ASSESSMENT OF RESOURCE RELOCATION WITH CP AND CPK INDEXES: A SIX SIGMA CONTRIBUTION FOR SOFTWARE DEVELOPMENT PROCESS

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In software development, human effort is the measure of the process capacity. To understand the demand, relocation is the most used practice, which makes it one of the potential causes of process variability. For Six Sigma, to know a processs capacity is a pre-requirement for eliminating its variability and, for this, it suggests the employment of the Cp and Cpk capacity indexes. The first measures the capacity in meeting a specification, whereas the other also takes a certain goal into consideration. This work analyzes the results of using these indexes for directing the resource relocation and base the oportunity cost assessment used in the negotiations with client-users. The results showed more accuracy in the assessment of process capacity and in estimating the oportunity cost, minimizing risks and making the modifications made in their projects more visible to client-users.

Palavras-chaves: Capacity assessment, Cp and Cpk indexes, Six Sigma for software process, Effort measures

1. Introduction

Software client-users want developers to deliver products with high quality, rapidly – according to their urgency perception, at low price and, also, that developers provide them with the necessary support during the whole life cycle they use the software, notwithstanding what this may mean to the developer (CHRISSIS et al., 2006).

For software developers, the ideal situation would be to be able to always see to each of the projects according to the conditions proposed, which would mean the maximization of the financial return (ZUBROW and CHASTEK, 2003).

If they cannot have on the adequate capacity and availability, the organization developers cannot satisfactorily meet the demand, which at the extreme, prevents from attaining the expected level of profitability and negatively affects client-user's satisfaction; in case the amount of resources available is exaggerated, it causes idleness that will corrode profitability. The situation is aggravated the more projects compete for the same resources at the same time, which at least causes a delay for the one that loses the resource (CARD, 2002).

For intensively using interaction and an intellectual iteration between clients-users and developers, the basic resource for determining the development time and the cost is the effort applied by the developers (AMARAL et al., 2007).

One of the techniques recommended by Six Sigma is the use of Cp and Cpk capacity indices. They express the process capacity in producing adequate results. While the Cp index measures the total extent or potential of the process, based only on data obtained from the process (developer's view), the Cpk index makes the same assessment also taking into consideration a certain goal proposed faced with the average (expectation) of the process (client-user's view) (PARCHAMI and MASHINCHI, 2010).

These indices, named **c**onventional process capability indices, have been used widely and successfully in most of today's manufacturing sectors. These process capability indices, however, can only measure the process consequence resulting from various combinations of process mean and process variance on site by measuring the output without concern as to cost (JEANG and CHUNG, 2009).

Some design constraints are the restrictions resulting from the process capability limits, the feasible process range, and the functionality requirements (PARCHAMI and MASHINCHI, 2010).

This work analyzes the results of a practical experience in the use of these indexes for assessing the development teams' effort in some projects in an ERP software developer organization, in which resources relocation is a vital condition for businesses. Capability indices employment has allowed identifying the causes of effort variation and directed the opportunity cost assessment of the resources relocation among the projects.

An example about effort relocation is introduced to demonstrate the applicability of the presented approach so that the optimal mean and tolerance values can be determined using Cp and Cpk indices. Besides contributing to the improvement of the financial results of these projects, the commercial relations with client-users that benefited from the acceleration of their projects turned more transparent, which contributed to increasing client-users' reliability in the developer organization management. For secrecy reasons, only samples of some projects are presented.

2. Software Production

Software production is, at the same time, an artcraft activity, which depends on human creativity, and an industrial activity, liable of organization. The software development phases are: conception, conceptual design, construction, tests and implementation, which present scope, competencies, works, participation, intermediary products and specific efforts (ZUBROW and CHASTEK, 2003).

In the initial (conception) and final (implementation) phases, it is necessary for the client-user to participate more than in the intermediary phases, since this is when the client-user explicits its requirements and starts using the software in its work routines, respectively. In these phases, any estimation is subjected to higher variation, because the developer is not responsible for control the work or the client-user availability. In the intermediary phases (conceptual design, construction and tests), practically only the developers participate; the estimations thus tend to be more stable and standardized, offering better control opportunity (FLORAC and CARLETON, 1999; BIEHL, 2004; FAN *et al.*, 2009).

