WAI, the best web sites correspond to the Faculties of Economic Sciences of "Al. I. Cuza" University of Iasi and "Babes-Bolyai" University of Cluj-Napoca.



**Figure 3.** The WAI values for the five Romanian Faculties of Economic Sciences

From the accessibility viewpoint, it's obvious that the faculties of Iasi, Cluj-Napoca, Timisoara and Brasov hold the best presence in search engines, meaning their web sites are the first outputs of Google search engine. Related to the popularity, things are changed, meaning only the faculty of Cluj-Napoca has a popularity of 606 results for its web site ([www.econ.ubbcluj.ro](http://www.econ.ubbcluj.ro)) while the others have a popularity of 2 results for their web sites.



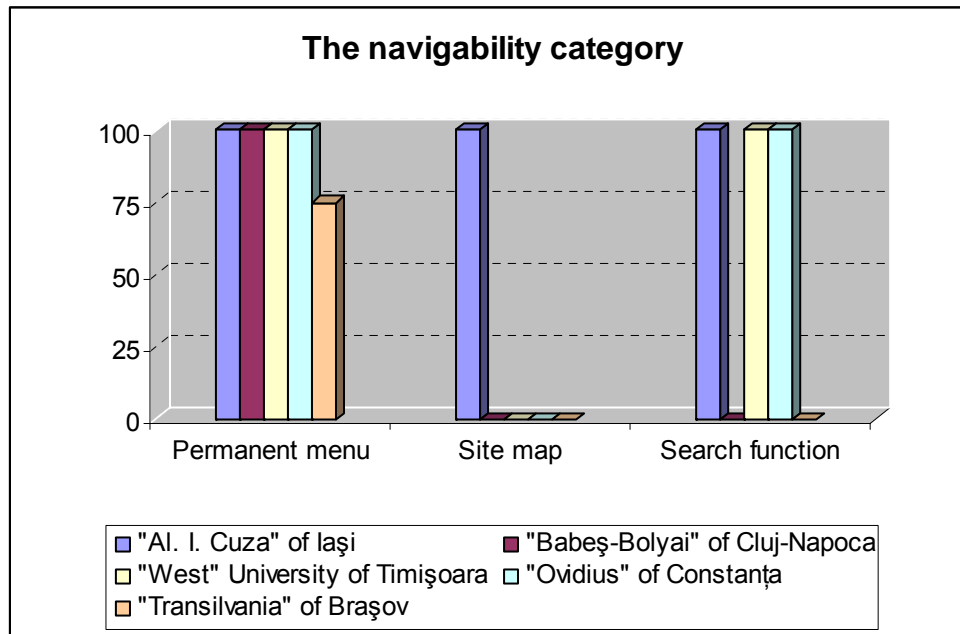
**Figure 4.** The two factors of the accessibility category

Regarding the five web sites access speed, we consider that all the web sites have an optimum access time reported to their number of pages and there are no lags in their access. So they all get a 100% percent, meaning they all get 10 points in the web assessment index.

Excepting the Faculty of Economic Sciences of Brasov which has a tree menu, difficult to use, the other faculties web sites hold a permanent menu tree, in top of pages, which is easy to use, permitting the navigability in every section of the web site. Only one of the five reviewed web sites has a site map, and this is Faculty of "Al. I. Cuza" University of Iasi. The site map is a very important element of the web structure, because it allows us to take a look at the entire site, simplifying the localization of the sections we are interested in. The search function is very important for the site, because it performs an intern search, within the web site. Only three of the five web site analyzed, own a keyword search function.

If we appertain to the entire category, we can notice that, considering the navigability, on the first place is the Faculty of Economic Sciences of Iasi, with a 100% percent, followed by the faculties of Timisoara and Constanta with a 70% percent, faculty of Cluj-Napoca with a 40% percent and the faculty of Brasov with a 30% percent. Even if the faculty of Cluj-Napoca is the second best web site of the

five sites analyzed, it has a lot of failings from navigability viewpoint and navigability elements could improve a lot this web site.



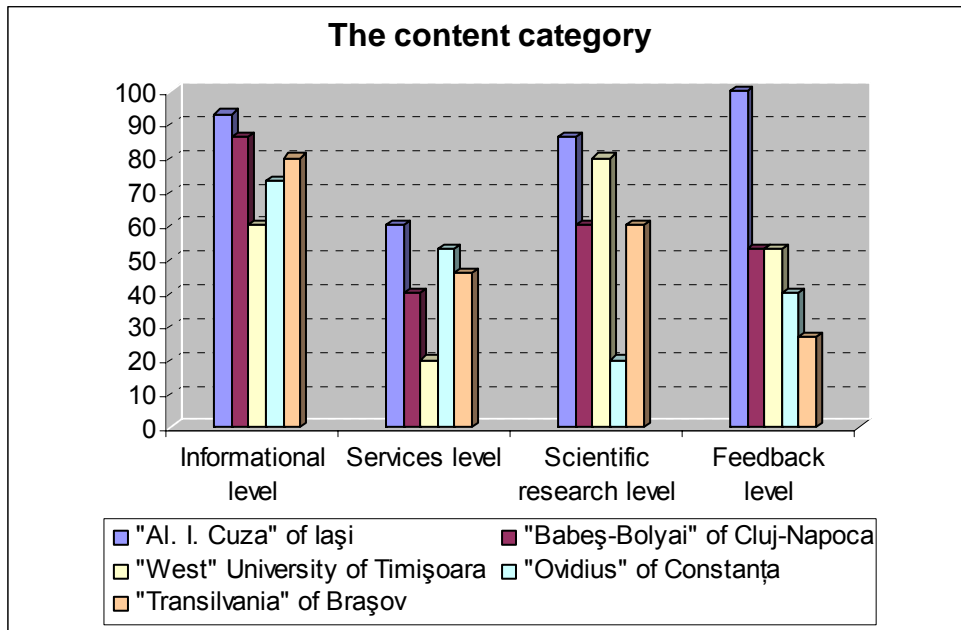
**Figure 5.** The factors of navigability category

The content category is the most important aspect in our study. As we can see, there is a various graphic for content category, meaning the five web sites are very different from this point of view. That is, their services are still deficient. At this category, the Faculty of Iasi offers the best services for their students and personnel with a 78,46% percent, followed by Cluj-Napoca with a 55,38% percent, Timisoara and Brasov with a 49,23% percent and Constanta with a 43,07% percent. The informational level is the only level where the all five web sites have a percent bigger then 50%, while the services level (services for students) is the level where the higher percent, 60%, is attained by Iasi and the lowest percent, 20%, is attained by Timisoara.

After this category study, we consider that this five web sites are designed for presentation, more than for education support. In our opinion, these web sites should be improved, so that they can be a real support for the students, namely it should be implemented a digital library and they should offer the students the possibility to find out information about their results centralization, based on an account with user and password for login on their personal page.

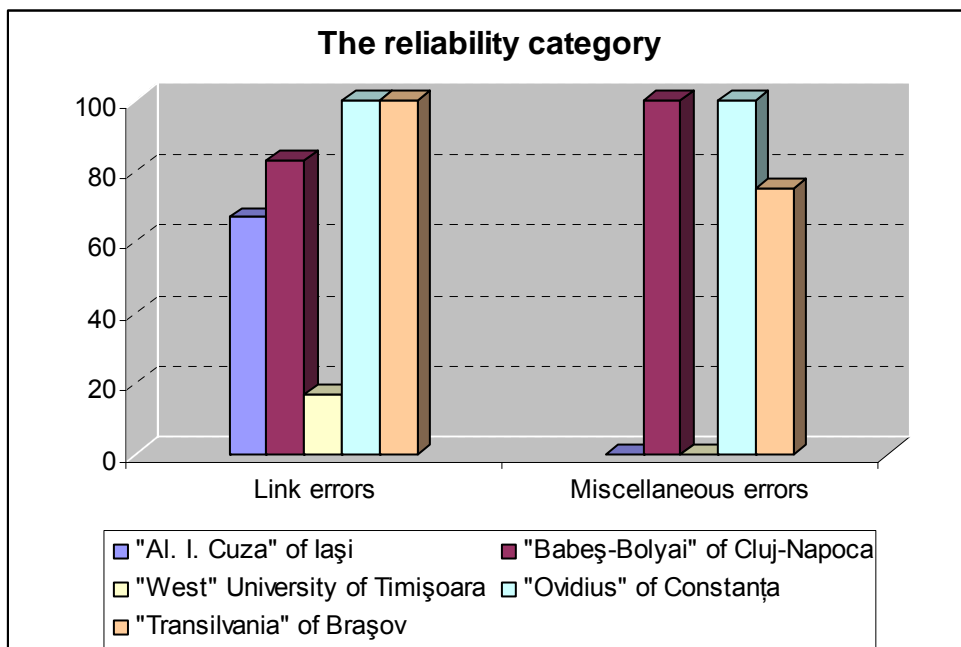
At scientific research level, the faculty of Iasi holds a 86% percent, followed by Timisoara with a 80% percent of scientific research information.

It is very important for a web site structure to contain a feedback establishment. Generally, the web sites hold a Contact button which allows to find out the address information, telephone (general information contact), but also there is a form that enables the feedback establishment by asking questions via the form. From the five web sites analyzed, only the faculty of Iasi settles a feedback with their users, the other faculties offering only general information contact.



**Figure 6.** The levels of the content category

Regarding reliability, the most reliable web sites are the sites of the faculties of Constanța with a 100% percent, Cluj-Napoca and Brasov with a 90% percent compared with the site of Iasi with an only 40% percent and Timisoara with a 10% percent. The reliability is a very important aspect of a web site, meaning that no matter how complex the site is, it should not contain any link errors or any miscellaneous errors.



**Figure 7.** The analyzed factors of the reliability category

## 5. Conclusions and discussions

Although the Faculty of Economic Sciences from Iassy city has a best web sites (according to the WAI), its web site can be much improved regarding the reliability and the popularity of the web site. From the five web sites analyzed it offers the best students services and the higher possibility for scientific research.

The web site of the Faculty of Economic Sciences from Cluj-Napoca city, could be improved by adding a site map and a search function and by diversifying the services offered to the students.

The web site of the Faculty of Economic Sciences of Timisoara, has many link errors, which means that it is not functional enough. It could be improved by working at the reliability, at popularity and also diversifying the set of the services.

The Web site of the Faculty of Economic Sciences from Constanta city has a very bad presence in the search engines and popularity, although it has highest reliability of the five sites reviewed. It necessitates diversifying of the services offered and could be improved by adding a site map.

The last site analyzed is the web site of the Faculty of Economic Sciences from Brasov city. In our opinion, the tree menu should be changed by another easier to use (a menu containing submenus and options), it could be added a site map and a search function, but also it is recommended to diversify the services for the students.

We conclude that Romanian universities have partly accomplished the objectives of supporting their educational project by means of the academic web sites reviewed in this paper and they need improvement where the WAI indicator has recorded poor results or absent characteristics.

Although many firms and institutes have a web site which is intended to be their image, in many cases this web sites does not complete all the characteristics of the web site assessment. Many times, the only concern is the web design aspect, which is not enough for a site. There are more aspects on a web site than web design, aspects on which we have debated above.

## References

1. Evans, J., R., and King, V. E. **Business-to-business marketing and the World Wide Web: Planning, managing and assessing web sites**, Industrial Marketing management, Vol. 28, 1999, pp. 41-50
2. Mendling, J. *et al* **Indirect Revenue Models for E-Learning at Universities - The Case of Learn@WU**, Vienna University of Economics and Business Administration, 2004, pp. 2-5. (<http://wi.wu-wien.ac.at/home/mendling/publications/04-ELW.pdf>)
3. Miranda, F., J., Cortés, R., and Barriuso, C. **Quantitative Evaluation of e-Banking Web Sites: an Empirical Study of Spanish Banks**, The Electronic Journal Information Systems Evaluation, Vol. 9, Issue 2, 2006, pp. 73-82.
4. Olsina, L., Godoy, D., Lafuente, G., J. and Rossi, G. **Specifying quality characteristics and attributes for websites**, First ICSE Workshop on Web Engineering, Los Angeles, USA, 1999
5. Olsina, L., Rossi, G. **A Quantitative Methodology for Quality Evaluation and Comparison of Web Applications**, SADIO Electronic Journal of Informatics and Operations Research, Vol 3, No. 1, October 2000
6. Pöllä, M. **Quality Assessment of Web Sites**, T61.6060 Special Course in Computer and Information Science IV: Decision support with data analysis, Helsinki, 2007

7. Schubert, P. **Extended Web Assessment Method (EWAM) - Evaluation of E-Commerce Applications from the Customer's Viewpoint**, Proceedings of the 35th Hawaii International Conference on System Sciences, 2002.
8. Shahin, A. **SERVQUAL and Model of Service Quality Gaps: A Framework for Determining and Prioritizing Critical Factors in Delivering Quality Services**, 4<sup>th</sup> International Conference on Quality Management, Tehran, 19-21 December, 2004.

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## IT PROJECT METRICS

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**Abstract:** *The objectives of IT projects are presented. The quality requirements that these projects must fulfill are established. Quality and evaluation indicators for running IT projects are built and verified. Project quality characteristics are presented and discussed. Model refinement for IT project metrics is treated and a software structure is proposed. For an IT project which is designed for software development, quality evaluation and project implementation mode metrics are used.*

**Key words:** *IT metrics; IT projects; quality; quality characteristics*

### 1. IT projects

They represent an important category of projects and their management implies specific particularities because:

- Their unique character; informatics systems and software are developed only one time to bring in new solutions;
- The reproduction of the resulted products is defined by costs nearing zero, determined by the possibility to make copies on modern storage devices;
- The work force used to develop the IT project is highly qualified and represents, in most cases, over 85% of the projects value;
- The development cycle of an IT project must include without question solution improvement stages to bring in the latest technologies in the field; neglecting these new technologies will lead to an old solution which may be rejected by the beneficiaries and the informatics market;

- The structure of the development cycle is adapted the pursued objective, the allocated resources, which leads to decisions regarding the continuance or abandonment of the projects, when the reviewed efficiency criterion suggest one of the two choices; this explains the fact that of 100 projects, over 50 are abandoned in the development process, only 10 projects get in maintenance and only 2-3 go in to the reengineering process;
- In the context of an evolving information and knowledge based society, all IT projects must be oriented to be user friendly, in order to grant free access to broader categories of information to every citizen.

IT project imply vast amounts of money. For projects in constructions, the amount of money needed range between thousands and millions of euros, and the resulting product is tangible, it becomes functional and is directly perceived.

For IT projects the amount of money needed starts from ten thousands euros and finally the result can only be seen in computers and networks, which are no more than 15% of the projects value. The hidden part of 85% must prove its efficiency through functionality, in time. This is why it is necessary building IT project metrics, to measure:

- How are the resources used;
- Which are the products' performances;
- How efficient will the products be in exploitation;
- Which are the risks of not finishing the project or to compensate deviations from the project.

Currently there are numerous metrics for every software typology, for every quality characteristic and for cost estimation.

It is important these metrics are analyzed and a practical approach for using quantitative methods is developed such that in the IT field the grounds of decisions will change the structure of projects and make the number of projects that get reengineered to increase.

## **2. Quality characteristics of IT projects**

The IT projects quality characteristics form a dynamical, complex and optimal system.

The systemic character is given by the interdependences between characteristics. At a given time  $t$ , a quality characteristic of a project positively influences the level of another characteristic at time  $t+1$ . Also, that characteristic has a negative influence on the level of another quality characteristic.

The dynamic character is linked to the fact that interdependence intensity between characteristics varies in time. More, the importance of quality characteristics changes from one IT project to another, from user to user or even inside the project, the modification occurs from one stage of the project to another.

The complex character resides in the large number of quality characteristics, in the number of interdependencies, and mostly in the directions in which they manifest. The accumulated experience in elaborating and implementing projects shows that the characteristics system becomes more complex as the objectives are better pursued and the level of performance is higher.



The optimality of the quality characteristics system oversees the quantitative side of costs that the tendency to plan and complete projects with a higher quality level generates.

There is a solution of the quality optimization model that shows the moment in which the improvement of quality is no longer sustained through costs, which are far greater than the costs needed to fix the corresponding defects of a lower quality level of the IT project.

If  $M$  is considered the number of the quality characteristics  $C_1, C_2, \dots, C_M$  of the projects, for each characteristic must be stated:

- the content ;
- the factors of influence;
- the associated models
- the use of indicators in taking decisions;
- the indicators aggregation.

**Complexity** is the characteristic used in differentiating projects. A project  $A_i$  is more complex than a project  $A_j$  if:

- the type number of resources used is greater;
- the number of stages through which the project is finished is greater;
- the number of machines used is greater;
- the number of different operations done by each machine is greater;
- the qualification needed by workers to operate the machines is higher;
- the number of links between stages is greater;
- the execution time is greater;
- the organizational effort is greater;
- the density of execution procedures is higher.

A graph is associated to the project  $A_i$  in which the nodes are either stages or activities, and the arcs are the ones that set the precedence. If:

- $n_1^i$  – the number of nodes of the graph  $G(A_i)$  for the project  $A_i$
- $n_2^i$  – the number of arcs which link the nodes of the graph  $G(A_i)$

the complexity  $CP$  of the project  $A_i$  in a Halstead way is given by:

$$CP(A_i) = n_1^i \log_2 n_1^i + n_2^i \log_2 n_2^i$$

A project  $A_i$  is more complex than a project  $A_j$  if and only if:

$$CP(A_i) > CP(A_j)$$

Meaning

$$\frac{(n_1^i)^{n_1^i} \cdot (n_2^i)^{n_2^i}}{(n_1^j)^{n_1^j} \cdot (n_2^j)^{n_2^j}} > 1$$

If in time in an organization projects are implemented of which a project  $A_k$  is considered a model, the relative complexities of the projects  $CR(A_1), CR(A_2), \dots, CR(A_M)$  are obtained from:

$$CR(A_i) = \frac{C(A_i)}{C(A_k)}$$

The project model has the relative complexity  $CR(A_k) = 1$ .

The  $K$  completeness of project  $K$  is a quality characteristic which refers to two aspects:

$K_o$  – the completeness of the offer regarding the content of the document which is under evaluation

$K_i$  – the completeness of the implementation regarding the stages developing process and the completeness of the process

If  $p_1$  is the percentage of the elaboration stage of the offer and  $p_2$  is the percentage of the developing of the project  $p_1 + p_2 = 1$  and  $p_1, p_2 \in (0,1)$  it results that the level of completeness  $KP$  of project  $A_i$  is given by:

$$KP = p_1 * K_o + p_2 * K_i.$$

The level of completeness  $K$  of any construction regards:

$np$  – the number of parts imposed to consider the construction accepted

$nr$  – the number of parts effectively realized

and the relation is obtained:

$$K = \frac{\min\{np, nr\}}{\max\{np, nr\}}$$

A project contains:

- eligibility criterion to which variables that belong to  $\{0,1\}$  are associated to; if in the project the imposed requirements are respected the value 1 is given to a criterion  $Cr_i$ ; if a project must fulfill  $L$  eligibility criterions the indicator  $IL = \prod_{i=1}^L \alpha_i$  is calculated where  $\alpha_i$  is the level of the  $Cr_i$  criterion,  $\alpha_i \in \{0,1\}$ ;
- the technical side definition, in which definitions are given, processes are described, models are built; the completeness refers to the degree in which these descriptions include all the components known by specialists; the descriptions must offer a suggestive picture in connection with what is going on in the actual choused domain; there must not be a lack of elements which by their absence:
  - o prove that the authors do not have a grasp on the domain;
  - o show that the authors of the project do not have knowledge of materials, equipment, processes, operations, effects and models.

The specialists that analyze a new project have a clear image about the structure that includes mandatory parts, minimum requirements and by comparison see what is missing or what has been treated shallow.

**Clarity** is a very important characteristic not only for the offer made for a project but also to the development process.

