Projects Complexity Evaluation

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Abstract: *Projects complexity is the universal measuring unit for all the projects. Complexity represents a characteristic that is common to all the projects. Projects are differentiated through the complexity degree. Some projects are simple others are complex. The objective of this paper is to offer measuring models of the projects complexity, in order to see in reality how complex a project is, comparing to another.*
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1 Introduction

Management means people, material resources and processes, means decision and especially the evaluation of every stage with a view to corrections.
The accumulated experience is not sufficient. It is accentuated by the new knowledge that science offers through the using of new concepts, new algorithms and especially through step by step selecting of the paths that lead to superior results.
Management extends over the production, over the quality and now newer, over projects conceiving and, respectively, over projects implementing in the terms of the risks manipulation.
It takes place a development onto a new plan, where everything is seen through the efficiency viewpoint, having in view the costs framing between acceptable limits.
Projects are elaborated with people, hardware and finally for transposing into practice are necessary important resources. A project management guarantees its achievement. Firstly the differences between the projects are given through the costs differences. In order to see the costs level realism of a project it is required the performing of a systematic study of the correlation between complexity and costs. Complexity evaluation will create an exactly enough imagine over the cost level a project in normal terms must have.
In order to evaluate the complexity there are identified a concept series from among resources diversity, appearance frequencies, activities types, risk degrees, are only a few. A special role grants to studying the projects carry out.
Software complexity is the starting element in the projects complexity study, since there are numerous similitudes between software and projects.
This paper presents models and makes a comparative analysis as well as an evaluating series for projects whose management is ended.

2. Complexity – quality attribute

Products and services are differentiating one from each other through form, functionality, performance level, components, assembling and using conditions, origin, acquisition price, given guarantees, and asked environment conditions
There are products and services addressed to the same aim made by distinct firms on the market. Differences between the products or the services having the same destinations are registered at the technical, economic and social characteristics, the only element which isn't different being the performed function. The systematically approach issue of the services and products complexity is old.
A product is considered simple if it consists of a part, and the part is the result of simple processing. A simple processing needs an item of equipment and an operation.
Operation is considered simple if it supposes the existence of a single type of linear motion, or circular motion.
The products and services complexity-based differentiation is important for the

identification of the resources necessary which drive to complexity growing, for stimulating people who realizes complex products. It is acceptable for a complex product to be more expensive than a simple product. More, it is acceptable for a more complex product to realize more functions or new functions instead of a reduced complexity product.

In the price structure interfere both the technical-functional and the socio-economic aspects. The demand/supply ratio is essential. As complex a product is, as many functions it realizes, is affected in the economic plan if the supply overrun the demand.

Services and products complexity lie at the basis of setting up the cost estimation models. There is a strong link between a product or service complexity and the direct consumptions. The more complex a product or service is, the bigger raw materials, processing and assembling operations diversity is.

In order to assure some processes comparability is necessary to introduce in the evaluation models some resulting variables, as the complexity coefficients.

Both a project and its management are a product, have a cost. Project cost estimation issue is extremely difficult because every project is characterized through a very high innovation degree.

Project management supposes creating optimal conditions for transposing into practice all the elements that are described in the project, by assuring the effective detailing in the conditions of the risk management between acceptable limits. Project carry on includes deviations that depend on many elements, from which the complexity is the most important.

Such all the characteristics and quality attributes, complexity must be measured. It is necessary to define indicators that allow primary data gathering and then performing the aggregation in order to obtain an image over complexity and especially to assure the possibility of comparing the obtained values.

Passing from assigning simple or complex ratings to identifying some differentiation levels (very complex, complex, less complex, simple, very simple) represents quality estimation modalities. Complexity indicators are numerous, within all the cases being necessary definitions of the work hypotheses.

If a product or a service needs resources consumptions, the complexity (C) is defined by the relation:

$$C = 1 - \frac{1}{n}$$

where n is the resources types number.

For instance, for the A product are necessary five resources types, and for the B product are necessary 10 different types of resources. The two products complexities are:

$$C_A = 1 - \frac{1}{5} = 0{,}8$$

$$C_B = 1 - \frac{1}{10} = 0{,}9$$

This means that the B product is more complex than the A product.

The issue of diversity element types aggregation which form a product or the issue of diversity service specific operations types aggregation, is in estimating expressions like:

$$C = 1 - \prod_{i=1}^{n} \frac{n}{f_i}$$

where:

n – number of types that give the elements diversity that interact for a product;

f_i - frequency with which the I type elements appearances are registered

For the P product realization are necessary f_1 distinct raw materials, f_2 equipment, f_3 operations and f_4 workers. The types number, n is 4.

It results through the aggregation

$$C_P = 1 - \frac{1}{f_1} \cdot \frac{1}{f_2} \cdot \frac{1}{f_3} \cdot \frac{1}{f_4}$$

For $f_1 = 5,\ f_2 = 3,\ f_3 = 8,\ f_4 = 4$ results: $C_P = 1 - \frac{4}{480} = 1 - \frac{1}{120} = 0.9916$

This project looking data aggregation indicator doesn't take into account the interdependencies between activities.