Owing to the fact of intensively using interaction and intellectual iteration between clients-users and developers, the estimation base of this activity is the amount of employed time of human resources. The effort is the measure of process capacity to meet the projects demands. As the effort effectively employed for conducting an activity is only known after it really ends, it is necessary to make an estimation that is used to remunerate resources, including the Return-of-Investment (ROI) (MISTRIK *et al.*, 2010).

The determination of a standard time is a statistical shortcut that can be obtained by a combination (α) between the history recorded by the organization in similar projects and by the goals to be attained, both at the organization level and for the project itself, the business scale economies (optimistic time), variability and uncertainty (pessimistic time) (DINSMORE and COOKE-DAVIES, 2006).

The effort is liable of variation for a number of causes, such as: technological evolution, requirements instability, project complexity, developers proficiency, work procedures effectively conducted, workload instability, resources relocation (volume and frequency) from one project to the other, partial delivery of the software functionalities, among others. These causes call for adjustments and refining of the effort calculated, both as a whole and for each development phase (KAN, 2002) (ZUBROW and CHASTEK, 2003).

The effort assessment undergoes an adjustment that takes into account the expectation of the best (optimistic time – OT), the worst (pessimistic time – PT) situation and the history (HI), as shown by the following formulation (DINSMORE and COOKE-DAVIES, 2006):

$$\text{Execution time} = \frac{OT + PT + 4 \times HI}{6}$$

In general, the optimistic time (OT) is smaller than the historical time (HI) and and this is smaller than the pessimistic time (PT). The closer it is to the pessimistic time of the negotiation with the client-user, the greater will be the margin of negotiation and the possibility of accelerating project, and the smaller the negative impact caused on project, in case a resource is lost (DINSMORE and COOKE-DAVIES, 2006).

The deadline foreseen is the ratio between the effort foreseen and the amount of resources allocated in executing the project. The linear ratio between the variables is merely a conceptual simplification, since, not necessarily, by alter the numerator or denominator, the ratio is not proportionally altered. The estimations must be founded on facts and on the history of the organization that denote its capacity in meeting them, honoring the commercial conditions negotiated and guaranteeing the expected return. The development process attributes must be fully measurable or, when merely noticed, possible of being expressed in numbers and in monetary value (CARD, 2002; MISTRIK *et al.*, 2010)

3. Process capacity assessment

Any process presents some sort of variation, the causes of which may be divided into two groups: common or special. Special causes generate variations that affect the process behavior in an unpredictable way, generating results off the control boundaries and producing results totally discrepant concerning the other values (SARGUT and DEMIRORS, 2006).

A process is under control (or statistically stable or foreseeable) when only common causes produce the variability. They affect all the individual values of the process and can only be reduced or eliminated by changes or improvements in the process. The normal operation of a process is defined in terms of the average (μ) and of the standard deviation (σ), within the ($\mu - 3\sigma$) bandwidth up to ($\mu + 3\sigma$). These points are considered the natural boundaries of any process, or more precisely, control boundaries (respectively, lowest: low control limit - LCL and highest: upper control limit - UCL) (SARGUT and DEMIRORS, 2006; RAMOS, 1995).

A process is capable if the variation is between the specification boundaries (lowest: LIE and highest: LSE) imposed by the client-users and by the management; in case it is not within these boundaries, the process is said to be incapable of meeting the requirements. The narrower the dimension (difference between the highest and lowest specification boundary, defined by the lowest and highest points, respectively, low specification limit – LSL and upper specification limit - USL), the better the process, as it presents smaller variation (HARRY, 1998).

If the upper and lower specification limits (SLs) of a process are imprecise the ordinary capability indices are not appropriate for measuring its capability. The capacity assessment can be made for variables presenting a continuous behavior (such as time) or discrete (such as the number of flaws). In the case of continuous data, among other indices, the capacity study can be conducted by means of assessing indices: Cp and Cpk indices (oriented to the true capacity assessment) (GOH *et al.*, 1998) (MONTGOMERY, 2004).