The offer is a text. The implemented project is a product, a service, an action.

The clarity of text  $T_i$  associated with project  $A_i$  is analyzed in the following manner:

- the text  $T_i$  is decomposed in parts  $a_{i1}, a_{i2}, \dots, a_{ir}$ ;
- each part  $a_{ij}, j = 1, 2, \dots, r$ , is connected with resources, actions and equipments;
- the logic content of  $a_{ij}$  with the logic of the process development;
- parts of the text are connected with resources building up pairs  $(a_{ij}, r_p)$

If the pairs parts of text – resources are completely defined then the text  $T$  is clear. If parts of text or resources are not paired, the project does not have a good clarity level. The clarity is influenced in a negative way by pairs in which for different parts of text the same resources come up.

The necessity of defining probabilities which are associated with the pairs  $(a_{ij}, r_p)$  also has a negative influence on clarity.

Correctness is quality characteristic of a project, through which the ones that make the offer ant participate in the development of the project ensure:

- the concordance between theory and practice
- the use of results obtained by other specialists, results that were verified in practice;
- the use of concepts as they were defined, maintaining the context unaltered;
- respecting the defined procedures for executing operations;
- through all the means used, that the requirements imposed by obtaining a high level of quality for the product or service in its final form, are respected.

The correctness of a project offer is demonstrated, and the correctness of a product or the execution of a service is pointed out either by analysis, or by establishing the effects the product or service will generate. A product or a service is correctly or incorrectly realized.

If it is accepted that the product or service is partially correct, the correctness measuring indicator moves from the values 0 or 1 to the interval  $[0,1]$ .

The problem of correctness in calculating costs and efficiency regards:

- the hypothesis on the basis of which the efficiency calculations are made;
- establishing the expenses levels for each chapter by pointing out quantities, unitary price, and interval limitation;
- using the calculation models as they were defined;
- bounding the variables regarding specific consumes through comparative analysis with projects already implemented;
- respecting the control keys;
- respecting the inequalities regarding the expense structure in conditions of the impossibility of not transmitting from one capital to another of the expenses.

For the definition of IT projects the following are defined:

- the criterions  $Cr_1, Cr_2, \dots, Cr_h$ ;
- the domains of variation measured for each criterion  $[a_1, b_1], [a_2, b_2], \dots, [a_h, b_h]$ .

If for criterion  $Cr_i$  the level  $x_i$  is measured, then the correctness of the project is given by:

$$CG = \prod_{i=1}^h x_i$$

$$\prod_{i=1}^h a_i \leq CG \leq \prod_{i=1}^h b_i$$

The correctness norm is realized by defining the relation:

$$\prod_{i=1}^h \frac{a_i}{b_i} \leq CGN = \prod_{i=1}^h \frac{x_i}{b_i} \leq 1$$

There are numerous cases in which the relative correctness of a criterion  $CR_i$  is obtained using a report like:

$$CR_i = \frac{A_i}{h_i}$$

Where:

$A$  – the number of fulfilled sub criteria

$h$  – the total number of subcriteria

In this case the global correctness is

$$CG = \left( \prod_{i=1}^h CR_i \right)^{\frac{1}{h}}$$

**Consistency** is a quality characteristic which is used to point out to what extent an IT project is built respecting precise rules, without including components which have the role of annihilating what was prior executed.

The text of the project includes stages, chapters developed in ascendant order with the next components being constructed based on the ones before.

A project is under defined if the text or the product doesn't contain those elements that insure its functionality.

The project is over defined if it includes a lot more components than necessary. The numerous details make it hard to accomplish, and the function for which it is constructed is lost among many other functions, some having nothing in common with the initial objective.

Only a defined project, in which every component has its role well established, is a consistent project.

A project structure,  $SP$ , is considered, having the complexity  $C(SP)$ , structure which corresponds to projects, products or IT services considered to be functional, which exist and have a degree of satisfaction at user level greater than 0.8, the degree of satisfaction is given by:

$$GS = NF/NT$$

Where

$NF$  – the number of users that have successfully finished the problem for which they used the resources of the project;

$NT$  – the total number of users that accessed the resources belonging to the project.

The consistency  $CO$  for the project  $A_i$  is given by:

$$CO = \frac{\min\{C(SP), C(A_i)\}}{\max\{C(SP), C(A_i)\}}$$

Ability to complete is another characteristic that all evaluators take in consideration and it is influenced by:

- the experience of the team which proposes a solution for an IT problem;
- the estimation of resources used for implementing the solution;
- the estimated duration of the project;
- identified resources and procedures used to attenuate the effects.

The practice of elaborating an offer and implementing it presume:

- knowledge of technologies;
- rigorous knowledge of duration and minimal and maximal consumptions necessary to complete activities;
- the correct defining of precedence;
- identifying the operations needed to prepare;
- building a timeline for activities;
- regrouping the activities such that the equipment and highly qualified workforce are efficiently used.

If in a project are identified:

$NA$  – number of activities;

$D_i$  – time to complete activity  $i$ ;

$K_i$  – number of resources necessary for completing activity  $i$ ;

$x_{ij}$  – resource consumption  $j$  for completing activity  $i$ ;

$t_{si}$  – start time for activity  $i$ ;

$t_{fi}$  – end time for activity  $i$ ;

The planned and effective levels are established.

For the planned levels mark  $p$  will be used; the planned level for activity  $xxx$  will be  $xxx^p$ .

For the effective level the mark  $e$  will be used, such that variable  $xxx$  will have the effective level  $xxx^e$ .

The indicator  $IUR$  regarding the use of resources is built using the relation:

$$IUR = \frac{\sum_{i=1}^{NA} \sum_{j=1}^{k_i} \alpha_{ij}}{\sum_{i=1}^{NA} k_i}$$

where

$$\alpha_{ij} = \begin{cases} 1, & x_{ij}^p = x_{ij}^e \\ 0, & \text{for the rest} \end{cases}$$

The ability to complete is seen also compared to optimistic or pessimistic attitude manifested by those who make an offer or implement a project.

If the planned level for a resource is  $x_{ij}^p$ , the minimal consumption for completing operation  $x_{ij}^{min}$ , and the maximal consumption for a resource is  $x_{ij}^{max}$  the level realistic approach is built as the indicator  $IR$  given by:

$$IR = \frac{\sum_{i=1}^{NA} \sum_{j=1}^{k_i} \beta_{ij}}{\sum_{i=1}^{NA} k_i}$$

Where

$$\beta_{ij} = \begin{cases} 0, x_{ij}^p = x_{ij}^{\min} \text{ sau } x_{ij}^p = x_{ij}^{\max} \\ 1, \text{ for the rest} \end{cases}$$

**Reliability** is quality characteristic of IT projects which states the degree in which the stages in the life cycle of the project are developing successfully

The life cycle of an IT project includes:

- E1- the offer elaboration stage
- E2- project implementation stage
- E3- the current use of the product resulted after... through the project
- E4- the maintenance process
- E5- using the product post maintenance
- E6- taking the product out of use

Each of these stages has associated an importance coefficient  $p_i, i=\{1,2,3,4,5,6\}$ .

Each stage  $E_i$  is characterized by a duration  $D(E_i)$ .

The physical duration norm of the life cycle of the project is given by:

$$DFN = \sum_{i=1}^6 D(E_i)$$

The corrected duration norm of the project is given by:

$$DFNC = \sum_{i=1}^6 p_i D(E_i)$$

$$DFNC < DFN \quad \text{because } p_i \in (0,1) \sum_{i=1}^6 p_i = 1 \text{ resulting that } D(E_i) > p_i D(E_i) \text{ for } i=1,2,3,4,5,6.$$

In the background of every stage processes are running. If a process  $\theta_j$  is stopped because of various causes, the duration of the process  $DP(\theta_j)$  increases with  $\Delta(\theta_j)$  which increase depends on:

- the complexity of the cause that determined the interruption;
- the ability of the team to eliminate the cause;
- the resources that are redirected to eliminate the cause;
- the place where the cause was spotted; as a cause is spotted later, the resources used and durations are increasing;

The physical running cycle norm of the project is identical with the effective duration if and only if  $\Delta(\theta_j)=0 \forall j \in N$ . In reality, throughout the lifetime there are recorded interruptions of specific stages  $\Delta(E_i)$ , such that the effective duration of the cycle:

$$DFE = \sum_{i=1}^n (D(E_i) + \Delta(E_i))$$

The norm reliability of the project  $P, f(P)$  is given by:

$$f(P) = \frac{DFN}{DFE}$$

The corrected reliability  $fc(p)$  is given by the relation:

$$f_c(P) = \frac{DFNC}{DFEC}$$

where  $DFEC = \sum_{i=1}^n [p_i D(E_i) + h_i \Delta(E_i)]$  where  $h_i, i=1,2,3,4,5,6$  are the fractions associated to the importance which is given to the duration of process delaying from the stages  $E_i, i=1,2,..6$ .

Compared to other products or services in which reliability is characterized by quality in use, at the beneficiary, giving the degree in which the product or service accomplishes the set objective, in case of the IT projects, the reliability of a project is mistaken with the reliability of the life cycle because:

- in all the stages the workforce plays an important role, representing more than 85% of the production costs;
- the successful functioning of the finite product strictly depends on the operating of each subsystem; the offer lays down the conceptual foundation and resource allocation; the elaboration of the offer is a stage of the life cycle of the IT project; the offer elaboration process reliability is essential to the entire product;
- the eventual deploying of an reengineering process is meant to redefine basic elements of the offer, and the multiple mobilization effect of the new structure of an IT project is limited to all the other stages that follow.

It is important to identify in the existing projects in the databases those variables with the help of which the levels of difference  $\Delta(E_i)$  are calculated to help compute the effective reliabilities of these projects in the norm version and most of all in the corrected version.

Given the Project P in the table 1 below,

**Table 1.** Data for P project

Name	Norm duration	Effective duration	Interruption duration	Total
E1	6	12	8	20
E2	24	38	12	50
E3	50	60	40	100
E4	10	15	5	20
E5	5	10	10	20
E6	5	10	10	20
<b>Total</b>	100	145	85	230

The reliability of project P =  $\frac{145}{230}$ .

There are other quality characteristics of an IT project like:

- comparability
- reusability
- orthogonality
- reproduction ability

For these characteristics the research must be continued such that the results will be operational in daily practice.

### 3. IT project model quality refinement

Models are built starting from a model of hypothesis. It is necessary to go on to the stage of refining the models. The refinement process consists of:

- Reducing the number of variables;
- Decreasing as much as possible the degree of incorporated nonlinearity ;
- Guaranteeing minimal loss of information by using simplified models.

The refinement of IT projects assumes:

- Taking in consideration only the data that is collected usually for elaborating the offer and running the projects;
- Retaining in the indicator structure the variables that decisively influence the evolution of the project from a practical point of view;

Refinement is made on two levels:

- At the first level, from the set of indicators  $I_1, I_2, \dots, I_M$  a subset is retained formed by the indicators  $I_i, I_{i+1}, \dots, I_{i+K}, K \ll M$ .
- At the second level, the retained indicators operate with the variables  $X_i, X_{i+1}, \dots, X_{i+H}, H \ll L$  instead of using the variables  $X_1, X_2, \dots, X_L$ .

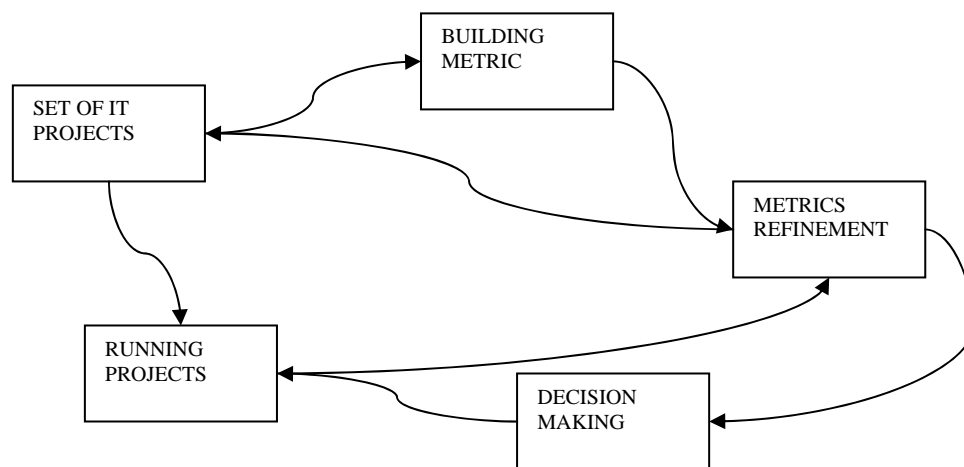
It means that instead of analyzing  $M$  characteristics, a number of  $K$  characteristics is analyzed.

Instead of  $L$  variables, the refined indicators operate with  $H$  variables.

The effort must be reduced without significant loss of information obtained from using the metrics. The decisions taken based on the refined metrics of the IT projects must lead to maintaining the process of implementation in the limits recognized acceptability.

IT projects metrics refinement must allow the use of existent data bases, and the implementation of simplified indicators must not be affected by the defined data structures, without requiring new data structures or data reorganization.

The IT project metrics refinement process is carried on like in figure 1.



**Figure 1.** Usage of refined models



The refinement process is customizable by defining limits referring to:

- the minimum list of variables that defines the indicators;
- the accepted loss of information level.

Under the conditions the indicators  $I_1, I_2, \dots, I_K$  are considered in which the variables  $X_1, X_2, \dots, X_L$  are used, through refinement it is imposed:

- the maximum number of indicators to be  $M_{max}$ ;
- the maximum number of variables to be  $H_{max}$ ;
- the error level must not be higher than  $E$ .

Refinement presumes:

*P1*- definition of the initial solution for the refinement process which includes all the  $K$  indicators, all the  $L$  variables and the criterion through the measurements are made;

*P2*- taking the data bases that regard IT projects that have frequent definition classes and best implementation, known as successful projects.

*P3*- evaluation of indicators  $I_1, I_2, \dots, I_k$  with the data taken from the data bases for the  $L$  variables

*P4*- calculating the aggregated error criterion

*P5*- elimination of the  $x_i$  variable from the indicators

*P6*- evaluation of the indicators

*P7*- calculation of the criterion

*P8*- building the  $Er_i$  array

*P9*- repeating the steps  $P_5 - P_8$  to eliminate the variable  $x_{i+1}$  from the list

*P10*- after building the array  $Er_1, Er_2, \dots, Er_L$  it is sorted in descending order and the variables for which the error has the smallest value are eliminated

*P11*- the steps  $P_5 - P_{10}$  are repeated until the given error level is obtained; it is possible this level is reached in the first iteration and the refinement process stops;

Once the variable list is refined, the refinement of indicators starts.

*P12*- the list  $I_1, I_2, \dots, I_K$  of indicators and the list of refined variables  $X_1, X_2, \dots, X_H$  are considered;

*P13*- the indicators are calculated using the relation and are considered an initial solution for the aggregate performance indicator

$$IP^0 = \sum_{j=1}^H p_j I_j \quad \text{where } p_j - \text{weight}$$

and a certain level is obtained

*P14*- the indicator  $I_k, k=1, \dots$  is eliminated

*P15*-  $IP$  is calculated and a vector  $\alpha_1, \alpha_2, \dots$  is built

*P16*- steps  $P_{14} - P_{15}$  are repeated until the indicators are eliminated one by one

*P17*-  $\alpha_1, \alpha_2, \dots$  are ordered decreasing

*P18*- the indicator which has the smallest error difference with  $IP^0$  is eliminated

*P19*- the steps  $P_{14} - P_{18}$  are repeated until the maximum admitted number for indicators is reached

The refinement activity is a repeating process convergent to a stable process. To complete the refinement simulation methods and genetic algorithms and neuronal networks are built.

#### **4. Software for implementing IT metrics**

The software product for evaluating IT projects assumes:

- building a list with  $K$  quality characteristics  $KAL\ 1, KAL\ 2, \dots, KAL\ k$
- building a list of indicators  $I\ 1, I\ 2, \dots, I\ k$
- building a list with  $M$  variables
- making the connection between the  $M$  variables and fields in the data base
- launching the refinement process
- obtaining a sublist of characteristics with a sublist of indicators which are obtained with a sublist of variables
- validating the sublist of indicators as a metric of IT projects

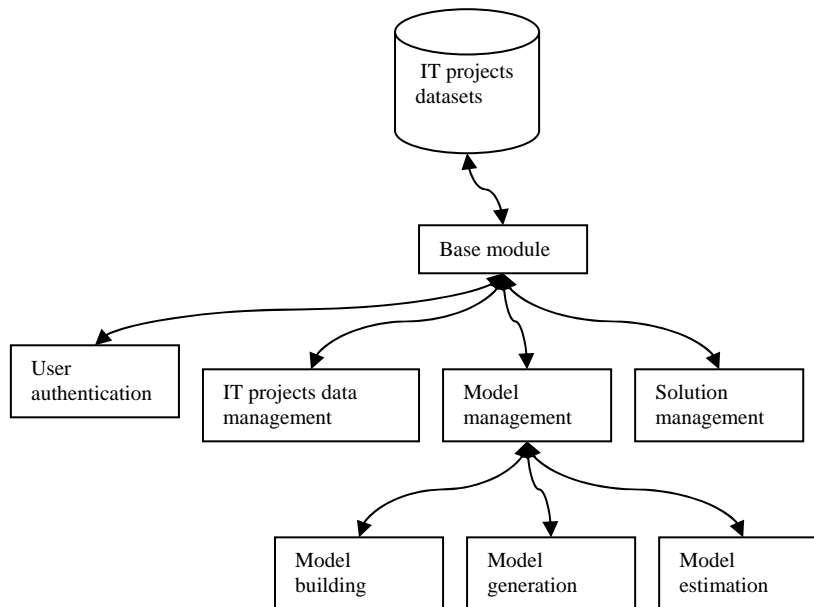
The software product designed to implement IT metrics is a complex construction which:

- must be accessed off the internet;
- has user authentication ;
- accepts definitions of data bases;
- takes fields from the data base and constitutes the series that make estimations;
- allows the selection of structures of initial indicators  $I\ 1, I\ 2, \dots, I\ k$ ;
- offers a list of performance criterion for selecting indicators and variables;
- generate indicator structures for the refinement process;
- calculates the level of refined indicators on request or periodically to fundament decisions.

The software product has the functions:

- user authentication;
- the management of data sets that correspond to the problems to solve;
- estimation of model coefficients;
- model refinement;
- model structure generation;
- aggregation level calculation to fundament decisions;
- options, parameters and solutions are saved if the data sets are valid;
- adding of information and identification data.

The software structure is given in figure 2.



**Figure 2.** Software structure for IT project metrics implementation

The software product is taking numerous elements that constitute a modelbase.

The modelbase is a complex construction in which lists are included with:

- dependent variables and independent variables;
- linear and nonlinear models structures;
- registered data sets and generated data sets;
- implementation of the coefficients estimation algorithms;
- procedures for the hypothesis verification;
- procedures for the estimated values calculation;
- models hierarchizing procedures.

These very important components are elements with which the modelbase is populated. For the modelbase to become operational, an administration system has to exist.

First of all, the administration system has to operate distinctly with data sets, with the procedures and with the models structures.

Second of all, the administration system functions have to effectuate the fast finding of the data sets, of the models structures and of the procedures in order to secure the processes development in concordance with the demands of the analyst economist.

Third of all, the administration system has to be equipped with functions which permit the data sets adding, the models adding and the procedures adding. The perspective has to be changed, through which the modelbase bringing up to date implied data / models / procedures deleting or changing of some parts of these with new sequences.

The acceptance of the bringing up to date function exclusive through adding comes to bring a concordance between the natural way of understanding the evolution with the corresponding reflection of it on informatics level.

The modelbase administration system operates with non homogenous entities, important aspect in securing the flows consistency.