Every project has project associated a graph in which the nodes are represented through activities, and the arcs define precedence or successions.

If a G graph contains N nodes and V arcs, the cyclomatic number associated with the graph, n_G is given by the relation:

$$n_G = V - N + 2$$

If in the D project, for performing the repairing of a chemical installation are necessary 6000 (N) activities and the restrictions looking the execution order are materializing through 8000 arcs (V), than the cyclomatic number associated to the D project is:

$$n_G = 8000 - 6000 + 2 = 2002$$

In a more comprehensive context, the issue of the projects complexity modeling takes into account the necessity of establishing the n_s steps number, N_m number of the management team members, N_a the activities number, N_r the resources types number, N_a the number of activities characterized by risk which exceeds a given a limit, N_f the number of financing portions, N_e the number of evaluation points.

For the C complexity it is realized a nonlinear aggregation model like:

$$C = N_s \log_2 N_s + N_m \log_2 N_a + N_r \log_2 N_r + N_a \log_2 N_a + N_f \log_2 N_f + N_e \log_2 N_e$$

If it is noticed

$S = N_s + N_m + N_a + N_r + N_a + N_f + N_e$,

possible because all the dimensions show the number of types (types appearance frequency), the complexity standardized indicator is:

$$\overline{C} = \frac{C}{S \log_2 S}$$

If for the T project are given:

- the number of steps, $N_s = 16$
- the number of management team members, $N_m = 4$
- the number of activities, $N_a = 8$
- the number of cubic activities, $N_a = 8$
- the number of evaluation points, $N_e = 4$

the complexity is:

$$C_T = 16\log_2 2^4 + 4\log_2 2^2 + 32\log_2 2^5 + 8\log_2 2^3 + 8\log_2 2^3 + 4\log_2 2^2 =$$
$$16 \cdot 4 + 4 \cdot 2 + 32 \cdot 5 + 8 \cdot 3 + 8 \cdot 3 + 4 \cdot 2 = 64 + 8 + 160 + 24 + 24 + 8 = 144$$

and the $\overline{C}$ project complexity will be:

$$C_T = \frac{144}{72 \cdot \log_2 72} = \frac{2}{3 + 2\log_2 3}$$

The complexity of the projects that are drawing up represents a differentiating indicator of the projects.

3. Projects Complexity Influencing Factors

Projects complexity differs depending on many factors. The systematical analysis of the project components allows factors identification and differentiation.

Project management, as a new profession, brings structural and compartmental changes for all the objectives to realize. Changing the conception concerning the start moment, and, respectively, the final moment for realizing a product, a service, the trend for removing activities come back to execution, resources consumption control, are only some of the elements that determine the project complexity, when there are expected high levels of performance. In one-way it is conceived a process with no defects for products and in an-

other, when the number of defects is between the normal limits.

The specialist types diversity, but also their scattering in the project gives project complexity. In one way is approached a project that contains homogeneous grouped activities and differently is managed the project within adjacent activities are always heterogeneous.

Influencing factors of the project complexity are grouped in the following categories:

- structural factors that depend on the project elaboration field and the analyzed objective size;
- factors that concern all the elements behavior that interact in the processes development within the project
- dynamic factors, whose presence is felt both in the project elaboration period and on the project implementation length.

The project management is possible when the volume of information which is moving in a large-enough system and when all the economic agents activities are based on pieces of information.

It is important to recognize every type of influence factor of the project complexity because the complexity evaluation models including will be made taking into account every one importance.

Knowing the influencing factors allows identification of the ways that they lead to increasing or decreasing the complexity of the product, the services or the project.

Establishing connections between these factors makes measuring the effects that increasing or decreasing interactions determine possible.

There are taken into consideration factors A and B with initial values a, and b. Increasing is marked by a "+" sign and decreasing by a "-" sign. For a certain level of the complexity that depends on these two factors there are:

$C_{++} = f(a_+, b_+)$, $C_{+} = f(a_+, b-)$, $C_{+0} = f(a_+, b)$

$C_{0+} = f(a, b_+)$, $C_{-0} = f(a_-, b)$, $C_{0-} = f(a_+, b)$

The systematic analysis of these factors is oriented on:

- Comparing the base level for the complexities with modified levels C_{++}, C_{--}, C_{+-}, C_{-+}, C_{0+}, C_{+0}, C_{+0}, C_{-0}, C_{0-};
- Establishing whether the result of the compare is or is not stable.

The sequence of modifications +++…+ has m consecutive criteria corresponding to it. Establishing the relation that is considered active refers to the situation

$$C_{(+)m-1}(+)_{m-1} < C_{(+)m}(+)_m.$$

The more detailed analyses of the relation between the modification of the factors is oriented on the situations $C_{(+)m-k}(+)_{m-i} < C_{(+)m}(+)_m$ with taken into account of all the other types of modifications.

This study proves his utility when there are taken in consideration problems regarding to costs. This is because increasing complexity of a project imposes more expenses that have to be covered with important amounts of money.

The core of this study refers to concentrating information about the projects, the ways to elaborate and implement them. Usually a project manager uses his own experience to organize better projects next time. The records that he makes are not systematic and have a personal character.