When monitoring a process via a quality control charts, it is often useful to compute the capability indices for the process. Specifically, when the data set consists of multiple samples, such as data collected for the quality control chart, then one can compute two different indices of variability in the data. One is the regular standard deviation for all observations, ignoring the fact that the data consist of multiple samples; the other is to estimate the process's inherent variation from the within-sample variability. Note however, that this estimator is only valid if the process is statistically stable (SARGUT and DEMIRORS, 2006).When the total process variability is used in the standard capability computations, the resulting indices are usually referred to as process performance indices (as they describe the actual performance of the process), while indices computed from the inherent variation (within- sample sigma) are referred to as capability indices (since they describe the inherent capability of the process) (PARCHAMI and MASHINCHI, 2010).

The need to remain competitive in order to survive in current world market has led the enterprises to consider how to minimize costs while maximizing quality. The process capability index (as Cp and Cpk indices) is a value which reflects quality status, thus enabling process controllers to acquire a better grasp of the quality of their on-site processes. They may be used for measuring their ability to carry out tasks our achieve production-related goals. In process capability analysis, the deviation between process mean and desing target can be reduced by having the process mean close to the design target without extra production costs being incurred (JEANG and CHUNG, 2009).

Every process has some variation and this can only be found through analysis of data collected during the operation (LIUKKONEN and TUOMINEN, 2003). The performance variation of any process affects the execution time, the costs and labor process as a whole, product quality and ultimately customer satisfaction (RAMOS, 1995). The variations can be attributed to any one of the elements the production process: inputs, process or management. The appeals may be caused by incorrect specification of raw materials, operation error, wear of machines and tools; is related to the production process, the cause can be attributed to working or incorrect, then, when related to management , the causes may be due to differences in planning or failure in the allocation of resources, among others (LOWRY et al., 1995).

Whereas the distribution of the results of a process is normal, changes can only be explained by causes or special or normal causes (RAMOS, 1995). Special causes are caused by uncontrollable events, produce results that are totally disparate, do not allow to establish a pattern or probability distribution and create instability in the process (MONTGOMERY, 2004). The normal distribution is a continuous probability distribution that often gives a a good description of data that cluster around the mean and describe any variable that tends to cluster around the mean. The graph of the associated probability densdty function is bell-shaped, with a peak at the mean (LIUKKONEN and TUOMINEN, 2003).

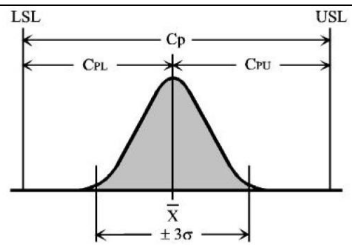
Six Sigma is a structured methodology that improves quality by the continuous perfection of production processes either of an asset or of a service, by optimizing operations, by systemically eliminating flaws, taking into consideration all the important business aspects that that should differentiate the company for their client-users (MARASH, 2000; CAKMAKCI, 2009).

3.1. Cp capacity index

This index corresponds to the ratio between the tolerance of the engineering specification or the client-user's (USL - LSL) and the total extent (total dispersion) of the natural boundaries of the process (UCL – LCL), measuring the potential capacity of the process (developer's point of view). It is not sensitive to data displacements (special causes) (Harry, 1998). The algebraic and graphic representations of this index are shown at picture 1.

PICTURE 1 – ALGEBRAIC REPRESENTATION OF Cp AND Cpk INDICES AND ITS GRAPHICAL REPRESENTATION

Cp index	Cpk index	Normal distribution

$Cp = \dfrac{USL - LSL}{UCL - LCL} = \dfrac{USL - LSL}{6\sigma}$	$Cpk = \min\left(\dfrac{\mu - LSL}{3\,\sigma} ; \dfrac{USL - \mu}{3\,\sigma} \right)$	

where:

– σ is the process standard deviation,
– UCL is the highest control limit,
– LCL is the lowest control limit,
– USL is the highest specification limit and,
– LSL is the lowest specification limit.