Fourth of all, an open character is secured, the users having at their disposal the possibility of defining personal algorithms for interpolation and extrapolation, for pseudoaleatory numbers generation, for the coefficients estimation, for implementing personal models selection criteria.

Fifth of all the, defining of the specific concepts regarding the finding, selection, extraction, targets the triplets (data, models structures, procedures), which group complex proceedings.

Sixth of all, a growth of the generalization degree for the transaction concept is produced, which in case of the modelbase implies the traversing of some flows in which it is operated simultaneously with data sets, with data structures and with procedures.

The new conglomerate, more complex than the object structure that includes the operands and operators, develops a new projection on the philosophy of designing an administration system, the administration system of the modelbase, in which new typologies specific to the implemented processes in the field of artificial intelligence are included besides the already usual proceedings.

Utilizations of the modelbase imply activations of some sequences of procedures from the modelbase.

The administration system of the modelbase is a construction with a very high complexity degree. The users must have the possibility of starting a small diversity of economic analysis projects.

For example, the coefficients estimation of a model on the basis of a data set consists of:

- the specification of the exogenous variables number and of the endogenous variables number;
- the specification of the data series terms number;
- the insertion of the data table;
- the delimitation of the variables list corresponding to the data series position.

Also, some results regarding the estimations quality are displayed.

This procedure is specific to the situation in which the user has a clear image on the phenomenon and this one's analysis is already a routine activity.

Model generators are software applications taking as input datasets and information regarding model nature, structure and complexity and produce different models from a certain model class.

Linear model generators take as input a dataset containing a number of independent variables and a dependent variable and produce linear models combining influence factors.

Linear model generators with lagged arguments allow the elaboration of constructions which permit the modeling of the cases when a variation in an influence factor has a delayed effect on the dependent variable. The generator produces combinations of both influence factors and lags, identifying best models.

Standard nonlinear model generators use predefined analytical forms for generating models. General nonlinear model generators build automatically analytical expressions containing influence factors.

All generators order their results according to performance indicators.

Model complexity is assessed by measures based on Halstead metrics, taking into account the number of operators and operands. Complexity measures help comparing models and building performance indicators.

The quantitative study of phenomena is encouraged by the volume of historically recorded information. Its purpose is to take decisions leading to continuous improving of performance indicators for subsequent projects.

Modelbases are complex software constructions offering functions for:

- defining, retrieving and updating models;
- modeling applications management;
- estimation and validation of coefficients;
- automated model generation from existing datasets;
- dataset management.

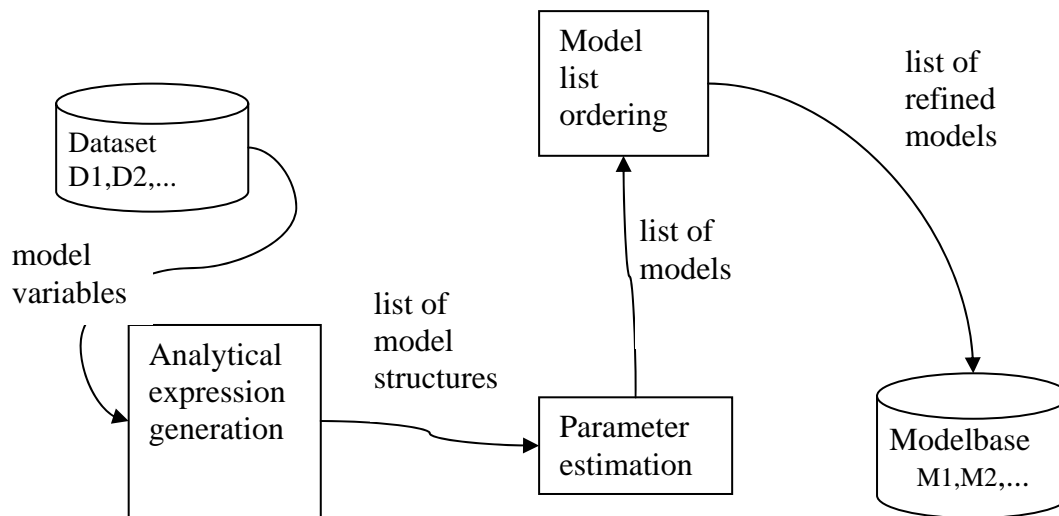
Model generators are modelbase instruments that build model structures from a given class using variables found in the dataset given as input. Model classes group models with the same structure, e.g. linear models, linear models with lagged variables, nonlinear models. For each class a model generator is developed. Each dataset contains data series for the recorded variables. The endogenous variable is specified and the generator builds analytical expressions using influence factors. For each model structure, coefficients are estimated and a performance indicator is computed. The resulting model list is ordered by the performance indicator. The analyst chooses between the best models an appropriate form that later will be used in estimating the studied characteristic.

In the context of model generation, the refinement process is described as follows.

Consider the dataset  $S$  and a model generator  $G$ . The set of models generated by  $G$  to fit the dataset  $S$  is  $L_M$ . The model set  $L_M$  is characterized by the following:

- the number of models is large;
- models have a variety of values for the performance criterion ranging from the worst fitting model to the best fitting model;
- models have a variety of values for the complexity, ranging from the most simple expressions to very complex ones;
- the best fitting models are not compulsory the most complex ones, and also, the simplest models are not the worst in explaining the studied phenomenon.

The refinement process using model generators is described by the following diagram shown in figure 3.



**Figure 3.** The model refinement process

The refinement process takes the following steps:

- the dataset is built; it contains data series for the dependent variable and independent variables;
- using variable names found in the dataset, model structures are generated; the list of generated model structures is denoted by  $L_G$  and contains a large number of models, also depending on the constraints or type of the generation algorithm;
- for each model structure in  $L_G$ , coefficients are estimated, along with statistical performance indicators, obtaining the list of estimated models,  $L_E$ ;
- for each model found in  $L_E$ , an aggregated performance indicator is computed; the  $L_E$  list is ordered by this performance indicator and an arbitrary number of models is chosen, forming  $L_R$  list, the refined list of models;
- the refined list of models is saved into a modelbase and then used by the human analyst to choose one or more models to be used in estimating the studied phenomenon.

## 5. Conclusions

Taking into consideration the importance of IT projects the continuance of the study is mandatory:

- Quality characteristics;
- Identifying new indicators;
- Making the data collection and metrics calculation an automatic process;
- Recording reaction to the decision quality to see what are the indicators which need perfecting.

In current time there are instruments used to assist elaboration processes of IT projects. These instruments are meant to ensure the completeness of IT projects.

If the following are built:

- activity lists;

- resource lists;
- job lists.

and for each the number of elements is established from the list, as an instrument is meant to impose:

- the complete description of the elements in each list;
- the correlation of elements between lists;
- the aggregation of data from the generated matrices by the combination of lists.

If a series of relations are imposed regarding:

- the structure of the offer text;
- the expense structure;
- the activity precedence ;
- the rates of financing.

the instruments are meant to:

- verify if the structure is respected;
- generate the parts of structure;
- reduce the number of repeats from one component to the other;
- control the levels of complexity;
- include aggregated levels;
- eliminate abbreviations introducing the elements clearly;
- ensures the qualitative level of the criterions;
- evaluate the level of allocated resources;
- use correct words from a specialty vocabulary.

For a data base in which the records regarding the evolution of a project are saved, the dates must be complete and correct.

If data is taken from several projects the following are calculated:

- differences between the consumption or normed duration;
- The interval belonging frequencies and consumption variation;
- The probability that a variable will follow a certain repartition law.

The complete image over an IT project is obtained only through the implementation of a correctly constructed metric, refined and completely validated.

## **Bibliography**

- Boja, C., Ivan, I. **Metode statistice în analiza software**, Ed. ASE, Bucharest, 2004
- Ivan, I., Boja, C. **Managementul calitatii proiectelor TIC**, Ed. ASE, Bucharest, 2005
- Ivan, I., Nosca, Gh., Popa, M. **Managementul calitatii aplicatiilor informatice**, Ed. ASE, Bucharest, 2006.
- Ivan, I., Popescu, M. **Metrici software**, INFOREC Publishing House, Bucharest, 1999
- Ivan, I., Ungureanu, D. **Project Complexity**, INFOREC Publishing House, Bucharest, 2002
- Ivan, I., Visoiu, A. **Baza de modele economice**, Ed. ASE, Bucharest, 2005
- Jalote, P. **Software Project Management in Practice**, Addison Wesley, 2002
- Toma, C., Ivan, I., Popa, M., Boja, C. **Data Metrics Properties**, Proceedings of International Symposium October 22-23, 2004, Iassy, Romania, pp. 45-56

- Visoiu, A. **Performance Criteria for Software Metrics Model Refinement**, Journal of Applied Quantitative Methods, Vol. 2, No. 1, March 30, 2007
- Visoiu, A., Garais, G. **Nonlinear model structure generator for software metrics estimation**, The 37th International Scientific Symposium of METRA, Bucharest, May, 26th - 27th, 2006, Ministry of National Defence, published on CD
- Visoiu, A., Ivan, I. **Rafinarea metricilor software**, Economistul, supliment "Economie teoretica si aplicativa", no.1947(2973), August 29, 2005

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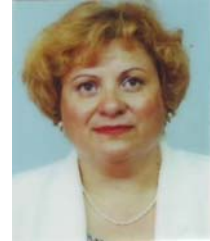
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## **CONTROL OF PROJECTS - A CYBERNETIC CONTROL**

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**Abstract:** *Control is the last element in the implementation cycle planning-monitoring-controlling. Information is collected about system performance, compared with the desired (or planned) level, and action taken if actual and desired performance differ enough that the controller (manager) wishes to decrease the difference. Note that reporting performance, comparing the differences between desired and actual performance levels, and accounting for why such differences exist are all parts of the control process. In essence control is the act of reducing the difference between plan and reality. Control is focused of the three elements of project-performance, cost and time. The project manager is constantly concerned with these three aspects of the project. Is the project delivering what it promised to deliver or more? Is it making delivery at or below the promised cost? Is it making delivery at or before the promised time? It is strangely easy to lose sight of these fundamental targets, especially in large projects with a wealth of detail and a great number of subprojects. Large projects develop their own momentum and tend to get out of hand, going their own way independent of the wishes of the project manager and the intent of the proposal.*

**Key words:** cybernetic control; negative feedback loop; first order control system; second-order control system; third-order control system

In project management field, there are few things that can cause a project to require the control performance, costs or time.

**Performance:**

- Unexpected technical problems arise.
- Insufficient resources are available when needed.
- Insurmountable technical difficulties are present.
- Quality or reliability problems occur.
- Client requires changes in system specifications.
- Inter functional complications arise.
- Technological breakthroughs affect the project.

**Cost:**

- Technical difficulties require more resources.
- The scope of the work increases.
- Initial bids or estimates were too low.
- Reporting was poor or untimely.
- Budgeting was inadequate.
- Corrective control was not exercised in time.
- Input price changes occurred.

**Time:**

- Technical difficulties took longer than planned to solve.
- Initial time estimates were optimistic.

- Task sequencing was incorrect.
- Required inputs of material, personnel, or equipment were unavailable when needed.
- Necessary preceding tasks were incomplete.
- Customer-generated change orders required rework.
- Governmental regulations were altered.

And these are only a few of the relatively “mechanistic” problems that project control can occur. Actually, there are no purely mechanistic problems on projects. All problems have a human element, too. For example, humans, by action or inaction, set in motion a chain of events that leads to a failure to budget adequately, creates a quality problem, leads the project down to a technically difficult path, or fails to note a change in government regulations. If, by chance, some of these or other things happen (as a result of human action or not), humans are affected by them. Frustration, pleasure, determination, hopelessness, anger and many other emotions arise during the course of a project. They affect the work of the individuals who feel them – for better or worse. It is over this welter of confusion, emotion, fallibility, and general cussedness that the PM tries to exert control.

All of these problems, always combinations of the human and mechanistic, call for intervention and control by the project manager. There are infinite “slips” especially in projects where the technology or deliverables are new and unfamiliar, and project managers, like most managers, find control is a difficult function to perform. There are several reasons why this is so. One of the main reasons is that project managers, again like most managers, do not discover problems. In systems as complex as projects, the task of defining the problems is formidable, and thus knowing what to control is not a simple task. Another reason control is difficult is because, in spite of an almost universal need to blame some person for any trouble, it is often almost impossible to know if a problem resulted from human error or from the random application of Murphy’s Law.

Project managers also find it tough to exercise control because the project team, even on large projects, is an “in-group”. It is “we” while outsiders are “they”. It is usually hard to criticize friends, to subject them to control. Further, many project managers see control as an ad-hoc process. Each need to exercise control is seen as a unique event, rather than as one instance of an ongoing and recurring process. Whitten offers the observation that projects are drifting out of control if the achievement of milestones is threatened. He also offers some guidelines on how to resolve this problem and bring the project back in control.

Because control of projects is such a mixture of feeling and fact of human and mechanism, of causation and random chance, we must approach the subject in an extremely orderly way. This why we start by examining the general purposes of control. Then we consider the basic structure of the process of control. We do this by describing control theory in the form of a cybernetic control loop. While most projects offer little opportunity for the actual application of automatic feedback loops, the system provides us with a comprehensive but reasonably simple illustration of all the elements necessary to control any system. From this model, we then turn to the types of control that are most often applied to projects. The design of control systems is discussed as are the impacts that various types of controls tend to have on the humans being controlled. The specific requirement of “balance” in a control system is also covered, as are two special control problems: control of creative activities, and control of change.

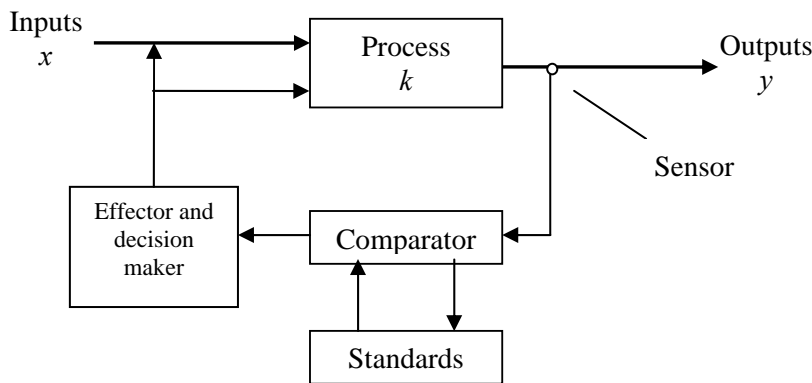
The process of controlling a project (or any system) is far more complex than simply waiting for something to go wrong and then, if possible, fixing it. We must decide at what points in the project we will try to exert control, what is to be controlled, how it will be measured, how much deviation from plan will be tolerated before we act, what kinds of interventions should be used, and how to spot and correct potential deviations before they occur. In order to keep these and other such issues sorted out, it is helpful to begin a consideration of control with a brief exposition on the theory of control,

No matter what our purpose in controlling a project, there are three basic types of control mechanisms we can use: cybernetic control, go/no-go control and post-control. We will describe the first type and briefly discuss the information requirements of each. While few cybernetic control systems are used for project control, we will describe them here because they clearly delineate the elements that must be present in any control system, as well as the information requirements of control systems.

### Cybernetic control

Cybernetic or steering control is by far the most common type of control system. The key feature of cybernetic control is its automatic operation. Consider the diagrammatic model of a cybernetic control system shown in figure 1. As Figure 1 shows, a system is operating with inputs being subjected to a process that transforms them into outputs. It is this system that we wish to control. In order to do so, we must monitor the system output. This function is performed by sensors that measure one or more aspects of the output, presumably those aspects one wishes to control. Measurements taken by a sensor are transmitted to the comparator, which compares them with a set of predetermined standards. The difference between actual and standard is sent to the decision maker, which determines whether or not the difference is of sufficient size to deserve correction. If the difference is large enough to warrant action, a signal is sent to the effectors, which acts on the process or on the inputs to produce outputs that conform more closely to the standard.

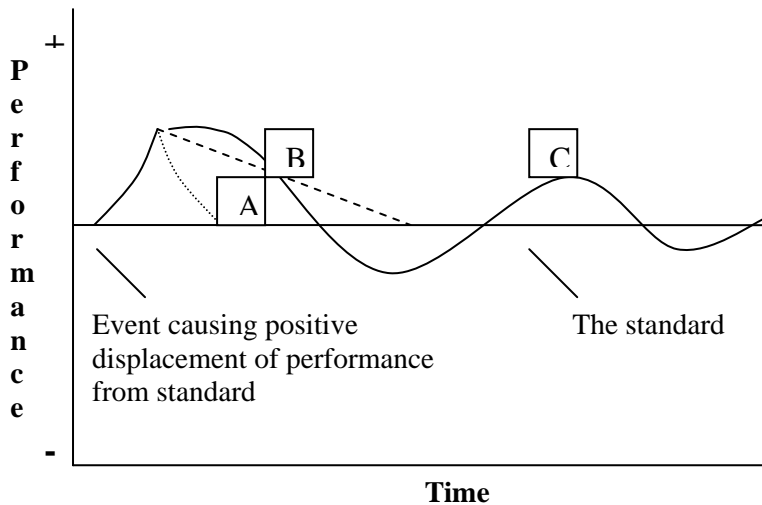
A cybernetic control system that acts to reduce deviations from standard is called a *negative feedback loop*. If the system output moves away from the standard in one direction, the control mechanism acts to move it in the opposite direction. The speed or force with which the control operates is, in general, proportional to the size of the deviation from the standard. The precise way in which the deviation is corrected depends on the nature of the operating system and the design of the controller. Figure 2 illustrates three different response patterns. Response path A is direct and rapid, while path B is more gradual. Path C shows oscillations of decreasing amplitude. An aircraft suddenly deflected from a stable flight path would tend to recover by following pattern C.



**Figure 1.** A cybernetic control system

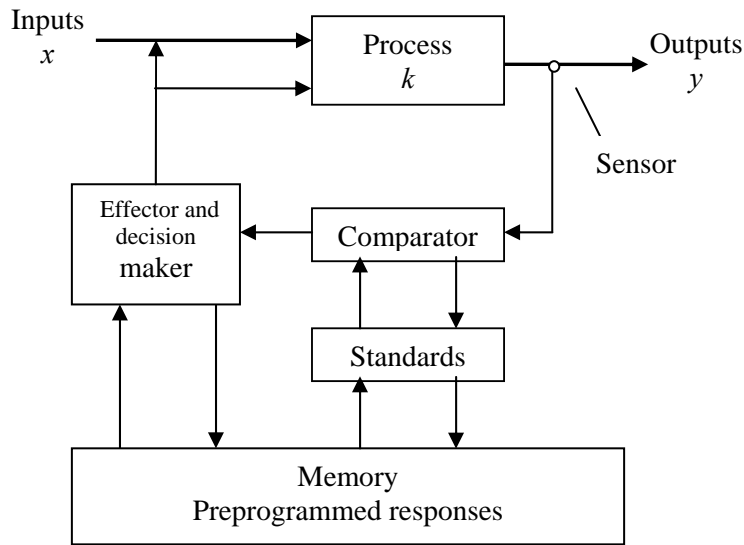
**Types of cybernetic control systems**

Cybernetic controls come in three varieties, or *orders*, differing in the sophistication with which standards are set. Figure 1 show a simple, *first order control system*, a goal seeking device. The standard is set and there is no provision made for altering it except by intervention from the outside. The common thermostat is a time-worn example of a first-order controller. One sets the standard temperature and the heating and air-conditioning systems operate to maintain it.