If there are recorded in the account system operating documents than there are created the bases for the analyses of the structure and of the evolving of the project.

To accomplish this there is need for specialized software development. This software should also include modules dedicated to evaluating the complexity of projects and creating a database with all the values of the indicators used to express the complexity of these projects and as sell the total costs of these projects. An efficient analysis is possible only when there is available such a database.

4. Using the Complexity Coefficients

There are considered the projects P1, P2, P3, …, Pn.

Revealing of the productivity of the workers that are doing activities characterized through codification, effort, time, and vol-

ume of products or services imposes the shipping to the relation:

$$W = \frac{1}{A} \frac{\sum_{i=1}^{n} V_i}{\sum_{J=1}^{m} M_j}$$

where:

m – number of the types of classifications of the workers

M_j – number of workers in the group j of competitiveness

n – number of products

V_i – the value of the products made during the interval of time considered

A – the number of hours that the time interval has

$$W^1 = \frac{1}{A} \frac{\sum_{i=1}^{n} k_i V_i}{\sum_{j=1}^{m} M_j}$$

where K_i represents the complexity coefficients that are bigger with the complexity of product P_i getting bigger. All of these coefficients obey the rule $K_i = 1$.

The product that is considered to be less complex has a coefficient of 1. All the others are obtained using this formula:

$$k_i = \frac{C_i}{\min\{C_i\}}$$

$$1 = i = n$$

where C_i represents the complexity of the product P_i estimated using a specific model. It is important that all these estimations to use the same coefficients of complexity.

There are considered resources R_1, R_2,…, R_m

If there are developing costs estimation models for products with different degrees of complexity, the procedure follows in steps.

First, it is made the resources types estimation and there are estimated the consumptions levels.

NRE variable represents the estimated number of the resources types, and V_{ej} represents the estimated level of the R_j resource, having the K_{ej} estimated cost.

It is resulting through a linear aggregation process the pure estimated cost given by the relation:

$$C_{pur} = \sum_{j=1}^{NRE} K_{ej} \cdot V_{ej}$$

Due to many factors that concur in a project performing, either supplementary consumption appear, either price fluctuations are registering, either due to gaps penalizations are paid.

All these are reflecting through a E multiplicity coefficient, E>1. C_{mod} modified cost of the project is obtained from

$$C_{\text{mod}} = E \cdot C_{pur}$$

If there are included the risk factors with multiple engaging effects, it is necessary the using of the R risk coefficient, also R>1.

C_{est} estimated cost model of the project is given by the relation

$$C_{est} = R \cdot C_{mod}$$

So the cost model of a project as basis for starting a negotiation, given by the relation:

$$C_{est} = R \cdot E \sum_{J=1}^{NRE} K_{ej} \cdot V_{ej}$$

includes both the elements strictly necessary to execution, and especially, the different natures perturbations which appear on the project carry over length. Project management has to maintain the effective cost of the project between acceptable limits (C_{ef}), mean that:

$$\Delta = \left| C_{ef} - C_{est} \right| < 0{,}1\, C_{est}$$

If projects are classified by type constituting homogeneous subsets (Hi Tech projects subset, services project subset, art fields oriented projects subset, industry reshaping projects subset, banking system reshaping) than it proceeds to models elaboration for the estimation of the project complexity based costs.

It is considered a homogeneous subset of the P_1, P_2, …P_s projects, where s represents the number of already executed projects.

For every project it is registered the triplet $< P_I, C_{esti}, C_i >$, i =1, 2,…s
Using the data series corresponding to the considered triplet, by means of the less squares method there are estimated a and b model coefficients:

$$CL_{est} = a\ C_i + b$$

For a new P_j project with an estimated C_j complexity it is obtained the estimated cost:

$$CL_{estj} = a\ C_j + b$$

In time it proceeds to the differences calculus.

$$\Delta_j = \left| \hat{C}L_{estj} - C_{efj} \right| \quad j = s+1, s+2,...2s$$

The model validation is possible if in parallel there are also made estimations for the projects $P_{s+1}, P_{s+2,} \ldots P_{2s}$

$$\Delta_j < \Delta_j \qquad j = s+1, s+2,...,2s$$

in at least 85% of the cases.
It will be concluded that the complexity based linear model offers a better estimation for the project cost, than the model that uses multiplicity coefficients.

5. Conclusions

The complexity estimation model identifies factors that induce the differences between set components.
When there are made measurements and is calculated the complexity, is created the context to see the size in which the used model is non-compensatory, sensitive or non-non-catastrophic. After establishing the variations limits of the exogenous variables in order to obtain acceptable levels of the model behavior in agree with these features, there are established the grow and decrease complexity paths against every project basis objective.
The project complexity study is extremely important in order to establish the measure in which the project manager plays or not an active role. More, through including the risk factors and their fluctuations towards the growth, allows the amplified effects establishing over the whole project, which is directly reflected both in the estimated cost, and in the project effective cost.
Complexity based models create the favorable prerequisites for the simulations making of the different situations. Step by step it will achieve convenient project structures, which harmonizes the interests of all that form the realization constituted consortium, but also the beneficiaries interests.

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