The Cp values are interpreted as follows:

– If $Cp < 1$, then the process is incapable;
– If $1 < Cp < 1.33$, then the process has an average capacity;
– If $Cp > 1.33$, then the process has high capacity.

The higher the Cp index value, the greater the probability that the process abides by specifications.

3.2. Cpk capacity index

The Cpk index considers the process average value and specification limits, which allows it to be interpreted as a measure of the real capacity of the process. This is an adjustment made to correct statistical distortions, which allows assessing the consistency of the process around its average. Once the process is stable, the assessment of this index does not consider the control limits. The Cpk is defined as the smallest value between Cpi and Cps, which are the Cp index calculated in relation to the lowest and highest specification limits, respectively (HARRY, 1998). The algebraic notation for Cpk is shown at PICTURE 1.

When a process in centered in the average, the Cp and Cpk values are the same.

4. Cp and Cpk indices use

As seen above, the determination of the estimated time, as observed, is a statistical artifice that may be obtained by a combination between the historical average and the natural and random variations that influence the conduction of the process. For each activity, it is possible to establish three amounts of time, representing the boundary situations: best situation expected (optimistic time), worst situation expected (pessimistic time) and situation expected.

As the Cp and Cpk indices represent process capacity in producing values within certain boundaries, they may be used to explain (control limits) and adjust (specification limits) the relation between values of a certain variable that specify operation boundaries (PARCHAMI and MASHINCHI, 2010).

If this concept is applied to the time variable, it is possible to advocate that, the more capable the process (stable and efficient), the smaller the difference between optimistic and pessimistic time (or between optimistic time and normal time, or between normal time and pessimistic time) must be. Likewise, the inverse is also admissible, that is, the more incapable the process (unstable or inefficient), the greater the difference between the optimistic and pessimistic times must be (adapted from Card, 2002).

The index Cp is ripe to evaluate the data variation of a process. The closer the distribution curve, the smaller the variation and the higher the index value indicating Cp process capability in relation to meeting of what was specified. Therefore, the higher the value of Cp is the best process behavior (JALOTE and SAXENA, 2002; SPIRING, 2010).

FIGURE 2a
UNCAPABLE PROCESS

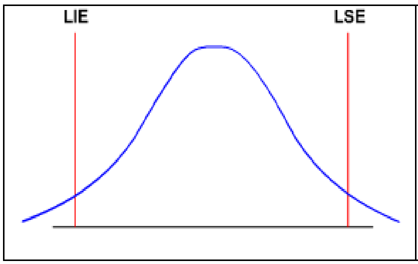


FIGURE 2b
SATISFACTORY PROCESS

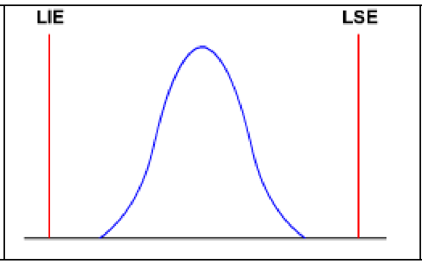
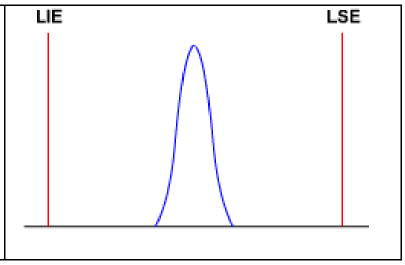


FIGURE 2c
CAPABLE PROCESS



The Figures 2a, 2b and 2c show three different behavior of the data variation of a process in relation to specification limits. A process becomes much more capable the smaller the variation.

The Cpk index is to analyze data concentration around the average. The farther away the value concentration in relation to the process mean, the more the process is incapable; it is showing at picture 3a, 3b and 3c (JALOTE and SAXENA, 2002; SPIRING, 2010).