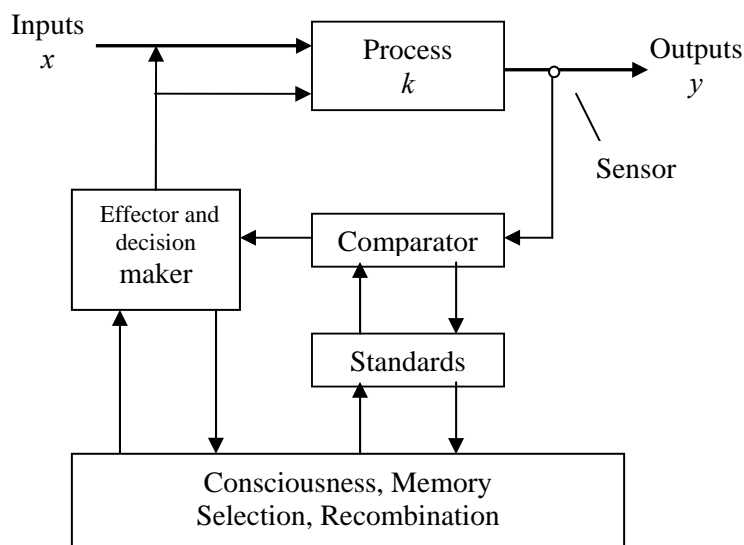
**Figure 2.** Typical paths for correction or deviation of performance from standard

Figure 3 show a *second-order control system*. This device can alter the system standards according to some predetermined set of rules or program. The complexity of second-order systems can vary widely. The addition of a clock to a thermostat to allow it to maintain different standards during day and night makes the thermostat a second-order controller. An interactive computer program may alter its responses according to a complex set of pre-programmed rules, but it is still only a second-order system. Many industrial projects involve second-order controllers – for example, robot installations, flexible manufacturing systems, and automated record keeping or inventory systems.



**Figure 3.** A second-order feedback system- preprogrammed goal changer

A *third-order* control system (Figure 4) can change its goals without specific preprogramming. It can reflect on system performance and decide to act in ways that are not contained in its instructions. Third-order systems have reflective consciousness and, thus, must contain humans. Note that a second-order controller can be programmed to recognize patterns and to react to patterns in specific ways. Such systems are said to “learn”. Third-order systems can learn without explicit preprogramming and therefore can alter their actions on the basis of thought or whim. An advantage of third-order controllers is that they can deal with the unforeseen and unexpected. A disadvantage is that, because they contain human elements, they may lack predictability and reliability. Third order systems are of great interest to the PM for reasons we now discuss.



**Figure 4.** A third-order feedback system – reflective goal changer

## **Information requirements for cybernetic controllers**

In order to establish total control over a system, a controller must be able to take a counter-action for every action the system can take. This statement is a rough paraphrase of Ashby's Law of Requisite Variety. This implies that the PM\ controller is aware of the system's full capabilities. For complex systems, particularly those containing a human element, this is simply not possible. Thus we need a strategy to aid the PM in developing a control system. One such strategy is to use a cost\benefit approach to control – to control those aspects of the system for which the expected benefits of control are greater than the expected costs. We are reminded of a firm that manufactured saw blades. It set up a project to reduce scrap losses for the high-cost steel from which the blades were made. At the end of the one year project, the firm had completed the project – cost \$ 9700, savings \$4240. (Of course, if the savings were to be repeated for several years, the rate of return on the project would be acceptable. The president of the firm, however, thought that the savings would decline and disappear when the project ended.)

Relatively few elements of a project (as opposed to the elements of a system that operates more or less continuously) are subject to automatic control. An examination of the details of an action plan will reveal which of the project's tasks are largely mechanistic and represent continuous types of systems. If such systems exist, and if they operate across a sufficient time period to justify the initial expense of creating an automatic control, then a cybernetic controller is useful.

Given the decisions about what to control, the information requirements of a cybernetic controller are easy to describe, if not to meet. First, the PM must decide precisely what characteristics of an output (interim output or final output) are to be controlled. Second, standards must be set for each characteristic. Third, sensors must be acquired that will measure those characteristics at the desired level of precision. Fourth, these measurements must be transformed into a signal that can be compared to a standard signal. Fifth, the difference between the two is sent to the decision maker, which detects it, if it is sufficiently large, and sixth, transmits a signal to the effectors that causes the operating system to react in a way that will counteract the deviation from standard. If the control system is designed to allow the effectors to take one or more of several actions, an additional piece of information is needed. There must be built-in criteria that instruct the effectors on which action(s) to take.

Knowledge of cybernetic control is important because all control systems are merely variants, extensions or non-automatic modifications of such controls. Because most projects have relatively few mechanistic elements that can be subjected to classic cybernetic controls, this concept of control is best applied to tracking the system and automatically notifying the project manager when things threaten to get out of control.

## **References**

1. Dobre, E. **Project Financing**, in Bodea, C. N. (coord.) „Handbook on Project Based Management”, Ed. Economica, Bucharest, 2002
2. Lock, D. **Management de proiect**, Ed. Codecs, 2000
3. Gareis, R. **The Professional Project Start**, in „The Gower Handbook of Project Management”, 2000

4. Ivan, I., Pocatilu, P., and Ungureanu, D. **Project Complexity**, Ed. Inforec, Bucharest, 2001
5. Kerzner, H. **Project Management - a System Approach to Planning, Scheduling and Controlling, Sixth Edition**, John Wiley & Sons, Inc, 1998
6. Project Management Institute, **A Guide to the Project Management Body of Knowledge (PMBOK Guide)**, Project Management Institute, 2000
7. Wikstrom, K., and Rehn, A. **Project perspektiv**, Abo Akademi, KTH Stocholm, 1999
8. Meredith, J. R., and Mantel, S. J. Jr. **Project Management - a managerial approach**, John Wiley & Sons, New York, 2000
9. \*\*\* **Project Management Institute**, <http://www.pmi.org>
10. \*\*\* **Wikipedia**, [http://en.wikipedia.org/wiki/Project\\_management](http://en.wikipedia.org/wiki/Project_management)

## **THE ELASTICITY OF THE PRICE OF A STOCK AND ITS BETA**

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**Abstract:** *Systematic risk in an investment in a security is measured by the security's beta. The beta of a stock is considered as a very important parameter in asset pricing. It is used to estimate the expected return of a stock with respect to its market return. Beta is estimated by the regression method. In this paper, we consider some problems associated with the concept of beta and its estimation. We also advocate for the use of elasticity as an alternative to beta.*

**Key words:** *Beta; CAPM; characteristic line; price index; risk; least squares; elasticity*

### **1. Introduction**

Estimating the expected return on investments to be made in the stock market is a challenging job before an ordinary investor. Different market models and techniques are being used for taking suitable investment decisions. The past behaviour of the price of a security and the share price index plays a very important role in security analysis. The straight line showing the relationship between the rate of return of a security and the rate of market return is known as the security's characteristic line. The slope of the characteristic line is called the security's beta. The concept of beta introduced by Markowitz(1959) is being widely used to measure the systematic risk involved in an investment. Ordinary least square (OLS) method is used by researchers and practitioners for estimating the characteristic line.

The measure beta is an inevitable tool in portfolio management. Asset pricing without beta is unimaginable. The Capital Asset Pricing Model (CAPM) is used to determine a theoretically appropriate required rate of return of an asset that is added to a portfolio. See Sharpe (1964), Linter (1965) and Mossin (1966). Beta plays a prominent role in CAPM. Therefore, the usefulness of CAPM mainly depends on the authenticity of beta.



In this paper, we explore the meaning of beta and its incapability to measure the sensitivity of return of a security to market returns. We also strongly recommend the use of the concept of elasticity of the price of a stock as an alternative to measure the sensitivity of its price corresponding to the market movements. Using the term elasticity, we modify the CAPM introduced by William Sharpe (1964), John Linter (1965) and Jan Mossin (1966).

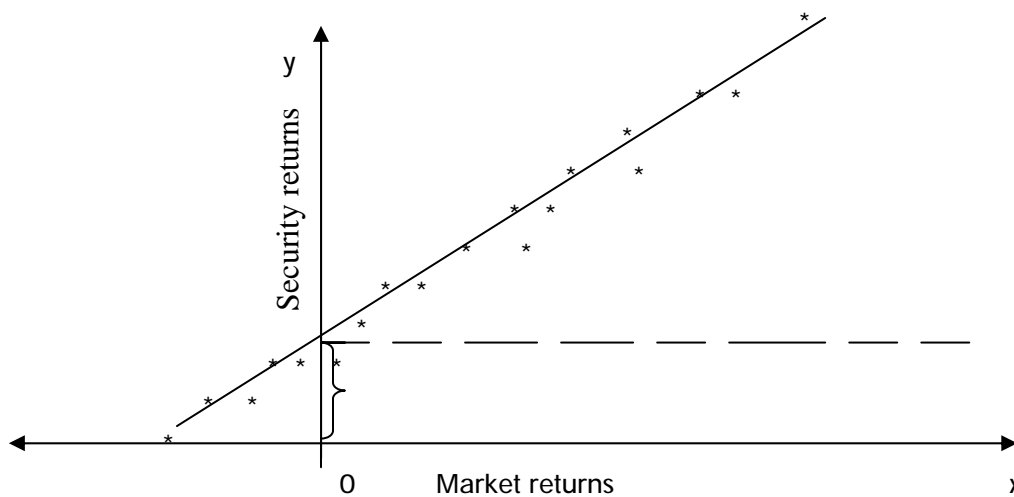
This paper is organized as follows. Section 2 discusses the characteristic line of a stock and its limitations in measuring the relationship between the return of a security and the market return. In Section 3 we introduce the concept of the elasticity of a stock and the advantages of elasticity over beta in measuring the sensitivity of the price of a stock with respect to market movements. Section 4 is devoted to a discussion of the idea of modifying the CAPM by replacing beta by elasticity. In section 5 we give an illustration and a comparison of calculated values of beta and elasticity. Section 6 concludes the paper with the main advantages of our results.

## 2. Characteristic line and beta

The price 'Y' of a stock depends on a number of factors some of which are internal to the company and others external. Empirical studies show that there is a linear relation between the share price index 'X' and Y. Let  $(X_1, Y_1), (X_2, Y_2), \dots (X_n, Y_n)$  be 'n' observations relating to X and Y made at 'n' consecutive periods of time. If 'x' denotes the percentage rate of return of the price index and 'y' denotes that of the security, then the values of x and y are given by

$$x_i = 100 (X_{i+1} - X_i) / X_i \text{ and } y_i = 100 (Y_{i+1} - Y_i) / Y_i \text{ for } i = 1, 2, 3, \dots, n-1$$

The characteristic line representing the relationship between x and y is given in Figure(1).



**Figure 1.** The characteristic line of a stock

The equation of the characteristic line can be written as

$$y = \alpha + \beta x \tag{1}$$

where  $\alpha$  and  $\beta$  are constants. The slope of characteristic line is the security's beta. The characteristic line is estimated by the least squares method. At present, beta is taken as the

measure of the sensitivity of the security's price Y with respect to market changes. Beta shows how the price of a security responds to market forces. It is an indispensable tool in asset pricing.

**2.1. Problems of the characteristic line and beta**

As beta is the slope of a straight line, it is always a constant. Blume (1971), Hamada (1972) and Alexander & Chervani (1980) challenged the stability of beta. They argued that beta is time varying. Black (1976) linked beta to leverage which changes owing to changes in the stock price. Mandelker & Rhee (1984) related beta to decisions by the firm and thus a varying measure. The relationship between macro-economic variables and the firm's beta, as illustrated in the work of Rosenberg & Guy (1976) points to the varying character of beta. Since beta is evaluated as the covariance between the stock returns and index returns, scaled down by the variance of the index returns and the index volatility is time-varying (Bollerslev et al. 1992), beta is not constant over a period of time. Roll et al (1994) point out the inefficiency of the CAPM for estimating the expected returns using beta.

The constancy nature of beta raises doubts about the suitability of using it as a measure of the sensitivity of the security's return corresponding to market returns. This led us to think of a suitable measure that reflects instantaneous changes of the market.

Even if x and y are related by (1), beta alone cannot be used to measure the sensitivity of the price of the security. The parameter  $\beta$  also will play a major role unless its value is tested statistically insignificant. To measure the market sensitivity, the concept of elasticity is more useful. We discuss elasticity in the next section.

To understand and measure the response of the price of a security with respect to market changes, we need only the relationship between X and Y. Using regression method, the best linear equation can be estimated as

$$Y = a + b X \tag{2}$$

where a and b are constants.

**3. Elasticity of price of a stock**

The term 'elasticity' is a technical term used mainly by economists to describe the degree of responsiveness of the endogenous variable in an economic model with respect to the changes in the exogenous variable of the model. It measures the percentage change in the endogenous variable when the exogenous variable is increased or decreased by 1 %. So the concept of elasticity will be useful to measure the sensitivity of the price of a stock corresponding to market movements. If  $Y = f(X)$  is the functional relationship between X and Y, then the elasticity of Y with respect to X is given by

$$\eta = \frac{X}{Y} \cdot \frac{dY}{dX}$$

**Theorem 1.**

The elasticity of price of a security with respect to price index is a constant 'k' if and only if the relationship between the price Y of the security and the price index X is of the form

$$Y = C X^k \quad \text{where } C > 0, k > 0$$

By definition,

$$\eta = \frac{X C k X^{k-1}}{C X^k} = k$$

Conversely, if the elasticity is a constant, then

$$\frac{X}{Y} \cdot \frac{dY}{dX} = k$$

which implies

$$\frac{dY}{Y} = k \cdot \frac{dX}{X}$$

On integration of both sides,

$$\log Y = k \log X + \log C = \log C X^k$$

which implies

$$Y = C X^k, \quad C > 0, k > 0$$

Where  $\log C$  is the constant of integration. If  $k = 1$ , then  $Y = C X$  which represents a straight line passing through the origin. For any other value of  $k$ , the relationship is a power curve. This indicates that the sensitivity of the price of a security is a varying measure unless the relationship between the price of the security and the price index is a power curve.

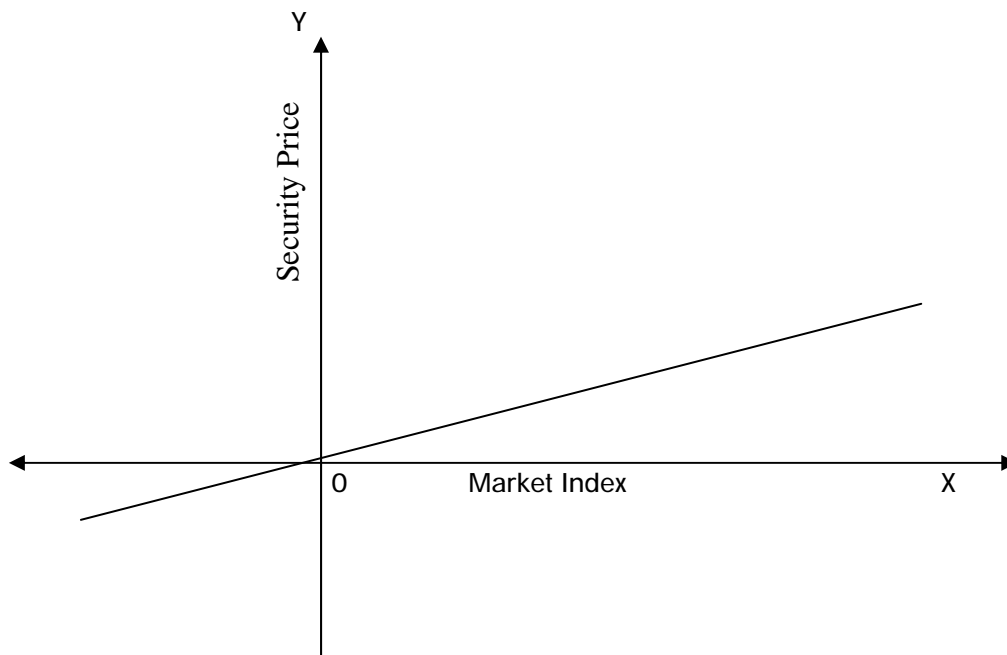
If  $X$  and  $Y$  are related by (2), then

$$\eta = \frac{bX}{a + bX}$$

Note that the value of  $\eta$  is not a constant. It depends on the value of  $X$ . So,  $\eta$  varies when  $X$  varies. This means that the sensitivity of the price of a stock is not the same at all levels of the index. Further, the value of  $\eta$  depends on both the parameters  $a$  and  $b$ .

Case (i).  $\eta = 1$ .

This is the case when the price return of a stock is the same as that of the market return. This means that the price of a security increases (decreases) by 1 % when the share price index increases (decreases) by 1 %. In this case,  $a = 0$ . Since the intercept is zero, the regression line passes through the origin. See Figure 2.

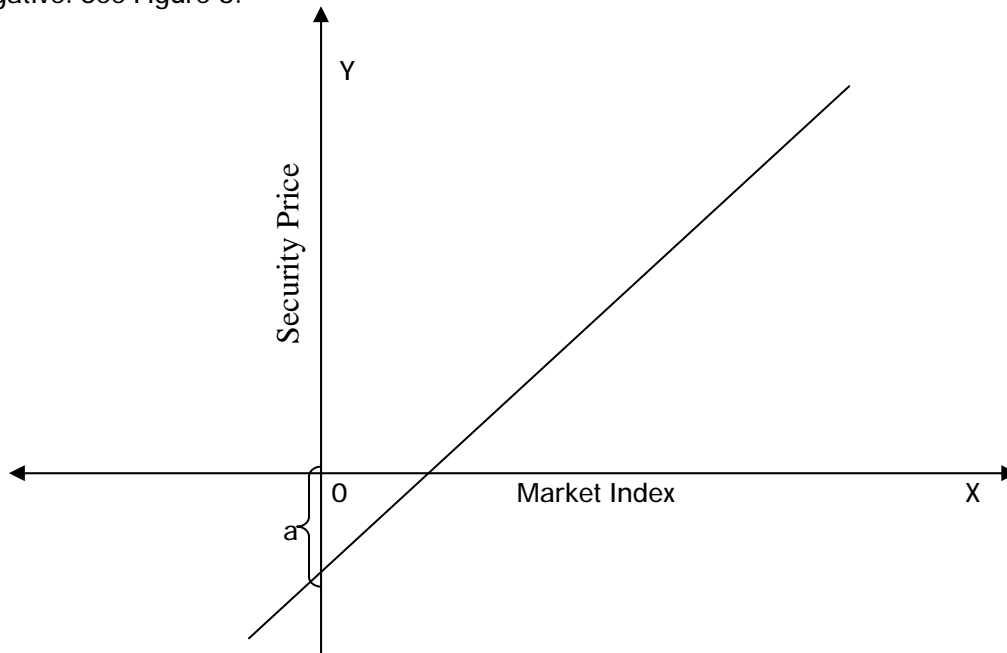


**Figure 2.** The regression of price of a stock on market index when  $\eta = 1$ .

It is very interesting to see that the elasticity remains unity for any regression line passing through the origin irrespective of the slope of the line.

Case (2).  $\beta > 1$ .

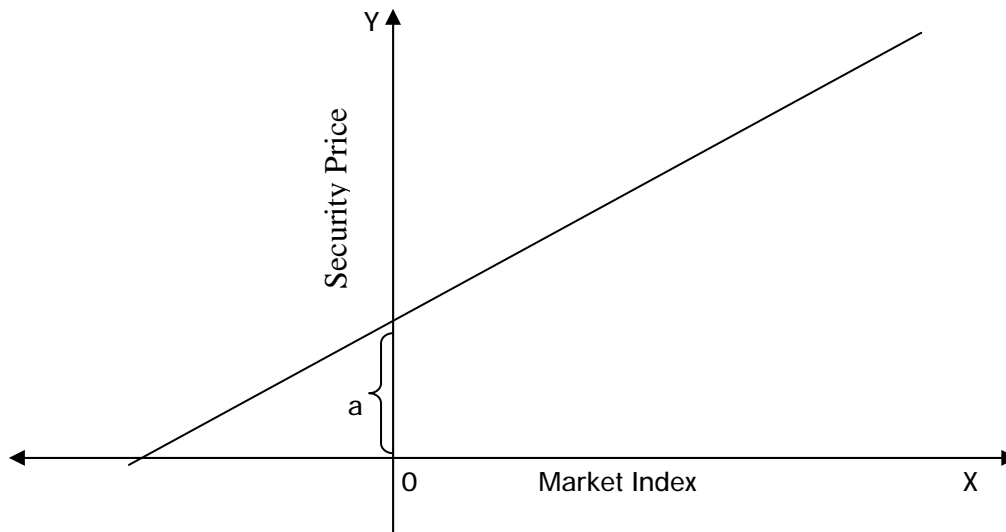
This is the case when the price return of a stock is more than proportional to market return. Since the price of a stock and the market index are generally positively correlated, the slope of the regression line 'b' is positive. Therefore,  $\beta > 1$  only if 'a' is negative. See Figure 3.



