USING PROBABILISTIC FEATURE MODELS TO DETERMINE SUCCESS CRITERIA FOR ICT PROJECTS

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Abstract

Since the 1960's many authors accepted the triple constraints (time, cost, specification) as a standard measure of success and this still appears to be extremely important in evaluating the success of ICT projects. However, an ICT project cannot always be seen as a complete success or a complete failure. Moreover, the parties involved may perceive the terms "success" or "failure" differently.

The authors developed a quasi-experiment (gaming) in order to determine the criteria used by the different parties involved to judge the success of an ICT project. The results of this quasi experiment were analysed using probabilistic feature models for frequency data – PMD-models.

This research indicates that the impact of the triple constraints on the judgement of success is rather small. Other criteria, as there are user happiness and financial or commercial success are far more important. Furthermore, parties who's involvement ceases after the handover tend to concentrate more on budget and satisfying the parties involved, while the other parties concentrate more on time limits, predefined specifications and long-term financial or commercial success.

Keywords: ICT projects, success criteria, management, quasi experiment

1 INTRODUCTION

"To measure is to know" is a well-accepted credo amongst managers. This is not different for the ICT- and project management environment. In order to lead an ICT project towards high levels of success, a manager should know the criteria by which success is measured (i.e. success criteria). Fulfilling these criteria should be the manager's prime concern.

Since the 1960's many authors accepted the triple constraints (time, cost, specification) as standard success criteria. It is assumed that if a projects completion time exceeds its due date or expenses overrun the budget, or outcomes do not satisfy a company's predetermined specifications, the project is a failure (Ingram, 2000; Wright, 1997; Turner, 1993).

However, determining whether an ICT-project is a success or a failure is far more complex (Belassi & Tukel, 1996). Unlike a construction project, an ICT project cannot always be seen as completely successful or completely failed (Wateridge, 1998). Moreover, different parties involved (e.g. management, projectteam, users, supporter, stakeholders) might perceive the project's success differently (Pinto & Slevin, 1989). But even among individuals of the same party, opinions might vary, since every individual has his/her own set of criteria against which the project is measured and these may be very subjective (Fowler & Walsh, 1999). Furthermore, not every criterion can be measured at the same time. Some criteria can only be assessed long after the determination of the project, as for example the commercial success of a software package (Wateridge, 1996).

The aim of the research is to determine the set of success criteria used by the different parties involved in an ICT project. On the one hand, this information is used to check whether the triple constraints are appropriate criteria to evaluate ICT projects' success (i.e. does fulfilling the triple constraints automatically mean that the project is perceived as successful?). On the other hand, a better insight into success criteria should enable managers to improve their guidance of the project. Based on the results of the research, management guidelines are formulated.

2 LITERATURE REVIEW

As Fowler & Walsh (1999) state, the definition of the concept of ICT success is, in itself, potentially problematic. There is no consensus on the criteria for ICT project success, except for three standard criteria - meeting time, meeting budget and meeting requirements (Wateridge 1995, 1996).

Several authors suggested enhancing the triple constraints with additional criteria. Four groups can be distinguished. A first group of criteria used to extend the triple constraints are technical in nature (maintainability, computer operations function, technical performance etc). These criteria were important until a decade ago. The shift from supporting technology to enabler and the increasing impact of ICT provoked a shift from more technical to more management-oriented criteria (Ward et al, 1990; Hochstrasser & Griffiths, 1991; Willcocks, 1994).

A second group are criteria that are related with hypes (ex. meeting quality levels was a much-used criterion at the time when TQM became popular). This group of criteria clearly reflected a specific (IT)-management concern.

The third group incorporates the viewpoints of the parties involved, other than the project managers. The triple constraints are often perceived as being too short-term and too much reflecting the project managers' view (Turner 1993, Wateridge, 1998). Therefore, criteria like "sufficient benefits for the owner" and "satisfying user specifications" were perceived as additional success criteria.

A fourth group of criteria enters perceptions into the evaluation. The recognition that the **perceived** success is of paramount importance to the eventual success of ICT projects regardless the actual return

(Baker et al, 1993; Turner, 1993) lead to a set of criteria that contains items like "favourable attitudes towards the system on part of the users", "happy users & sponsor" (Lucas et al, 1990; Sanchez, 2002; Boddy, 2002; Wateridge, 1998)

Not every party involved in an ICT project uses all these criteria to judge success. The set of criteria is different for every party and often contains a combination of criteria from the different groups. Turner (1993) states that the *management* (owner / sponsor) is primarily interested in the benefits the project brings. Time, cost and specifications are constraints that effect their judgement because they influence the benefits of the project, but they are not the primary concern (Turner, 1993). Management is thus interested in the triple constraints, but only to the extent in which they contribute to the expected gains.

Users feel that the system delivered should meet their requirements and that they should be happy with the system (Wateridge 1998). Their objective is usually to obtain the best (not optimum) product, at any price. They will not perceive a project as a failure if it is implemented a few weeks too late or over budget.