FIGURE 3a
UNCAPABLE PROCESS

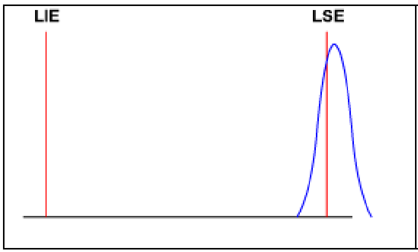


FIGURE 3b
SATISFACTORY PROCESS

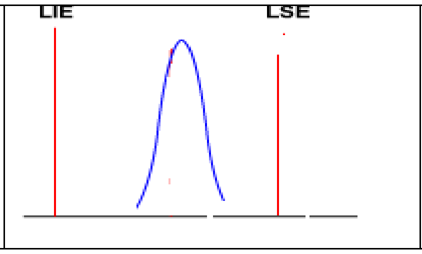
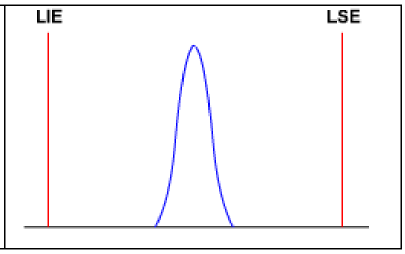


FIGURE 3c
CAPABLE PROCESS



Organizations must stop using the “goalpost” approach and instead use a procurement process that defines quality requirements in terms of the distribution about the target value. This idea may be understand in terms of the loss function. The loss function essentially says that the further a product or a service is from the target value, the greater the quality problems encountered by customers. This is where the process capability index, or Cp comes in to play. It is a measure of a process’s ability to meet a specification or it is a measure of a group of items’nearness to the target value (RUFFNER, 1996).

5. Opportunity cost

The opportunity cost is defined as the cost representing the sacrifice of choosing one alternative instead of another one or, rather, it is the value of the benefit one fails to gain for choosing one alternative instead of another one. This always occur in an exchange, loss, gain and substitution of resources in an activity (INNIS and LALONDE, 1994).

In any resource relocation between projects, one of them is favored, as it gets the resource, whereas the other is penalized, as it loses the resource and the benefit provided fails to occur, necessarily, in the same proportion. In this case, the main components of opportunity cost are (HOSSEINIFARD et al.,2009) (TARHAN and DEMIRORS, 2006):

– In the project that gets the resource: the project affords the cost of the resources transferred to it and also the cost concerning the accommodation of the new resources, the redistribution of work and the activity management; the benefit is manifested in the difference between the deadline formerly stipulated and the one effectively executed;

– In the project that loses the resource: the project affords the cost deriving from the delay caused, the cost concerning the accommodation of the remaining resources (increase in productivity), the redistribution of work and the activity management; the benefit provided is the parcel of cost of the resources transferred to the other project.

Pratical experience

The case analyzed refers to a software developer organization, with expressive presence in the Brazilian market, classified among the ten largest makers of ERP systems and software for industrial automation. At present, every year an average of 200 projects of different scopes, complexity and effort are executed. The company was established due to a division in the business of an industrial group, of which it was the area of computational systems development and of embedded software for some industrial automation products. The partners in the company are ex-managers of the former IT area of the industrial group and, for this reason, its formation is highly impregnated with industrial managements concepts and deep taylorist view.

The great challenge is to meet the client-users' demands, competing with companies counting on expressive investment in Information Technology and in quality and maturity models. Internally, the great difficulty is to conciliate process stability with client-users' goals in terms of urgency, flexibility and service rendering, not always well defined and structured. Umtil it understood and systematized the developer-client-user relationship, the organization suffered some drawbacks, but this made it seek techniques and procedures that were adequate to its needs. One of the critical survival factors of the company is the constant relocation of developers from one project to another so as to manage to meet the engagements made. Formerly, both the specialties relocated and the amount of time involved were empirically decided upon, according to the pressure exerted by the client-user, who felt harmed, and threatened to give up the services rendered by the organization.

Among a series of strategies adopted, one was to make the managerial and directive boards aware of the need to use, in a corporative, gradual and extensive way, practices and techniques recommended by the Six Sigma methodology for solving problems such as the improvement of software processes.

This article analyzes the results of the Cp and Cpk indices as a support to the assessment of the development teams' effort, subject to variations due to constant relocation. The use of the capacity indices was promptly directed to the survey of values that were more consonant with the opportunity cost of resources relocation and, with this, count on more negotiation elements with the client-users. In the long term, the aim was to change the client-users' perception of its image, transmitting a high level of credibility in the estimations produced, based on historical data, which had been brought forward for quite some time.