**Figure 3.** The regression of price of a stock on market index when  $\beta > 1$ .

Case (3).  $\beta < 1$ .

This is the case when the price return of a stock is less than proportional to market return. That is, the price of the security increases (decreases) by less than 1 % when the share price index increases (decreases) by 1%. Also,  $\beta < 1$  only if 'a' is positive. See Figure 4.



**Figure 4.** The regression of price of a stock on market index when  $\beta < 1$ .

#### 4. Modified CAPM

Since elasticity measures the sensitivity of a security's price movement relative to the market movement, it will be more meaningful to replace the beta coefficient in the CAPM by the elasticity of the security. Then the modified CAPM takes the form

$$R_s = R_f + \beta (R_m - R_f) \quad (3)$$

Where

- $R_s$  = the return required on investment
- $R_f$  = the return that can be earned on a risk-free investment
- $R_m$  = the return on the market index for a given index
- $\beta$  = the security's sensitivity (elasticity) to market movement for a given index

In the present form of the CAPM, beta remains the same irrespective of the sensitivity of the security with respect to market index. It depends only on the return on market and not on the index level. But, in the modified form, importance is given to  $\beta$  that varies as index varies. This is the striking advantage of the modified CAPM over the present form.

#### 5. Illustration

This study is based on prices of shares of Reliance Industries Listed (RIL) at Mumbai Stock Exchange (BSE) in India and the BSE's benchmark price index Sensex during the period March 1996 to March 2006. Data relating to the financial year closing prices (Y) of (RIL) Shares and the Sensex (X) are given in Table 1. The yearly returns of X and Y are denoted by x and y respectively.

The regression of Y on X is given by

$$Y = -110.839 + 0.098918 X \quad (4)$$

**Table 1.** Yearly returns of RIL shares and Sensex (Price in Indian Rupees)

Period	X	Y	x	y
Mar-96	3367	104.97		
Mar-97	3361	154.45	-0.18	47.14
Mar-98	3893	177.20	15.83	14.73
Mar-99	3740	130.50	-3.93	-26.35
Mar-00	5001	318.70	33.72	144.21
Mar-01	3604	391.20	-27.93	22.75
Mar-02	3469	398.40	-3.75	1.84
Mar-03	3158	278.50	-8.97	-30.10
Mar-04	5613	538.20	77.74	93.25
Mar-05	6679	546.20	18.99	1.49
Mar-06	11603	1033.40	73.72	89.20

Source: Annual reports of Reliance Industries Limited and BSE publications

The elasticity of the price of the stock is

$$\eta = \frac{0.0989 X}{-110.839 + 0.0989 X}$$

When  $X = 9000$ ,  $\beta = 1.14$ . This implies that when the price index is 9000, 1 % increase (decrease) in the index is followed by 1.14 % increase (decrease) and 10% increase (decrease) in the index is followed by 11.4 % increase (decrease) in the price of the share.

When  $X = 3500$ ,  $\beta = 1.47$ . This shows that the sensitivity is varying at different levels of the index. It can also be seen that the sensitivity of the price of the RIL stock is very high for low values of the Sensex and comparatively low for higher values of the Sensex. Also, since the intercept is negative,  $\beta > 1$ .

Now the characteristic equation based on the returns  $x$  and  $y$  is

$$y = 16.15 + 1.122 x \tag{5}$$

When the market return is  $x = 1\%$ ,  $y = 17.37\%$  which is an exaggerated value. Also, when  $x = 10\%$ ,  $y = 27.37\%$ . In this case, the proportionality is not maintained as in the case of  $\beta$ . This implies that relation (5) has no meaning. Therefore the beta value  $\beta = 1.122$  has no role in measuring the market sensitivity. Further, the different points  $(x, y)$  in the scatter diagram exhibit no functional relationship. For example, the points corresponding to March-2000 (33.72,144.21) and March-2005 (18.99,1.49) are not comparable. In fact, the Sensex and the price of the stock registered 33.55 % and 71.38 % in 2005 compared to the values in 2000. Since the coordinates  $(x, y)$  of a period are based on the values of the previous period, there is no common origin of measurements for the different points. As the different points in the scatter diagram will have no relationship between themselves, the concept of regression cannot be used for estimation purposes. This problem will be more aggressive if beta is estimated on the basis of a random sample.

Table 2. gives the returns of RIL shares ( $x$ ) and Sensex ( $y$ ) on arbitrary selected periods.  $X_1$  and  $Y_1$  are the values of  $X$  and  $Y$  arranged in another order. The returns of  $X_1$  and  $Y_1$  are denoted by  $x_1$  and  $y_1$  respectively.

**Table 2.** Returns of RIL shares and Sensex on arbitrary periods

X	Y	x	y	$X_1$	$Y_1$	$x_1$	$y_1$
3367.00	104.97			3740.00	130.50		
3361.00	154.45	-0.18	47.14	5001.00	318.70	33.72	144.21
3893.00	177.20	15.83	14.73	3604.00	391.20	-27.93	22.75
3740.00	130.50	-3.93	-26.35	3367.00	104.97	-6.58	-73.17
5001.00	318.70	33.72	144.21	3361.00	154.45	-0.18	47.14
3604.00	391.20	-27.93	22.75	3893.00	177.20	15.83	14.73
3469.00	398.40	-3.75	1.84	6679.00	546.20	71.56	208.24
3158.00	278.50	-8.97	-30.10	5713.00	540.30	-14.46	-1.08
5613.00	538.20	77.74	93.25	5786.00	576.50	1.28	6.70
6679.00	546.20	18.99	1.49	5186.00	486.00	-10.37	-15.70
3469.00	293.90	-48.06	-46.19	4756.00	423.30	-8.29	-12.90
3554.00	334.30	2.45	13.75	5677.00	534.90	19.37	26.36
3238.00	271.50	-8.89	-18.79	3469.00	398.40	-38.89	-25.52
4311.00	410.50	33.14	51.20	3158.00	278.50	-8.97	-30.10
5186.00	486.00	20.30	18.39	5613.00	538.20	77.74	93.25
5713.00	540.30	10.16	11.17	6325.00	514.80	12.68	-4.35
5786.00	576.50	1.28	6.70	8649.00	829.30	36.74	61.09
5677.00	534.90	-1.88	-7.22	3469.00	293.90	-59.89	-64.56
6325.00	514.80	11.41	-3.76	3554.00	334.30	2.45	13.75
4756.00	423.30	-24.81	-17.77	3238.00	271.50	-8.89	-18.79
8649.00	829.30	81.85	95.91	4311.00	410.50	33.14	51.20

The regression equation of  $y$  on  $x$  is

$$y = 8.20 + 1.167 x \quad (6)$$

The regression equation of  $y_1$  on  $x_1$  is

$$y_1 = 12.45 + 1.617 x_1 \quad (7)$$

The beta coefficients of (6) and (7) are considerably different. Further, the correlation coefficients between  $x$  and  $y$  is different from that between  $x_1$  and  $y_1$ . This shows that beta cannot be estimated on the basis of a random sample. But, the regression equation of  $Y$  on  $X$  is the same as that of  $Y_1$  on  $X_1$ . Similarly, the correlation coefficients between  $X$  and  $Y$  and that between  $X_1$  and  $Y_1$  are also the same. The elasticity also remains the same.

## 6. Conclusion

According to Nelson(2006), any asset pricing model should consider two areas of concern. The first concern is whether the model is well specified in random samples. The second concern is whether the model is powerful enough to explain stock returns. Our concept of elasticity and the modified CAPM address these two concerns. Also, this paper exposes the misconception of beta for measuring the sensitivity of the price of a security with respect to market movements. It also presents the mathematical logic against the fitting of a linear relation using regression method to a set of points that are not measured from an origin.

Our results show that the sensitivity of a stock is generally a varying aspect. Since beta is a constant as it is the slope of a straight line, it cannot be used to measure the sensitivity of a stock corresponding to market changes. The strong evidence in favour of time-varying betas (Bollerslev et al. 1992) highlights the limitations of ordinary least square betas. Further, the sensitivity of scrip's return depends largely on the elasticity of the price of the security. There are some securities that are more sensitive when the market index is at a peak level and less sensitive when the market index is at the moderate level. The expected rate of return varies from point to point. So, to estimate the expected rate of return corresponding to market returns, the use of the elasticity of price of the stock is advisable. Asset pricing based on elasticity will be more appealing than the one based on constant beta.

## References

1. Alexander, G., and Chervani, N. L. **On the estimation and stability of beta**, Journal of Financial and Quantitative Analysis 15, 1980, pp. 123-137
2. Black, F. **Studies of stock price volatility changes**, Proceedings of the 1976 Meeting of the American Statistical Association, Business and Economical Statistics Section, 1976, pp. 177-181
3. Blume, M. E. **On assessment of risk**, Journal of Finance, 24(1), 1971, pp. 1-10
4. Bollerslev, T., Engle, R. F., and Wooldridge, J. M. **Capital asset pricing model with time-varying covariances**, Journal of Political Economy 96(1), 1998, pp. 116-131
5. Chan, L., Hamao, Y., and Lakonishok, J. **Fundamentals and stock returns in Japan**, Journal of Finance, 46, 1991, pp. 1739 - 1764
6. Fama, E., and French, K. **The cross-section of expected stock returns**, Journal of Finance, 47, 1992, pp. 427- 465

7. Hamada, R. S. **The effects of the firm's capital structure of the systematic risk of the common stock**, *Journal of Finance* 27(2), 1972, pp. 435-452
8. Linter, J. **The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets**, *Review of Economics and Statistics*, 47(1), 1965, pp. 13-37
9. Mandelker, G., Rhee, S. G. **The impact of degrees of operating and financial leverage on systematic risk of a common stock**, *Journal of Financial and Quantitative Analysis* 19(1), 1984, pp. 45-57
10. Markovitz, H. M. **Efficient diversification of investments**, John Wiley and Sons, 1959
11. Mossin, J. **Equilibrium in a Capital Asset Market**, *Econometrica*, 34, 1966, pp. 768-783
12. Nelson, J. M. **Intangible Assets, Book-to-Market, and Common Stock Returns**, *The Journal of Financial Research*, Vol. XXIX, No.1, 2006, pp. 21-41
13. Roll, R., and Ross, S. **On the cross-sectional relation between expected returns and betas**, *Journal of Finance*, 49, 1994, pp. 101-121
14. Rosenberg, B., and Guy, J. **Prediction of beta from investment fundamentals**, *Financial Analysts Journal* (May-June), 1976
15. Sharpe, W. F. **Capital Asset Prices: A theory of Market Equilibrium Under Conditions of Risk**, *Journal of Finance*, 19(3), 1964, pp. 425-442



## SOME ASPECTS ON SOLVING A LINEAR FRACTIONAL TRANSPORTATION PROBLEM

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**Abstract:** *This paper presents the three-dimensional transportation problem, a double sum model in which the objective function is the ratio of two positive linear functions. This paper objective is to present how to obtain optimum with simplex method. To illustrate the procedure, a numerical example is given.*

**Key words:** *the three dimensional transportation problem; programming with fractional linear objective function; simplex method*

### Problem Description

I am proposing now to solve the 3-dimensional transport problem – a double sum model - with the fractional linear objective function and linear constraints:

$$\min f(x) = \frac{\sum_{i=1}^m \sum_{j=1}^n \sum_{k=1}^p m_{ijk} x_{ijk}}{\sum_{i=1}^m \sum_{j=1}^n \sum_{k=1}^p n_{ijk} x_{ijk}} \tag{1}$$

$$\sum_{j=1}^n \sum_{k=1}^p x_{ijk} = a_i \quad i = 1, m \tag{2}$$

$$\sum_{i=1}^m \sum_{k=1}^p x_{ijk} = b_j \quad j = 1, n \tag{3}$$

$$\sum_{i=1}^m \sum_{j=1}^n x_{ijk} = c_k \quad k = 1, p \tag{4}$$

$$x_{ijk} \geq 0 \quad i = 1, m \quad j = 1, n \quad k = 1, p \tag{5}$$

$$a_i, b_j, c_k > 0 \tag{6}$$

$$\sum_{i=1}^m a_i = \sum_{j=1}^n b_j = \sum_{k=1}^p c_k = T \tag{7}$$

Requiring the following specifications:

- m – the number of sources
- n – the number of destinations
- p – the number of means of conveyance
- ai – the available quantity in each source  $i = 1, m$
- bj – the necessary quantity in each destination  $j = 1, n$
- ck – the quantity with must be transported by means of conveyance  $k = 1, p$

$$\sum_{i=1}^m \sum_{j=1}^n \sum_{k=1}^p m_{ijk} x_{ijk} \geq 0 \quad \sum_{i=1}^m \sum_{j=1}^n \sum_{k=1}^p n_{ijk} x_{ijk} > 0$$

Matrix  $X = \{x_{ijk} \mid i = 1, m; j = 1, n; k = 1, p\}$ , which satisfies constraints (2) (3) (4) (5), is called a transportation plan (feasible solution) and plan X is called optimum if it satisfies (1).

When the condition (7) is satisfied, the resulting formulation is called a balanced transportation problem. Relation (7) is the necessary and sufficient condition for the existence of the solution: the level of the matrix of the constraint system is  $m+n+p$  showing that a non-degenerated transportation plan of problem (1-7) contains at least  $m+n+p-2$  non-null components;

The objective is to establish a transportation plan with minimum total expenses.

The function (1) is explicit quasi concave in  $S = \{X / (2) (3) (4) (5)\}$  i.e.:

If  $x_1, x_2 \in S, x_1 \neq x_2, f(x_1) \neq f(x_2), \lambda \in (0, 1)$  and  $x_0 = \lambda x_1 + (1 - \lambda)x_2$  then  $\min[f(x_1), f(x_2)] < f(x_0)$ .

For such function, local minimum is not necessarily a global minimum. Every differentiable [3] explicit quasi concave function is pseudo concave as well. An optimality criterion for local minimum is given in [1]

In this paper is made to generalize the results given by [2],[6]. This paper objective is to present how to obtain optimum with the help of the simplex method.

### Solving the problem

The considerations concerning the three-dimensional problem are valid.

An initial feasible solution can be obtained by using the known methods from the three-dimensional transport problem [4][5].

We denote  $I_x = \{(i, j, k) / x_{ijk} > 0, x_{ijk} \in X\}$

Due to (7) each nondegenerate solution will contain  $m+n+p-2$  positive components.

We consider the dual variables (simplex multipliers):

$$u_i^1, u_i^2, i = \overline{1, m}, \quad v_j^1, v_j^2, j = \overline{1, n}, \quad w_k^1, w_k^2, k = \overline{1, p}$$

defined such that:

$$m_{ijk} = u_i^1 + v_j^1 + w_k^1 \tag{8}$$

$$n_{ijk} = u_i^2 + v_j^2 + w_k^2 \tag{9}$$

for  $(i, j, k) \in I_x$  and

$$m'_{ijk} = m_{ijk} - (u_i^1 + v_j^1 + w_k^1) \quad \forall (i, j, k) \tag{10}$$

$$n'_{ijk} = n_{ijk} - (u_i^2 + v_j^2 + w_k^2) \quad \forall(i, j, k) \tag{11}$$

System (8) - (9) can be solved independently. So, system (8) - (9) has  $m+n+p-2$  equations with  $m+n+p$  variables. We can arbitrarily set  $u_1^1 = 0, v_1^1 = 0$  and solve for the other multipliers.

Having determined  $u_i^1, u_i^2, v_j^1, v_j^2, w_k^1, w_k^2$  we shall use these values to determine  $m'_{ijk}$  and  $n'_{ijk}$  for the non-basic variables.

Let  $X^* = (x^*_{ijk})_{ijk}$  be a feasible solution of the problem (1) - (7).

To establish the optimal criterion we express  $f(x)$  in terms of the non-basic variables only.

$$\begin{aligned} \sum_i \sum_j \sum_k m_{ijk} x_{ijk} &= \sum_i \sum_j \sum_k m_{ijk} x_{ijk} + \sum_i a_i - \sum_j \sum_k x_{ijk} \cdot u_i^1 + \sum_j b_j - \sum_i \sum_k x_{ijk} \cdot v_j^1 + \\ &+ \sum_k c_k - \sum_i \sum_j x_{ijk} \cdot w_k^1 = \\ &= \sum_i \sum_j \sum_k (m_{ijk} - u_i^1 - v_j^1 - w_k^1) \cdot x_{ijk} + \sum_i a_i u_i^1 + \sum_j b_j v_j^1 + \sum_k c_k w_k^1 = \\ &= \sum_i \sum_j \sum_k m'_{ijk} x_{ijk} + V_1 \end{aligned}$$

By means of a similar procedure we can also write :

$$\sum_i \sum_j \sum_k n_{ijk} x_{ijk} = \sum_i \sum_j \sum_k n'_{ijk} x_{ijk} + V_2$$

$$\text{where } V_s = \sum_{i=1}^m a_i u_i^s + \sum_{j=1}^n b_j v_j^s + \sum_{k=1}^p c_k w_k^s, \quad s=1,2 \tag{11}$$

Therefore the function  $f(x)$  becomes:

$$f(x) = \frac{\sum_{i=1}^m \sum_{j=1}^n \sum_{k=1}^p m'_{ijk} x_{ijk} + V_1}{\sum_{i=1}^m \sum_{j=1}^n \sum_{k=1}^p n'_{ijk} x_{ijk} + V_2}$$

For  $\forall(i, j, k) \in I - I_x$  we have

$$\frac{\partial f}{\partial x_{ijk}} = \frac{m'_{ijk} \sum_{I-I_x} n'_{ijk} x_{ijk} + V_2 - n'_{ijk} \sum_{I-I_x} m'_{ijk} x_{ijk} + V_1}{\sum_{I-I_x} n'_{ijk} x_{ijk} + V_2}$$

The partial derivatives of the function  $f(x)$  evaluated at the point  $x_{ijk} = x^*_{ijk}$  are:

$$\left. \frac{\partial f}{\partial x_{ijk}} \right|_{x_{ijk} = x^*_{ijk}} = \frac{m'_{ijk} V_2 - n'_{ijk} V_1}{(V_2)^2}$$

We note 
$$\Delta_{ijk} = m'_{ijk}V_2 - n'_{ijk}V_1$$

The dual variables  $u_i^1, u_i^2, v_j^1, v_j^2, w_k^1, w_k^2$   $i = \overline{1, m}$   $j = \overline{1, n}$

$k = \overline{1, p}$  determined, it would be easy to calculate  $\Delta_{ijk}$  for non-basic variables.

The solution  $X^*$  can be improved if it exists at least a value  $\Delta_{ijk} < 0$

Theorem A solution  $X^* = (x^*_{ijk})_{ijk}$  is a local optimum if  $\Delta_{ijk} \geq 0$  for all non-basic variables.

If one of this values is not positive, we choose

$$\Delta_{i_0j_0k_0} = \min\{\Delta_{ijk} \mid \Delta_{ijk} < 0\}$$

and we improve the value of  $f(x)$  by introducing  $x_{i_0j_0k_0}$  in the set of basic variables.

The variable which leaves the basis and the value of the basic variable in the basis can be determined as usual.

**Example**

Consider the problem with  $m=3, n=2, p=3,$  and

$a_1=24, b_1=40, c_1=16$

$a_2=8, b_2=19, c_2=31$

$a_3=27, c_3=12$

The matrices of costs:  $m_{ijk} / n_{ijk}$

		k=1	
	j	1	2
i \			
1		15/8	9/3
2		19/20	15/14
3		14/10	24/20

		k=2	
	j	1	2
i \			
1		18/15	14/10
2		20/15	21/15
3		11/10	23/20

		k=3	
	j	1	2
i \			
1		7/3	11/5
2		17/10	14/10
3		8/5	13/6

An initial feasible solution obtained as in [4],[5] is  $X_0$ :

		k=1	
	j	1	2
i \			
1		16	
2			
3			

		k=2	
	j	1	2
i \			
1			8
2		8	
3		15	

		k=3	
	j	1	2
i \			
1			
2			
3		1	11

for which the value of objective function is  $f_0 = \frac{828}{549} \approx 1,5$

Optimality verification : we determine the quantities  $u_i^1, v_j^1, w_k^1, u_i^2, v_j^2, w_k^2$

$i = \overline{1,3} j = \overline{1,2} k = \overline{1,3}$

from systems:

$u_1^1 + v_1^1 + w_1^1 = 15$

$u_1^2 + v_1^2 + w_1^2 = 8$

$$\begin{aligned}
 u_1^1 + v_2^1 + w_2^1 &= 14 & u_1^2 + v_2^2 + w_2^2 &= 10 \\
 u_2^1 + v_1^1 + w_2^1 &= 20 & u_2^2 + v_1^2 + w_2^2 &= 15 \\
 u_3^1 + v_1^1 + w_2^1 &= 11 & u_3^2 + v_1^2 + w_2^2 &= 10 \\
 u_3^1 + v_1^1 + w_3^1 &= 8 & u_3^2 + v_1^2 + w_3^2 &= 5 \\
 u_3^1 + v_2^1 + w_3^1 &= 13 & u_3^2 + v_2^2 + w_3^2 &= 6
 \end{aligned}$$

We obtain

$$\begin{array}{llllll}
 u_1^1 = 0 & v_1^1 = 0 & w_1^1 = 15 & u_1^2 = 0 & v_1^2 = 0 & w_1^2 = 8 \\
 u_2^1 = 11 & v_2^1 = 5 & w_2^1 = 9 & u_2^2 = 6 & v_2^2 = 1 & w_2^2 = 9 \\
 u_3^1 = 2 & & w_3^1 = 6 & u_3^2 = 1 & & w_3^2 = 4
 \end{array}$$

The matrices:  $m'_{ijk} / n'_{ijk}$

k=1		1	2
i \ j			
1	0/0	-11/-6	
2	-7/6	-16/-1	
3	-3/-1	2/10	

k=2		1	2
i \ j			
1	9/6	0/0	
2	0/0	-4/-1	
3	0/0	7/9	

k=3		1	2
i \ j			
1	1/-1	0/0	
2	0/0	-8/-1	
3	0/0	0/0	

For which  $V_1 = 828$

$$V_2 = 549, \quad V_1 \approx 1,5V_2$$

And matrix  $\Delta_{ijk} = m'_{ijk} \cdot V_2 - n'_{ijk} \cdot V_1 \approx V_2(m'_{ijk} - 1,5 \cdot n'_{ijk}) = V_2 \cdot \Delta'_{ijk}$

( $\Delta_{ijk} = 0$  for basic components).

Matrix  $\Delta'_{ijk}$ :

k=1		1	2
i \ j			
1	0	-2	
2	-16	-14,5	
3	-4,5	-13	

k=2		1	2
i \ j			
1	0	0	
2	0	-2,5	
3	0	-6,5	

k=3		1	2
i \ j			
1	2,5	0	
2	0	-6,5	
3	0	0	

The solution is not optimum because there are components  $\Delta_{ijk} < 0$ .

We improved solution:

Input criterion :  $\Delta_{211} = -16 = \min\{\Delta_{ijk} | \Delta_{ijk} < 0\}$

Output criterion: as in [4],[5]: for basic components :

$$\begin{array}{lll}
 z_{111} = 1 & z_{212} = 1 & z_{313} = -1 \\
 z_{122} = -1 & z_{322} = 0 & z_{323} = 1
 \end{array}$$

$$\theta = \min(x_{111}, x_{212}, x_{323}) = \min(16, 8, 11) = 8$$

$$x_{212} = \theta = 8$$

Solution actualization for basic components:

$$x'_{ijk} = x_{ijk} - \theta \cdot z_{ijk}$$

$$x_{212} = 0$$

$$x_{211} = 8$$

The new solution  $X_1$  is:

		k=1	
i \ j	1	2	
1	8		
2	8		
3			

		k=2	
i \ j	1	2	
1		16	
2			
3	15		

		k=3	
i \ j	1	2	
1			
2			
3	9	3	

for which the value of objective function is  $f_1 = \frac{772}{597} \approx 1,3$

Resume from optimality verification

### Bibliography

1. Aggarwal, S. P. **Indefinite quadratic fractional programming**, Cahiers du Centre d'Etudes de Recherche Operationelle, 1973
2. Corban, A. **Non Linear three-dimensional programming**, Rev. Roum. Math. Pures et Appl., 1975
3. Dantzig, G. B., Wolfe, F. **The Decomposition Algorithm for Linear Programs**, Econometrica, vol. 29, no. 4, 1961
4. Mangasarian, O. L. **Pseudo Convex Functions**, J. Siam Control, nr.3, 1965
5. Moanta, D. **Three dimensional transport problems**, Denbridge Press, New York, 2006
6. Moanta, D. **Teorie si practica in probleme de transport**, Cartea Universitara, Bucharest, 2006
7. Stancu Minasian, I. M. **A Three-Dimensional Transportation Problem with a Special Structured Objective Function**, Bulletin Math., Tome 18, no. 3-4, 1974

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1. Moanta D: Three dimensional transport problems, Denbridge Press, New York, 2006
2. Moanta D: Teorie si practica in probleme de transport, Cartea Universitara, Bucharest, 2006

## THE WEIGHTED POSSIBILISTIC MEAN VARIANCE AND COVARIANCE OF FUZZY NUMBERS

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**Abstract:** *In the context of Markowitz portfolio selection problem (Markowitz,1959), this paper develops a "weighted" possibilistic mean-variance and covariance portfolio selection model. In the process of selecting a portfolio, this work is concerned with the choice of the portfolio (Markowitz,1952).*

**Key words:** Portfolio selection; VaR; Possibilistic mean value; Possibilistic theory; Weighted possibilistic mean; Fuzzy theory

### 1. Introduction

This article is organized in the following way: Section 2 propose an overview of proportional transaction costs model; in Section 3 we consider the possibilistic theory proposed by Zadeh [15]<sup>2</sup> and we present the rate of return on security given by a trapezoidal fuzzy number; in Section 4, we stated the weighted possibilistic mean variance and covariance of fuzzy numbers. Thus are extended some recently results in this field [8,12,15].

### 2. The proportional transaction costs model

Transaction cost is one of the main sources of concern to managers see [1, 16].

Assume the rate of transaction cost of security  $j$  ( $j=1, \dots, n$ ) and allocation of  $i$  ( $i=1, \dots, k$ ) assets is  $c_{ji}$ , thus the transaction cost of security  $j$  and allocation of  $i$  assets is

$c_{ji}x_j$ . The transaction cost of portfolio  $x = (x_1, \dots, x_n)$  is  $\sum_{j=1}^n c_{ji}x_j, i = 1, \dots, k$ . Considering the

proportional transaction cost and the shortfall probability constraints, we purpose the following mean VaR portfolio selection model with transaction costs [14]:

$$\text{Max}_{x \in R^n} E(v_1) - \sum_{j=1}^n c_{j1}x_j, \dots, E(v_k) - \sum_{j=1}^n c_{jk}x_j \tag{2.1}$$

$$\text{Subject to } \Pr\{v_i < (VaR)_i\} \leq \beta_i, i = 1, \dots, k, \tag{2.2}$$

$$\sum_{j=1}^n x_j = 1, \tag{2.3}$$

$$M_{1j} \leq x_j \leq M_{2j}, \quad j = 1, \dots, n. \tag{2.4}$$

### 3. Triangular and trapezoidal fuzzy numbers

We consider the possibilistic theory proposed by Zadeh [15]. Let  $\tilde{a}$  and  $\tilde{b}$  be two fuzzy numbers with membership functions  $\mu_{\tilde{a}}$  and  $\mu_{\tilde{b}}$  respectively. The possibility operator (*Pos*) is defined in [12].

Let the rate of return on security given by a trapezoidal fuzzy number  $\tilde{r} = (r_1, r_2, r_3, r_4)$  where  $r_1 < r_2 \leq r_3 < r_4$ . Then the membership function of the fuzzy number  $\tilde{r}$  can be denoted by:

$$\mu(x) = \begin{cases} \frac{x - r_1}{r_2 - r_1}, & r_1 \leq x \leq r_2, \\ 1, & r_2 \leq x \leq r_3, \\ \frac{x - r_4}{r_3 - r_4}, & r_3 \leq x \leq r_4, \\ 0, & \text{otherwise.} \end{cases} \tag{3.1}$$

We mention that trapezoidal fuzzy number is *triangular* fuzzy number if  $r_2 = r_3$ .

Let us consider two trapezoidal fuzzy numbers  $\tilde{r} = (r_1, r_2, r_3, r_4)$  and  $\tilde{b} = (b_1, b_2, b_3, b_4)$ .

If  $r_2 \leq b_3$ , then we have

$$\begin{aligned} Pos(\tilde{r} \leq \tilde{b}) &= \sup\{\min\{\mu_{\tilde{r}}(x), \mu_{\tilde{b}}(y)\} \mid x \leq y\} \\ &\geq \min\{\mu_{\tilde{r}}(r_2), \mu_{\tilde{b}}(b_3)\} = \min\{1, 1\} = 1, \end{aligned}$$

which implies that  $Pos(\tilde{r} \leq \tilde{b}) = 1$ . If  $r_2 \geq b_3$  and  $r_1 \leq b_4$  then the supremum is achieved at point of intersection  $\delta_x$  of the two membership function  $\mu_{\tilde{r}}(x)$  and  $\mu_{\tilde{b}}(x)$ . A simple computation shows that

$$Pos(\tilde{r} \leq \tilde{b}) = \delta = \frac{b_4 - r_1}{(b_4 - b_3) + (r_2 - r_1)}$$

and

$$\delta_x = r_1 + (r_2 - r_1)\delta$$

If  $r_1 > b_4$ , then for any  $x < y$ , at least one of the equalities  $\mu_{\tilde{r}}(x) = 0$ ,  $\mu_{\tilde{b}}(y) = 0$  hold.

Thus we have  $Pos(\tilde{r} \leq \tilde{b}) = 0$ . Now we summarize the above results as

$$Pos(\tilde{r} \leq \tilde{b}) = \begin{cases} 1, & r_2 \leq b_3 \\ \delta, & r_2 \geq b_3, r_1 \leq b_4 \\ 0, & r_1 \geq b_4 \end{cases} \tag{3.2}$$



Especially, when  $\tilde{b}$  is the crisp number 0, then we have

$$Pos(\tilde{r} \leq 0) = \begin{cases} 1, & r_2 \leq 0 \\ \delta, & r_1 \leq 0 \leq r_2 \\ 0, & r_1 \geq 0 \end{cases} \quad (3.3)$$

where

$$\delta = \frac{r_1}{r_1 - r_2}. \quad (3.4)$$

We now turn our attention the following lemma.

**Lemma 3.1** [4] *Assume that trapezoidal fuzzy number  $\tilde{r} = (r_1, r_2, r_3, r_4)$ . Then for any given confidence level  $\alpha$  with  $0 \leq \alpha \leq 1$ ,  $Pos(\tilde{r} \leq 0) \geq \alpha$  if and only if  $(1 - \alpha)r_1 + \alpha r_2 \leq 0$ .*

The  $\lambda$  level set of a fuzzy number  $\tilde{r} = (r_1, r_2, r_3, r_4)$  is a crisp subset of  $R$  and denoted by  $[\tilde{r}]^\lambda = \{x | \mu(x) \geq \lambda, x \in R\}$ , then according to Carlsson et al [3], we have

$$[\tilde{r}]^\lambda = \{x | \mu(x) \geq \lambda, x \in R\} = [r_1 + \lambda(r_2 - r_1), r_4 - \lambda(r_4 - r_3)].$$

Given  $[\tilde{r}]^\lambda = [a_1(\lambda), a_2(\lambda)]$ , the crisp possibilistic mean value of  $\tilde{r} = (r_1, r_2, r_3, r_4)$  is

$$\tilde{E}(\tilde{r}) = \int_0^1 \lambda(a_1(\lambda) + a_2(\lambda))d\lambda,$$

where  $\tilde{E}$  denotes fuzzy mean operator.

We can see that if  $\tilde{r} = (r_1, r_2, r_3, r_4)$  is a trapezoidal fuzzy number then

$$\tilde{E}(\tilde{r}) = \int_0^1 \lambda(r_1 + \lambda(r_2 - r_1) + r_4 - \lambda(r_4 - r_3))d\lambda = \frac{r_2 + r_3}{3} + \frac{r_1 + r_4}{6}. \quad (3.5)$$

#### 4. The weighted possibilistic mean variance and covariance of fuzzy numbers

The classical mean-variance portfolio selection problem uses the variance as the measure for risk, which puts the same weight on the down side and upside of the return. In this section, we study the "weighted" possibilistic mean-variance and covariance portfolio selection model.

**Definition 4.2** [6] *Let  $\tilde{r} \in F$  be a fuzzy number with  $[\tilde{r}]^\lambda = [r_1(\lambda), r_2(\lambda)]$ ,  $\lambda \in [0,1]$ . The  $w$ -weighted possibilistic variance of  $\tilde{r}$  is*

$$\begin{aligned} Var_w(\tilde{r}) &= \int_0^1 \frac{r_2(\lambda) - r_1(\lambda)}{2}^2 w(\lambda)d\lambda \\ &= \int_0^1 \frac{1}{2} \left[ \frac{r_1(\lambda) + r_2(\lambda)}{2} - r_1(\lambda) \right]^2 + r_2(\lambda) - \frac{r_1(\lambda) + r_2(\lambda)}{2}^2 w(\lambda)d\lambda \end{aligned}$$

where weighting function is non-decreasing and satisfies

$$\int_0^1 w(\lambda) d\lambda = 1. \tag{4.1}$$

The standard deviation of  $\tilde{r}$  is defined by

$$\sigma_{\tilde{r}} = \sqrt{Var(\tilde{r})} \tag{4.2}$$

Let  $\tilde{r}$  fuzzy number and  $w$  be a weighting function, we define the weighted possibilistic variance of  $\tilde{r}$  by

$$Var_w(\tilde{r}) = \int_0^1 \frac{r_2(\lambda) - r_1(\lambda)}{2}^2 w(\lambda) d\lambda$$

and the weighted covariance of  $\tilde{r}$  and  $\tilde{b}$  is defined as

$$Cov_w(\tilde{r}, b) = \int_0^1 \frac{r_2(\lambda) - r_1(\lambda)}{2} \cdot \frac{b_2(\lambda) - b_1(\lambda)}{2} w(\lambda) d\lambda$$

If  $w(\lambda) = 2\lambda, \lambda \in [0,1]$

$$Var_w(\tilde{r}) = \frac{1}{2} \int_0^1 (r_2(\lambda) - r_1(\lambda)) \lambda d\lambda, \tag{4.3}$$

and

$$Cov_w(\tilde{r}, b) = \frac{1}{2} \int_0^1 (r_2(\lambda) - r_1(\lambda))(b_2(\lambda) - b_1(\lambda)) 2\lambda d\lambda. \tag{4.4}$$

Let  $\tilde{r} = (r_1, r_2, r_3, r_4)$  and  $\tilde{b} = (b_1, b_2, b_3, b_4)$  be fuzzy numbers of trapezoidal form.

Let  $w(\lambda) = (2\gamma - 1) (1 - \lambda)^{\frac{1}{2\gamma} - 1}$ ,

where  $\gamma \geq 1$ , be a weighting function then the power-weighted variance and covariance  $\tilde{r}$  and  $\tilde{b}$  are computed by

$$\begin{aligned} Var_w(\tilde{r}) &= (2\gamma - 1) \int_0^1 \frac{r_2(\lambda) - r_1(\lambda)}{2}^2 (1 - \lambda)^{\frac{1}{2\gamma} - 1} d\lambda \\ &= \frac{(2\gamma - 1)}{4} \frac{(r_2 - r_1)^2}{2\gamma - 1} + 2(r_2 - r_1)(\alpha + \beta) \frac{2(r_2 - r_1)(r_3 + r_4)}{2(4\gamma - 1)} + (\alpha + \beta)^2 \frac{(r_3 + r_4)^2}{3(6\gamma - 1)} \end{aligned} \tag{4.5}$$

$$\begin{aligned} Cov_w(\tilde{r}, \tilde{b}) &= (2\gamma - 1) \int_0^1 \frac{(r_2 - r_1)((1 - \lambda)(r_3 + r_4))}{2} \cdot \frac{(b_2 - b_1) + (1 - \lambda)(b_3 + b_4)}{2} (1 - \lambda)^{\frac{1}{2\gamma} - 1} d\lambda \\ &= \frac{(2\gamma - 1)}{4} \frac{r_2 - r_1}{2\gamma - 1} (b_2 - b_1) + \frac{(r_2 - r_1)(b_3 + b_4)(r_3 + r_4)}{2(4\gamma - 1)} + \frac{(r_3 + r_4)(b_3 + b_4)}{3(6\gamma - 1)}. \end{aligned} \tag{4.6}$$

**Theorem 4.1** [12] *The mean-variance efficient portfolio model is*

$$\max_{x \in R^n} \sum_{i=1}^q \lambda_i \bar{E}_w \sum_{j=1}^n \tilde{r}_{ji} x_j - \sum_{j=1}^n c_{ji} x_j \tag{4.7}$$

$$\text{subject to Pos} \sum_{j=1}^n \tilde{r}_{ji} x_j < \tilde{b}_i \leq \beta_i, \quad i = \overline{1, q}, \tag{4.8}$$

$$\sum_{j=1}^n x_j = 1, \tag{4.9}$$

$$M_{1j} \leq x_j \leq M_{2j}, \quad j = \overline{1, n}. \tag{4.10}$$

In the next theorem we extend ([12], Theorem 4.2) to the case weighted possibility mean- variance approach with a special weighted  $w(\lambda)$ .