When the use of these capacity indices were adopted, the following premises were determined:

- control limits = the lowest and the highest values recorded in the surveys,
- optimistic time (lowest specification limit) = historical time of the team ÷ 1.05 (that is, a 5 % goal);
- pessimistic time (highest specification limit) = historical time of the team x 1.33 (that is, 33% coverage);
- negotiation with the client-users in the bandwidth between the pessimistic and the historical time.

In the initial situation, the projects presented high data dispersion, which contributed for the organization to invest in the search for the main causes. Furthermore, several managers misunderstood the meaning of the Cp and Cpk capacity indices; instead of the correct capacity concept to meet an estimation, they understood the value of the result as the amount of effort necessary for a process. The main causes for the variability in processes were:

- very long waiting time between phases;
- rework for not having understood requirements;
- development process defined for each case in function of delay and pressure;
- systematic delay in delivery;
- lack of homologation of tests, generating rework after delivery.

Table 1 presents part of the data concerning the effort employed, collected from four fundamental processes in software development. The time unit adopted is the same for all the projects.

The fundamental processes of software development chosen were: requirements definition, design elaboration, software construction and implementation to the client-user.

The “before” column refers to the initial situation, when decisions were taken in the traditional fashion and the “after” column shows the values of the projects, the decisions of which were statistically supported; some causes of variability had already been dealt with and over 500 projects had already been executed. In each line, the projects “before” and “after” are similar in terms of scope, complexity, environment and effort foreseen.

TABLE 1 – TIME DATA BASE OF ACTIVITIES IN TEN PROJECTS

Activities	**Before**				**After**			
	Process1	**Process2**	**Process3**	**Process4**	**Process1**	**Process2**	**Process3**	**Process4**
Project 1	0,34	1,72	3,56	1,27	1,01	1,68	2,36	1,68
Project 2	0,36	1,83	3,78	1,35	1,13	1,89	2,64	1,89
:	:	:	:	:				
Project 10	0,61	3,11	6,43	2,29	1,86	3,10	4,34	3,10
UCL	0,83	3,93	9,02	3,27	2,21	3,56	4,89	3,1
USL	0,82	3,54	6,50	2,27	2,20	3,30	4,53	2,87
μ	0,44	2,22	4,59	1,64	1,17	2,15	3,20	2,08
LSL	0,20	0,92	3,96	0,14	1,14	1,47	3,09	2,07
LCL	0,05	0,51	0,17	0,01	0,14	0,73	1,51	1,06
σ	0,4091	0,5518	1,1421	0,4074	0,1723	0,3500	0,3123	0,2345
Cp	1,07	0,79	0,37	0,87	2,01	1,35	1,8	1,44
Cpks	1,02	0,30	0,35	0,41	1,29	1,37	1,42	1,12
Cpki	0,73	0,79	0,09	0,96	1,01	1,34	1,34	0,86
Cpk	0,73	0,30	0,15	0,41	1,01	1,34	1,34	0,86

The indices´ values show that the data variability (σ) was reduced, there was significant increase in the nominal capacity in all four processes (Cp index), timid evolution of the processes capacity as compared to the goals (Cpk index).

The difference between the indices´ values in the different processes show that each specialty of software development reacts differently to capacity control stimuli.

The internal processes more feasible for the control and standardization actions presented the best improvement in nominal capacity as compared to the goals set, whereas the worst results still show problems in product implementation, when the client-user receives the product and can make a comparison between the service ordered and the one delivered.

The most important, however, was to verify that the estimations began to be confirmed in the projects, which caused an increase in client-users' reliability in relation to the maturity with which the company stipulated the estimations (the effect expected for the long term was realized in short and medium-term).