**Theorem 4.2** Let  $w(\lambda) = (2\gamma - 1) (1 - \lambda)^{\frac{1}{2\gamma}} - 1$ ,  $\gamma \geq 1$  the weighted possibility mean variance (covariance) of the trapezoidal number  $\tilde{r}_{ji} = (r_{(ji)1}, r_{(ji)2}, r_{(ji)3}, r_{(ji)4})$  where  $r_{(ji)1} < r_{(ji)2} \leq r_{(ji)3} < r_{(ji)4}$  and addition  $\tilde{b}_i = (b_{i1}, b_{i2}, b_{i3}, b_{i4})$  is a trapezoidal number for  $(VaR)_i$  level,  $i = \overline{1, q}$ . For  $\lambda_i > 0, i = \overline{1, q}$ , then the possibilistic mean variance (covariance) portfolio selection model is

$$\begin{aligned} \max_{x \in R^n} \sum_{i=1}^q \lambda_i & \frac{(2\gamma - 1) \sum_{j=1}^n r_{(ji)2} x_j - \sum_{j=1}^n r_{(ji)1} x_j}{4(2\gamma - 1)} + \frac{(2\gamma - 1) \sum_{j=1}^n r_{(ji)2} x_j - \sum_{j=1}^n r_{(ji)1} x_j}{4(4\gamma - 1)} \frac{\sum_{j=1}^n r_{(ji)3} x_j + \sum_{j=1}^n r_{(ji)4} x_j}{4(4\gamma - 1)} \\ & + \frac{(2\gamma - 1) \sum_{j=1}^n r_{(ji)3} x_j + \sum_{j=1}^n r_{(ji)4} x_j}{12(6\gamma - 1)} - \sum_{j=1}^n c_{ji} x_j \end{aligned} \tag{4.11}$$

subject to

$$(1 - \beta_i) \sum_{j=1}^n r_{(ji)1} x_j - b_{i4} + \beta_i \sum_{j=1}^n r_{(ji)2} x_j - b_{i3} \geq 0, \quad i = \overline{1, q}, \tag{4.12}$$

$$\sum_{j=1}^n x_j = 1, \tag{4.13}$$

$$M_{1j} \leq x_j \leq M_{2j}, \quad j = \overline{1, n}. \tag{4.14}$$

**Proof:** From the equation (3.5), we have

$$\begin{aligned} \bar{E}_w \sum_{j=1}^n \tilde{r}_{ji} x_j &= \frac{(2\gamma-1) \sum_{j=1}^n r_{(ji)2} x_j - \sum_{j=1}^n r_{(ji)1} x_j}{4(2\gamma-1)} + \frac{(2\gamma-1) \sum_{j=1}^n r_{(ji)2} x_j - \sum_{j=1}^n r_{(ji)1} x_j}{4(4\gamma-1)} \\ &\quad + \frac{(2\gamma-1) \sum_{j=1}^n r_{(ji)3} x_j + \sum_{j=1}^n r_{(ji)4} x_j}{12(6\gamma-1)}, \quad i = \overline{1, q}, \gamma \geq 1. \end{aligned}$$

From Lemma 3.1, we have that

$$\begin{aligned} Pos \sum_{j=1}^n \tilde{r}_{ji} x_j < \tilde{b}_i \leq \beta_i, \quad i = \overline{1, q} \text{ is equivalent with} \\ (1 - \beta_i) \sum_{j=1}^n r_{(ji)1} x_j - b_{i4} + \beta_i \sum_{j=1}^n r_{(ji)2} x_j - b_{i3} \geq 0, \quad i = \overline{1, q}. \end{aligned}$$

Furthermore, from (4.11)-(4.14) given by Theorem 4.1, we get the following form :

$$\begin{aligned} \max_{x \in R^n} \sum_{i=1}^q \lambda_i &\frac{(2\gamma-1) \sum_{j=1}^n r_{(ji)2} x_j - \sum_{j=1}^n r_{(ji)1} x_j}{4(2\gamma-1)} + \frac{(2\gamma-1) \sum_{j=1}^n r_{(ji)2} x_j - \sum_{j=1}^n r_{(ji)1} x_j}{4(4\gamma-1)} \\ &\quad + \frac{(2\gamma-1) \sum_{j=1}^n r_{(ji)3} x_j + \sum_{j=1}^n r_{(ji)4} x_j}{12(6\gamma-1)} - \sum_{j=1}^n c_{ji} x_j \end{aligned} \quad (4.15)$$

subject to

$$(1 - \beta_i) \sum_{j=1}^n r_{(ji)1} x_j - b_{i4} + \beta_i \sum_{j=1}^n r_{(ji)2} x_j - b_{i3} \geq 0, \quad i = \overline{1, q} \quad (4.16)$$

$$\sum_{j=1}^n x_j = 1, \quad (4.17)$$

$$M_{1j} \leq x_j \leq M_{2j}, \quad j = \overline{1, n}. \quad (4.18)$$

This completes the proof.

Problem (4.15)-(4.18) is a standard multi-objective linear programming problem. Also we can obtain an optimal solution by using some algorithms of multi-objective programming [3, 11].

For  $\gamma \rightarrow \infty$  we see that  $\lim_{\gamma \rightarrow \infty} \widetilde{E}_w(\tilde{r}) = \frac{(r_2 - r_1)^2}{4} + \frac{(r_2 - r_1)(r_3 + r_4)}{8} + \frac{(r_3 + r_4)^2}{36}$ .

## References

1. Arnott, R. D., and Wanger, W.H. **The measurement and control of trading costs**, Financial Analysts Journal, 46(6), 1990, pp. 73-80
2. Bellman, R., and Zadeh, L. A. **Decision making in a fuzzy environment**, Management Science, 17, 1970, pp. 141-164
3. Caballero, R., Cerda, E., Munoz, M. M., Rey, L., and Stancu Minasian, I. M. **Efficient solution concepts and their relations in stochastic multi-objective programming**, Journal of Optimization Theory and Applications, 110(1), 2001, pp. 53-74
4. Carlsson, C., and Fuller, R. **On possibilistic mean value and variance of fuzzy numbers**, Fuzzy sets and systems, 122, 2001, pp. 315-326
5. Dubois, D., and Prade, H. **Possibility theory**, Plenum Press, New York, 1998
6. Fuller, R., and Majlender, P. **On weighted possibilistic mean value and variance of fuzzy numbers**, Turku Centre for Computer Science, 2002
7. Guohua, C., *et al* **A possibilistic mean VaR model for portfolio selection**, AMO-Advanced Modeling and Optimization, Vol. 8, No. 1, 2006
8. Inuiguchi, M., and Ramik, J. **Possibilistic linear programming: a brief review of fuzzy mathematical programming and a comparison with stochastic programming in portfolio selection problem**, Fuzzy Sets and Systems, 111, 2000, pp. 3-28
9. Markowitz, H. M. **Portfolio Selection**, Journal of Finance, 7, 1952, pp. 77-91
10. Markowitz, H. M. **Portfolio Selection**, John Wiley & Sons, New York, 1959
11. Preda, V. **Some optimality conditions for multiobjective programming problems with set functions**, Rev. Roum. Math. Pures Appl., 1993
12. Sudradjat, S. **On possibilistic approach for a portfolio selection**, Mathematical Reports, accepted, Februarie, 2007
13. Sudradjat, S., and Preda, V. **On portfolio optimization using fuzzy decisions**, 6<sup>th</sup> International Congress on Industrial and Applied Mathematics, Zurich, Switzerland, 16-20 July, 2007
14. Sudradjat, S., Popescu, C., and Ghica, M. **A portfolio selection problem with a possibilistic approach**, 22<sup>ND</sup> European Conference on operational research, Prague July 8-11, 2007
15. Zadeh, L.A. **Fuzzy sets as a basis for a theory of possibility**, Fuzzy sets and systems, 1, 1978, pp. 3-28
16. Zhou, X. Y., and Li, D. **Continuous time mean- variance portfolio selection**, A stochastic LQ framework, Applied Mathematics and Optimization, 42, 2000, pp. 19-33

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<sup>2</sup> Codifications of references:

[1]	Arnott, R. D., and Wanger, W.H. <b>The measurement and control of trading costs</b> , Financial Analysts Journal, 46(6), 1990, pp. 73-80
[2]	Bellman, R., and Zadeh, L. A. <b>Decision making in a fuzzy environment</b> , Management Science, 17, 1970, pp. 141-164
[3]	Caballero, R., Cerda, E., Munoz, M. M., Rey, L., and Stancu Minasian, I. M. <b>Efficient solution concepts and their relations in stochastic multi-objective programming</b> , Journal of Optimization Theory and Applications, 110(1), 2001, pp. 53-74
[4]	Carlsson, C., and Fuller, R. <b>On possibilistic mean value and variance of fuzzy numbers</b> , Fuzzy sets and systems, 122, 2001, pp. 315-326
[5]	Dubois, D., and Prade, H. <b>Possibility theory</b> , Plenum Press, New York, 1998
[6]	Fuller, R., and Majlender, P. <b>On weighted possibilistic mean value and variance of fuzzy numbers</b> , Turku Centre for Computer Science, 2002
[7]	Guohua, C., <i>et al</i> <b>A possibilistic mean VaR model for portfolio selection</b> , AMO-Advanced Modeling and Optimization, Vol. 8, No. 1, 2006
[8]	Inuiguchi, M., and Ramik, J. <b>Possibilistic linear programming: a brief review of fuzzy mathematical programming and a comparison with stochastic programming in portfolio selection problem</b> , Fuzzy Sets and Systems, 111, 2000, pp. 3-28
[9]	Markowitz, H. M. <b>Portfolio Selection</b> , Journal of Finance, 7, 1952, pp. 77-91
[10]	Markowitz, H. M. <b>Portfolio Selection</b> , John Wiley & Sons, New York, 1959
[11]	Preda, V. <b>Some optimality conditions for multiobjective programming problems with set functions</b> , Rev. Roum. Math. Pures Appl., 1993
[12]	Sudradjat, S. <b>On possibilistic approach for a portfolio selection</b> , Mathematical Reports, accepted, Februarie, 2007
[13]	Sudradjat, S., and Preda, V. <b>On portfolio optimization using fuzzy decisions</b> , 6 <sup>th</sup> International Congress on Industrial and Applied Mathematics, Zurich, Switzerland, 16-20 July, 2007
[14]	Sudradjat, S., Popescu, C., and Ghica, M. <b>A portfolio selection problem with a possibilistic approach</b> , 22 <sup>ND</sup> European Conference on operational research, Prague July 8-11, 2007
[15]	Zadeh, L.A. <b>Fuzzy sets as a basis for a theory of possibility</b> , Fuzzy sets and systems, 1, 1978, pp. 3-28
[16]	Zhou, X. Y., and Li, D. <b>Continuous time mean- variance portfolio selection</b> , A stochastic LQ framework, Applied Mathematics and Optimization, 42, 2000, pp. 19-33

## TERRITORIAL DEVELOPMENT AND NETWORKING IN THE EUROPEAN UNION AND ROMANIA: THE PARTNERSHIP SIGNIFICANCE

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**Abstract:** *In a complex and interdependent world, many of the problems to be solved - from reduction of unemployment and social exclusion to improving the economic competitiveness - the spatial, territorial dimension becomes more and more important. It has become the third dimension of the European Union cohesion policy, added to the economic and social ones. The territorial delineation of the economic issues leans toward an approach that reflects the necessity of involvement of all decisional levels and economic actors, both for identifying the problems and for implementing the optimal solutions. Starting from these overall considerations this paper explores the significance of the partnership setting up and development for the creation of sustainable territorial networks, able to support the implementation of regional policy in Romania, considering the overall European context.*

**Key words:** *territorial development; networks; partnerships; regional policy*

### Introduction

Many of the regions of the EU are endowed with big potential for sustainable economic growth and job creation. It includes a mix of territorially organised tangible and other resources such as social capital, institutional settings, community development and local entrepreneurship capacities.

Mobilisation of diverse territorial potentials requires a new understanding of territorial authority and cooperation with the private sector. The territorial influence of European Union Cohesion Policy and other policies (example: rural, environmental and transport) must be recognised at all levels. This implies that EU policies should improve

consideration of local, regional and national policies and development potentials by having a more coherent approach to territorial development. On the other hand, regional and local development strategies should focus more on the European needs and make a better are able to provide a network for information exchange and the sharing of best practice, thus fostering greater efficiency in the implementation of the programmes. Partnership ensures more bottom-up participation, the introduction of innovative ideas and different perspectives and serves as a network across various policies and sectors. This paper proposes an inquiry into the network formed at the regional level under the influence of different conditions, pointing out the importance of partnership in establishing territorial relationships.

## Background

The European Union Territorial Agenda is a strategic framework for the European territorial development, supporting the implementation of Lisbon and Gothenburg strategies through an integrated territorial development policy. The aim of this territorial agenda is the increase of global competitiveness and sustainable development of all European regions.

The Territorial Agenda demonstrates that, within the cohesion policy, geography matters. This involves a special attention that needs to be paid to the territorial cohesion, referring to the history, culture and institutional framework of each Member State. By taking into consideration these patterns can be better valorized the opportunities offered by the European territorial diversity and by the development opportunities of its territories.

Moreover, at the national level the regional policy must have a territorial dimension by directing the investments not only within developed areas, but also within areas with severe social and economic problems that tend to decouple from the economic development and that need urgent solutions for not becoming an obstacle in achieving the European objective of territorial cohesion.

The analysis within the *Territorial State and Perspectives of the EU* document shows that Europe will have to face some significant challenges in the coming years. The most important territorial tendencies and driving forces will influence differently the European cities and regions. Among the most important challenges identified within *Territorial State and Perspectives of the EU Document – Towards a stronger European Territorial Cohesion in the Light of the Lisbon and Gothenburg Ambitions* are (E.C., 2006):

- geographical concentration of activities supported by market forces and development of society;
- accelerating integration of the EU in the global economic competition;
- growing interdependency between the EU territory and neighbouring countries as well as the other parts of the world;
- impacts of the enlargement of the EU on the economic, social and territorial cohesion of the EU;
- aspects of unsustainable development leading to the overexploitation of the ecological capacity of the regions.

According to the Territorial Agenda the territorial cohesion should focus on regional and national territorial development policies able to ensure better exploiting of regional potentials and territorial capital, better positioning of regions by strengthening their potentials and cooperation, promoting the coherence of policies with territorial impact, both horizontally and vertically, so that they support sustainable development at national and



regional level. This requirement highlights the contribution that can be brought about by the creation and development of territorial networks.

### Regional networks – specific features and typology

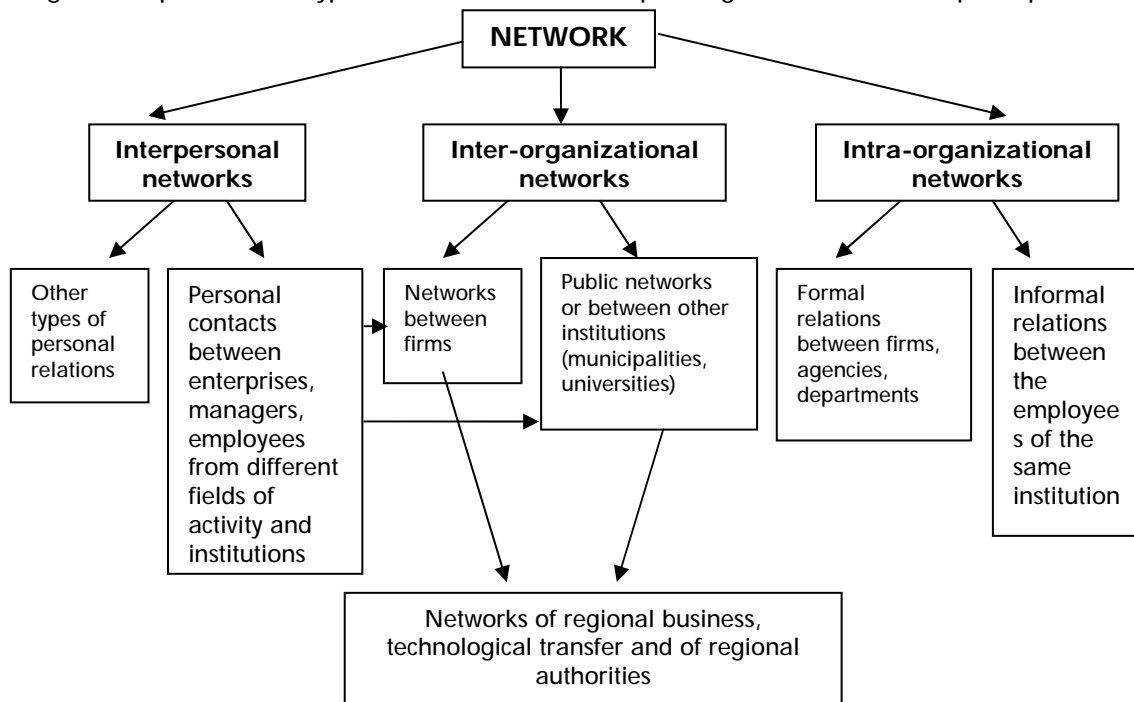
The *regional networks* are defined as cooperation between the business environment, governmental bodies, research institutes and universities, intermediary organisations, as well as other groups. (Cappellin, 2000) The business networks, as well as the public or other institutions ones are components of the integrated system of “regional network”.

The set-up of a regional network can be influenced by the partners’ origin and number, by the aim of the initiative that should be implemented, as well as by the objectives to be achieved within a network.

The regional networks are characterized by the following features (Sprengr, 2001):

- participants are part of different fields of activity (business, chambers of commerce and industry, governmental organisms and public institutions, research institutes, universities, social groups);
- participation is on a voluntary basis;
- participation is based on equal rights, dialogue, consensus and compromise, as well as self-governing;
- by taking into consideration the different interests a network leads to coordination and organisation;
- participants within a network do not have the authority and power to penalise the others or the authority to give directives the other regional partners;
- premises of success are the mutual trust and learning from each other.

Figure 1 depicts various types of networks and corresponding relations between participants



**Figure 1.** Types of networks and relations among participants

Source: Institute for Structural Policy and Economic Development, [www.isw-online.org](http://www.isw-online.org)

At European level, the literature devoted to this subject reveals the changes produced by the implementation of the regional policy. The set-up of a network is no longer the creation of the firms from the economic environment. The globalisation process, the competition for localisation, as well as the regional policy that encourages the mobilisation of resources and valorisation of the regional potential have determined the emergence of regional networks. Moreover, Sprenger (2001) considers that the decision of setting-up a regional network is influenced by the existence of a competencies deficit in the institutions that implement policies, insufficient and sometimes the lack of local funds and resources, by the increasing importance of soft factors for localisation and even by attracting new partners in the process of drawing-up and implementation of the regional policy.

Thus, the international literature identifies different forms of regional networks: regional clusters, regional centres of environmental excellence, regional employment and environment initiatives, Local Agenda 21 initiatives.

The regional clusters can be defined as regional accumulation of productive and services companies, research, education and other training institutions from various fields of activity, offering complementary services so that to encourage the cooperation within a network (Sprenger, 2001). Clusters are frequently found in automobile industry (e.g. Stuttgart, Upper Austria, etc.), but also in the area of environmental protection (e.g. Tyrolean Energy-Efficient House Cluster- Austria).

The regional centres of environmental excellence have as objective the creation and extension of the international competencies in research field and increase of economic implementation of research results. The aim of regional employment and environment initiatives is to maintain and create jobs and to help establishing the regional and local economy. These are characterized by bottom-up initiatives, partnership activities, innovation and integration of various politics (industrial, environment, social). Through the Local Agenda 21 initiatives is encouraged the dialogue between administration, citizens, local organization and private sector.

The regional networks can be of various types by taking into consideration the partners involved, the partnership type within the territorial network being influenced by the region's particular problems and institutional framework, as well as by the objectives to be achieved.

The networks, including strategic alliances, joint-venture, working groups represent a form of cooperation. The particularities identified by the international literature refer to the following aspects:

- networks allow all types of cooperation, even if the dominate relations are vertical and horizontal; there are also relations with other partners that do not participate in the network;
- networks are not characterised by detailed contracts or particular legal forms;
- they are set up without any time constrains and in some cases the cooperation relations are the basis for another types of partnership, respectively joint venture;
- network is not dissolved by the withdrawal of one partner; the remaining companies continue the activity within the network and can even accept new partners (Sprenger, 2001).

At the European level, the employment of the economic growth factors by turning them into good account within regional networks is supported by the regional policy of the

European Union and by each country as well. By means of the Structural Funds were encouraged partnerships and created collaboration networks by initiatives such as LEADER, URBAN.

At the same time, the member states, through the national funds, support a considerable number of programmes for creating regional networks (examples: Austria - promoting the industrial clusters, Finland - programmes for the centers of expertise network regarding improvement of the industrial firm competitiveness in the international environment; France - programme coordinated by DATAR for setting-up regional and local networks in order to support the initiatives within Agenda 21; Germany - innovation networks - cooperation between at least two research institutes or universities and four production firms), networks for strengthening the innovation capacity of the small and medium enterprises, networks for promoting cooperation in the industrial research (examples: Great Britain - programme for setting-up cooperation centers in research area between the research departments within the companies and research institutes, universities; Italy - local production systems, especially in the north-east and center of the country - NEC systems, based on a dense connection network between firms from different sectors of activity and the other regional actors). In the regional policy area, the network has recorded various forms according to the potential partners' reasons for cooperation, as well as the localisation in specific areas.

Internationally, the territorial network issue needs a multidisciplinary approach between the instruments offered by the economy, regional policy, management, network modeling (Table 1).

**Table1.** Anticipated advantages of regional networks

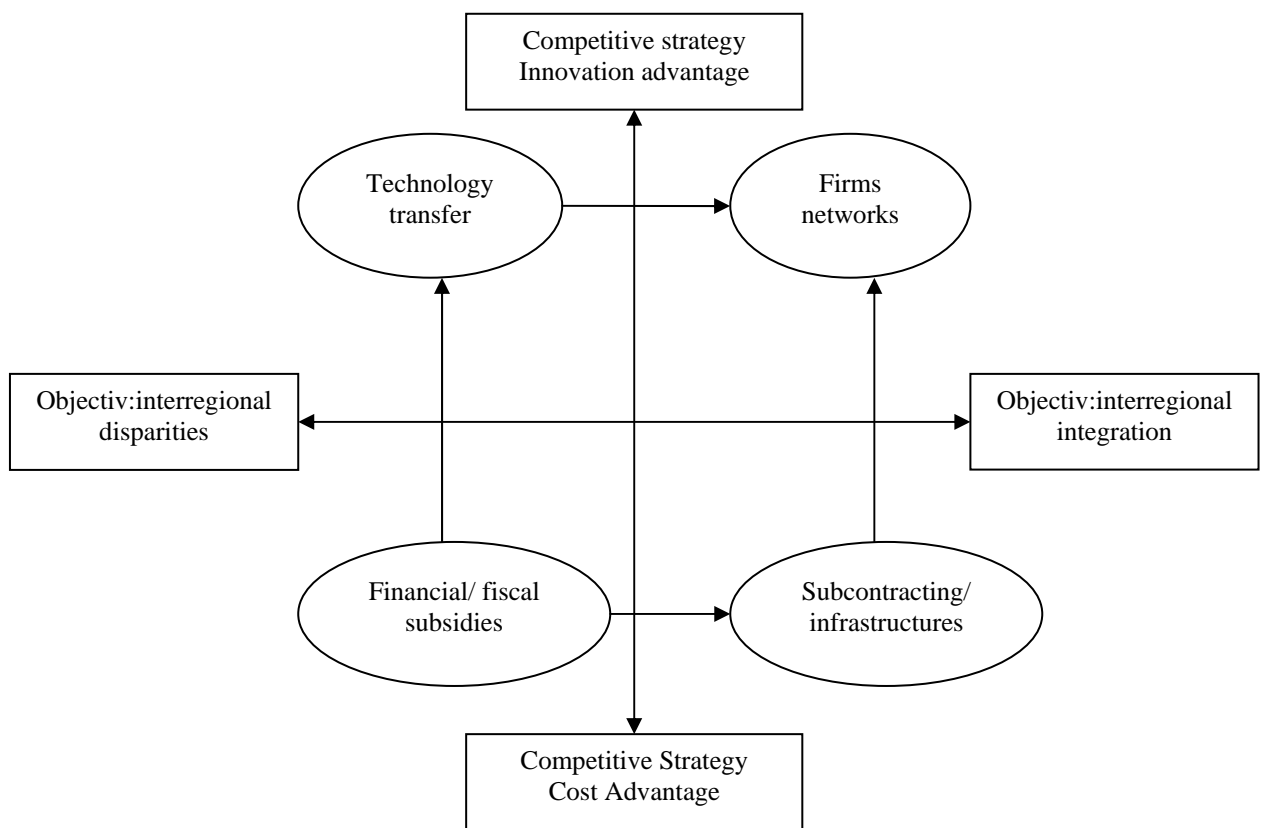
Economic advantages	Socio-cultural advantages	Ecological advantages
<ul style="list-style-type: none"> <li>- Finding and using the regional development potential</li> <li>- Increasing the regional added value</li> <li>- Increasing used of synergies effects through cooperative planning</li> <li>- Reducing the reaction time to regional structural problems</li> <li>- Development of new services and products</li> </ul>	<ul style="list-style-type: none"> <li>- People affected become participants</li> <li>- Are supported the regional initiatives, creativity and cultural identity</li> <li>- Solving the regional conflicts is supported by intermediary structures</li> </ul>	<ul style="list-style-type: none"> <li>- Increased importance of environmental regional problems</li> <li>- Increased regional responsibility</li> <li>- Improvement of the regional resource cycle</li> <li>- A better integration of the environmental dimension into regional development by ex-ante evaluation, indicators, project selection.</li> </ul>

Source: Sprenger, 2001, p. 21

*The scientific research undertaken in Romania with regard to the set-up of territorial networks is still incipient, the regional policy not approaching explicitly, systematically this subject. Various journals (such as *Entrepreneurial barometer of the National Council of Small and Medium private Enterprises, SME Magazine, Economy and Local Administration*) or studies developed within research projects (carried out by the International Centre of Entrepreneurial Studies from Bucharest, the Group of Applied Economics) have identified activities where incipient forms of clusters are developing. This is the case of software*

industry (Bucharest, Timisoara), navy construction (Galati, Constanta, Mangalia), woodcraft industry (Covasna, Harghita, Neam , Suceava), textile industry (Vaslui), china industry (Alba). Further on, the set-up and development of territorial network in Romania can be stimulated by establishing at the administrative level the general rules of implementing the policy, so that the economic actors can find, within the legal framework, the methods for a flexible integration on the market. (Constantin, 2002)

At the European level, as a result of globalization and intense economic exchanges, territorial networks tend to evolve to supra-regional ones by attracting the international competitors. The globalisation process increases the importance of regions as location for businesses and transforms the product competition into a distinct competition for localisation. Thus, the regional and local partners are determined to improve their regional economical culture and to promote the regional competitive advantages.



**Figure 2.** Instruments for regional economic policy

Source: Fischer, M. 2002, p. 49

As Figure 2 shows, the logic of current territorial development policies is that economic growth is based on the organisation of space that is shaped by a range of policies at all levels of government as well as by social trends, technological development and market forces. Some of these economic and social policies have unplanned spatial impacts which can compromise territorial development. Policies with a territorial focus not only counteract these effects but - more important - add value by integrating the economic, social and environmental dimensions of cross-sectoral policies. An important element in territorial development policies is the cooperation of various sectors of activity, levels of authorities and stakeholders, such as partnerships with the private sector and civil society that play an

important part in growth and development processes. Territorial development policies are an important instrument for strengthening regional territorial capital. (EC, 2006)

### **The partnership – an important step towards networking. Significance for the EU economic and social cohesion policy and Romania’s regional development**

The partnership represents one of the principles highlighted by the European regulations regarding the Structural Funds. They envisage a partnership among Commission, the member state, authorities and organisations appointed by the member state taking into account the national laws and their current practices (EC, 2006). The partnership principles must be applied in all stages of the Structural Funds employment process. The Commission has revealed that even if the partnership within regional authorities is a well known and accepted practice, which generally functions satisfactory, the local partnership is less developed especially due to the economic and social partners’ insufficient involvement.

Thus, at European scale, the partnership concept has been enforced due to the necessity of applying effectively the subsidiarity principle. This new direction takes into consideration the advantages of a public – private partnership: local interest compliance, investment cost and exploitation risks sharing as well as the lack of local public administration investments resources.

The public - private partnership concept represents a cooperation method among public authorities and private sector, respectively non-governmental organization, business association, companies for implementation of projects with positive effects on labor market and local and regional development. (Cappellin, 2000)

The partnership promotes cooperation between social and political actors, aiming to legitimate a political action, due to the fact that they are less involved in the decisional process and policy monitoring. The activities developed through partnership do not necessary follow profit results, but also performing social services, which contributes to general social welfare. Moreover, the partnership represents a collaboration instrument through which can be implemented public services improvement projects and can be ensured the programmes implementation coherence and their transparency. (Cappellin, 1997). At the same time, the partnership contributes to strengthening the governing system and local development.

Within the European countries does not exist and was not imposed a partnership standard system, even if lately is influenced more and more by the English model through two major objectives, namely labour market and local development in order to ensure the social and economic cohesion.

The partnership built between different levels of administration (central, county, local) and public sector plays an essential role in implementing the local and regional development projects financed by pre-accession and structural funds.

Public-private partnership arrangements appear to be particularly attractive for the new EU member states in view of their co-financing requirements, budget constraints, the need for efficient public services, growing market stability and the process of privatisation. Partnership, however, works only if there is an explicit policy commitment by national government to involve the private sector in public sector projects. A clear framework is needed for the application of partnership in different policy areas, since specific

arrangements need to vary from case to case depending on how far costs can be recouped through user charges and the extent of social objectives. Any partnership framework applied in the context of the Structural Funds should include an obligation, for all projects above a certain scale, to evaluate the possibility of using some kind of public-private partnership arrangement. The European Investment Bank and the European Investment Fund could provide a valuable contribution in this regard (Cappellin, 1997).

Partnership remains a core principle for management, monitoring and evaluation of the Funds and can add much value, particularly where the roles and responsibilities of the participants are clearly delineated. The Commission recommended that partnership be strengthened since it contributes to the success of programmes by giving them greater legitimacy, by making it easier to coordinate them and by increasing their effectiveness as well as transparency.

While there is broad consensus that partnership adds value to the effectiveness and impact of the Structural Funds, it may also introduce new layers of complexity into the process of designing and delivering policies, which can slow down decision making. There is, therefore, a trade-off between the additional complexity resulting from partnership and the improvements in design and implementation, which it can bring.

In practice, the studies regarding the partnership development (*„Partnership in the 2000-2006 programming period“, „Partnership for implementing the Structural Funds“ – DG REGIO*) undertaken at the EU level demonstrate the growing importance of applying the partnership principles, even more if the European Commission requires that the projects financed from the Community Funds must respect this principle. One of the evaluation criteria of the projects is the level of partners' involvement in the implementation of the projects financed; within the evaluation reports of the European Commission there is always a chapter dedicated to the partnership effects on the projects.

The partnership within regional policy tends to become the nucleus for setting-up a territorial cooperation network (*Maillat, 1990, Cappellin, 1998, Sprenger, 2001*), having as participants the public administration, the economic, social, but also cultural actors. Partnership in the design and implementation of programmes has become stronger and more inclusive, involving a range of private sector entities, including the social partners, as well as regional and local authorities. This has led to better targeted and more innovative projects, improved monitoring and evaluation of performance and the wider dissemination of information of their results, at the price, in some cases, of additional complexity of programme management.

In the partnership context, the regions have the responsibility of concentrating financial resources on the themes necessary to address the economic, social and territorial disparities at regional level.

Due to these reasons, institutionalised partnerships through **LEADER** (rural development through integrated programme and cooperation between local groups of actions), **EQUAL** (removing inequalities and discrimination in respect with access at the labour force), **INTERREG** (encouraging the interregional and transnational cooperation), **URBAN** (supporting the implementation of innovative strategies in towns and urban areas), are transformed into territorial networks aiming at the valorisation of the members advantages and obtaining multiplier effects.

The partnership importance at European level is revealed both through studies undertaken by independent research institutes (e.g. London Tavistock Institute – „Thematic

evaluation of the partnership principle" – 1999), and through European Union institutions (European Economic and Social Committee – „Partnership for implementing the structural funds", 2003). The conclusions of such studies reveal that the role of the socio-economic partners is different according to the development stage of the measures financed under Structural Funds, respectively the programming, implementation, monitoring and their evaluation. Furthermore, the public participation is a key component of increasing the quality of programming documents and ensuring their acceptance by the citizens.

Furthermore, for the new programming period 2007-2013 the European Commission continues the partnership policy, by creating new initiatives such as **JASPERS** (Joint Assistance in Supporting Projects in European Regions), **JEREMY** (Joint European Resources for Micro to Medium Enterprises), **JESSICA** (Joint European Support for Sustainable Investments in City Areas), through which are promoted projects for investments, economic growth and creation of new jobs. („The Growth and Jobs Strategy and the Reform of European cohesion policy. Forth progress report on cohesion", EC, 2006).

*In Romania*, in the regional policy drawing-up process were used formal as well as informal partnerships in order to ensure:

- the appropriate and correct implementation of approved programmes, together with their consistency with the established priorities and the general programming framework;
- a clear distribution of responsibilities of the socio-economic and institutional partners regarding monitoring and evaluation of the financial assistance;
- an appropriate importance on the environmental component, within a perspective of sustainable development, which ensures the use of public funds in conformity with the community policy and legal framework in this field.

The Government Decision no. 1323/2002, regarding the elaboration in partnership of the National Development Plan, ensured the legal basis for creating and developing the inter-institutional relations and the partnership structures at national and regional level, establishing at the same time the clear role of the ministries, Regional Development Agencies and other institutions involved in designing the National Development Plan.

As a result of this government decision were set- up:

- The Inter-institutional Committee for the elaboration of the National Development Plan (ICP): the membership consists of representatives from ministries, Regional Development Agencies (RDAs), central public institutions, research institutes and higher education institutions, as well as representatives of economic and social partners;
- Regional Committees for the elaboration of the Regional Development Plans (RCP): the membership consists of representatives from the Regional Development Agencies, the Prefectures, the County Councils, the decentralised services of central public institutions, representatives of research institutes and of higher education institutions, as well as representatives of the economic and social partners.

The created partnership structures operate through *thematic working groups*, in accordance with the issues analysed, as well as through *plenary meetings*, in a format which ensures a balanced representation of the central and local public administration, and public and private partners.

Moreover, in Romania took place an ample partnership process for the development of the programming documents for the period 2007-2013, respectively the seven operational programmes (regional development, transport, environment, competitiveness, territorial cooperation, strengthening the administrative capacity and technical assistance).

Taking into consideration that the Regional Operational Programme has been elaborated for solving the regional development problems, numerous consultative meetings with the regional partners took place so as to obtain a consensus in the fields of intervention that will be financed. Furthermore, at the regional level, due to the permanent exchange of information, a process for creation of communication and information networks has been developed between the partners involved. The next stage of the Regional Operational Programme, respectively the implementation one, will determine the created network to react through an active involvement in this process.

Considering the administrative structure and the Romanian legal framework, the public – private partnership may have as potential advantages:

- externalising the public administration activities that may be better carried on through private sector (concession, sale);
- the costs and risks distribution between public and private sector;
- community business involvement in projects of community interest;
- financial transparency during project implementation.

The risks that might appear during the partnership must be considered as well, respectively: the danger of partnership dissolving in a project implementation advanced stage, the doubtful legal status of ownership, the lack of transparency among the partners.

The partnership remains the main principle for the management and evaluation of the Structural Funds, providing added value, especially where the roles and responsibilities of the participants are clearly defined. In several cases it has led to the creation of a new institutional framework based on a series of cooperative networks or relations with various social and economic partners. In most cases it has enhanced institutional networking and cooperation between national and regional authorities. (EC, 2006)

## Conclusions

An organisational model such as territorial network is capable to promote the development and the continuous change of the available knowledge within an individual local production system by achieving a synergy between the internal resources of the local firms and the external resources of other regions and countries. Thus, it can be considered that the territorial network model encourages the connection between the organisation of the firms' economic relations and the regional territorial organisation, characterised by complex connections between industrial areas, urban centers, metropolitan quarters. Within the territorial network the institutional dimension of the local economic development process is very important. The increase of economies decentralisation and complexity determines the involvement of public institutions or of new collective organisations. Thus, the role of local and regional institutions is a catalyst one, integrator for promoting new solutions based on resource complementarity, stimulating local actors in project elaboration, proposals of strategic programmes and offering technical assistance for their implementation (Cappellin, 2002).



Traditionally, through the regional policy is granted financial support for the firms in the less developed regions, in order to reduce the regional disparities. Even in these conditions, the regional policy must be implemented by taking into consideration the competitive advantages and by using various instruments. Thus, through the promoted measures can be created service centers for small and medium enterprises, incubators for new innovative enterprises, technological parks, can be developed relations among firms and research institutes. At the same time the promotion of collaboration among developed regions and the less developed ones is highly recommended. Moreover, the regional policy must not promote only the cohesion and territorial integration of the regions but has to encourage and set-up networks within firms or strategic alliances at interregional level as well. For the regions confronted with economic decline the attraction of new investments is not sufficient, the creation of economic partnerships or collaboration between firms being also necessary.

The economic regional development must not consider only the promotion of "regional champions", respectively those sectors with high competitiveness, but also the encouragement of the local development by establishing local agreements, service centres or development agencies. By this approach is encouraged the development of the partnership between small and medium firms, as well as a better integration of firms, territories and intermediary institutions.

Thus, the recent approach of the territorial networks in the field of regional policy reflects the necessity of adopting a systemic approach at regional level, by creating some territorial branches in specialised areas, supporting the sectoral integration at local level, diversification and production reconversion. Therefore, it becomes obviously that the general development of a region is not a sum of local economic systems development, but is the result of their integration at the regional level. This approach needs investments for consolidating the partnerships between different actors at regional level. Moreover, the territorial networks need the correlation of the local development with the integration on interregional markets (Cappellin, 2002).

## References

1. Cappellin, R. **The governance of regional networks in the process of European integration**, *The CD-ROM Collection of Papers of the 41<sup>st</sup> Congress of European Regional Science Association*, Zagreb, 2000
2. Cappellin, R. **Regional industry policy and the new economy**, in Atalik, G., and Fischer, M. (eds), "Regional Development Reconsidered", Springer Verlag, 2002
3. Cappellin, R. **Federalism and the network paradigm: guidelines for a new approach in national regional policy**, in "Regional Governance and Economic Development", Edward Elgar, London, 1997
4. Constantin, D. L. **SMEs, Territorial Development and Networking: the case of Romania**, *The CD-ROM Collection of Papers of the 42<sup>nd</sup> Congress of the European Regional Association*, Dortmund, 2002
5. Danish Technological Institute, **Thematic Evaluation of the Structural Funds - Contributions to the Lisbon Strategy**, Copenhagen, 2005
6. European Commission, **Council Regulation no. 1083/2006, laying down general provisions on the European Regional Development Fund, the European Social Fund and the Cohesion Fund**

7. European Commission, **Territorial State and Perspectives of the EU Document – Towards a Stronger European Territorial Cohesion in the Light of the Lisbon and Gothenburg Ambitions**, Bruxelles, 2006
8. European Commission, **The Growth and Jobs Strategy and the Reform of European cohesion policy. Forth Progress Report on Cohesion**, Bruxelles, 2006
9. European Commission, **Territorial Agenda of the European Union – Towards a More Competitive and Sustainable Europe of Diverse Regions**, Informal Ministerial meeting on urban development and territorial cohesion, Leipzig, 2007
10. European Economic and Social Committee, **Partnership for implementing the structural funds**, Bruxelles, 2003
11. Fischer, M. **The new economy and networking**, in Fischer, M. (ed.) „Innovation, networks and knowledge spillovers”, Springer Verlag, Berlin, 2006
12. Government of Romania, **The Government Decision no. 1323/2002, regarding the elaboration in partnership of the National Development Plan**
13. London Tavistock Institute, **Thematic evaluation of the partnership principle**, London, 1999
14. Maillat, D. **SMEs, innovation and territorial development**, in Cappellin, R., and Nijkamp, P. (eds), “The Spatial Context of Technological Development”, Avebury, 1990
15. Sprenger, R. U. **Inter-firm Networks and Regional Networks**, NSS *ADAPT*, Bonn, 2001

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