The organization started to more confidently calculate the opportunity cost, for all the situations in which a client-user proposes to accelerate a project and the resources now available are not enough to meet this demand. The two policies adopted were:

– to compensate the normal unavailability deriving from work (vacations, resting time, training and others), the company expanded its employee team so as to count on a rotating resources contingent to always guarantee an adequate availability of resources;

– so as to better know the resources available, the company started to calculate the Cp and Cpk indices for each of its specialized resources (individuals and/or teams) in the different processes, since every time it had to relocate resources, it always did it per type of process to be conducted. For this, it started to calculate the Cp index for each of its resources and established a weight for relocations, as shown at table 2.

TABLE 1 – TIME DATA BASE OF ACTIVITIES IN TEN PROJECTS (RESULTS)

Cp Index	Cp < 1,0	1,0 < Cp < 1,33	Cp > 1,33
Bandwidth class	A	B	C
Weight for relocation	10 %	0 %	5 %

– the company modified the procedures for conducting the processes, partitioning the activities to the most, to avoid overcharge of resources and bottlenecks;

– the company elaborated a new criterion for identifying the resources to be relocated:

– to identify, among all projects being executed, those in which the necessary processes for relocation are not delayed and the activities that are not part of the critical path;

– to give preference to the projects and processes selected with the highest Cp capacity index values, as the higher this index, the greatest the process capacity is for meeting the estimation;

– to systemically recalculate the Cpk capacity index and compare them with the Cp index. When both values fail to converge to the average, this indicates some irregularity and opportunity for improving the process;

– to ordinate the projects that are liable of "losing" resources per Cp capacity index bandwidth:

– to verify whether the activities may be passed on to the other resources, making the desired resource totally available; in case these resources are unavailable, to verify whether the time to be withdrawn is enough to meet the urgency. In case it is not, to share the delay between both projects.

The opportunity costs composition was adapted to represent costs per effort unit, as shown in Table 3.

TABLE 3 – OPPORTUNITY COST COMPOSITION

Cost type	Concept	Project	
		Loses	Gets
Resource Cost	Effort x unit cost		+
Delay cost	Resource Cost * % of Cp Index	+	
Accommodation of others resources	5 % over Resource Cost	+	+
Management	10 % over Resource Cost	+	+

To demonstrate the procedures, the following relocation case is presented:

"Project X needed 14 additional time units of a resource for a process. Based on the selection criteria, this resource was available in two other projects - Y (Cp index bandwidth = "C") and Z (Cp index bandwidth = "A"), The unit cost of the resource was $ 20".

Project Z, according to the criteria, was the best candidate for providing the resource. Considering the criteria adopted, the opportunity cost for this redistribution was $ 364, which corresponds to an addition of 30% over the resource cost, as shown in Table 4.

TABLE 4: ASSESSMENT OF THE OPPORTUNITY COST

Cost type	Project	
	Loses	Gets
Resource Cost		$ 20 x 14 = $ 280
Delay cost	$ 280 * 5 % = $ 14	
Assessment of others resources	$ 280 * 5 % = $ 14	$ 280 * 5 % = $ 14
Management	$ 280 * 10 % = $ 28	$ 280 * 5 % = $ 14
Total of each project	$ 56	$ 308
Main Total		$ 364

After some time, the client-users noticed the importance of making a more accurate planning of their needs and of the use of the developer resources, which also contributed to improve the quality of the products delivered. The client-users started to be stricter about requirements and about the products received.

Conclusions

As in the traditional industry, a single technique is not enough for solving the resources allocation or relocation problem in software development, which paves the way for resorting to different techniques to better explain the result. The purpose of the techniques, therefore, is to highlight the profits and losses of each of the alternatives in different ways.

Experience allows concluding that the use of these indices provides a better accuracy for assessing the process capacity of each of the activities conducted and for each of the individual resources, target of relocation.

Furthermore, it is reasonable to suppose that, for an organization to enjoy the benefits provided by Six Sigma, it must meet some basic premises, such as managerial availability and adequate budget for control activities, which, in a large number of small companies, may mean an increase in operational costs not supported by the project portfolio.

The importance of assessing the opportunity cost is related to the fact that it more faithfully expresses the cost-benefit relation of any modification that has to be made in a software development project, decisively contributing for improving products quality, combating resources wast, valuing professional work. It becomes a fair measure that may be used as an alternative currency in negotiations with client-users.

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