Project managers are focusing on the short-term criteria (the triple constraints) that are set by the management because the sponsor judges them on meeting the triple constraints (Fowler & Walsh, 1999). This behaviour is amplified if their involvement ceases after the handover (Turner, 1993). Comparing the view of the project manager and the management, one notices that the project manager is primarily concentrating on short-term, process related criteria (Will we finish on time and within budget?) where the owner is concentrating on longer-term, product related criteria (Will the end result deliver gains?) (Wateridge, 1998).

Since the distance between the *supporters* (people that supply resources or services to the project in one form or another) and the *project manager* is usually smaller than the distance to the owner, the supporters will usually be more concerned about satisfying the project manager then satisfying the owner (Turner, 1993). They are thus more concerned about the short-term objectives of the project. The *stakeholders*' group (people affected by the project, but who receive no direct benefit from it, nor have direct influence on it) exists out of many different subgroups, all with their own goals and objectives. It comes as no surprise that a typical project will have some stakeholders who will support it and some who oppose it (Wright, 1997).

3 RESEARCH DESIGN

In opposite to most studies on the subject, a quantitative approach was selected. The data was gathered using a type of experiment[1], referred to as gaming. The participants of the "game" were asked to rate the success of ICT projects, based on information (i.e. project descriptions) provided by the researchers. This setup made it possible to control the number of variables and to avoid random influences. Furthermore, it created the possibility to manipulate variables and to test different settings.

The construction of the game happened in three steps:

In the *first step*, seven possible success criteria were selected based on a literature review (Milis & Mercken, 2001). The list of criteria existed out of the triple constraints, extended with criteria of group 3 and 4.

1. On time
2. Within budget
3. To specification

[1] Note that due to the absence of a "control group" and a "calibration measurement" this research approach cannot be classified as an experiment and thus should be regarded as a *quasi*-experiment.

4. Users happiness
5. Projectteam happiness
6. Management happiness
7. Financial or commercial success

In the *second step*, twenty-five descriptions of fictitious ICT projects were developed. They described large ICT projects, but which were supportive in nature and limited to a single company. One of the projects described was for example the development and introduction of new general ledger software.

Each project description contained the seven criteria. Some criteria are fulfilled, others were not. The descriptions were constructed in a way that the weight of the different criteria in a story was more or less the same. Over- or understressing a criterion could cloud the participant's judgement. Moreover, proxies are used to mask the criteria (example: in one of the descriptions "management happiness" was translated as "The management showed their gratitude by offering the project team a bonus"). The aim of not stating criteria openly is to avoid that participants develop an explicit theory by which they judge all cases. It was made sure that no other criteria were introduced unintended in order not to distract the attention from the seven criteria selected. It was made certain that there was no substantial correlation between the criteria (bivariate Pearson correlations range from –0,351 to 0,342).

Given these limitations, the construction of the project descriptions was very difficult task. The stories needed to be well balanced in order not to bias the research. The descriptions were peer-reviewed several times before they were exploited in this research.

In the *third step*, 26 participants (referred to as experts) were selected. These experts were all well acquainted with ICT projects and were either employees of one of the two large electricity-distributing companies that were participating, or consultants working for these companies. They had participated in several ICT projects in the past, though the role they fulfilled varied among the different experts.
Based on the role the different experts fulfilled, they could be classified into four groups:

- **Managers**: they represent the parent organization. They provide funds and are the main benefactors of the project (sponsor / owner).
- **Project team members – benefactors**: they are members of the projectteam and thus responsible for planning, organising and implementing the ICT project. Specific for this group is that their involvement does not cease after handover, i.e. they receive long-term benefits from the project (this group contains for example projectteam members that return to their department after the termination of the project to work with the new application).
- **Project team members – no benefactors**: as with the previous group, they are members of the project team, but their involvement ceases after handover. They may be allocated to other project, or they are consultants whose involvement terminates after finishing the project.
- **End users**: the users operate the outcome of the project on behalf of the management to achieve benefits.

Once these three steps were taken, the gaming could begin. During five consecutive days, the experts received an email with five project descriptions and were asked to judge the project's success based solely on the information provided. They were asked to reply by email within 24 hours (e.g. before the next set of descriptions arrived) to avoid comparison between answers. Furthermore, for pragmatic reasons it was easier to engage the experts for a limited amount of time every day compared to a situation where they were engaged during several consecutive hours. They were asked to state whether the project was a success or a failure. This resulted in a dataset with 650 binary datapoints (success or failure). On the sixth day, the experts received a list of additional questions that were developed to validate the initial selection of the criteria.

Note that neither the supporters nor the stakeholders are represented in the expert group. Their impact on the project is limited and their roles very diverse. Consequently, it is highly unlikely that a set of criteria can be found that is applicable for all supporters or stakeholders. Hence, no conclusions could be drawn for these groups, based on this study.

4 DATA ANALYSIS

The data was analysed using probabilistic feature models for frequency data, which is a non-linear technique. It is often referred to as probability matrix decomposition models (PMD), which are far better suited to analyse this type of binary three-way[2] data, compared to the traditional linear models.

4.1 Data analysis using probabilistic feature models for frequency data

A restricted version of the probability matrix decomposition (PMD) model (Maris, De Boeck, & Van Mechelen, 1996; Meulders, De Boeck, Van Mechelen, Gelman, & Maris, 2001) is used in order to investigate whether success on a specific criterion may be a sufficient or a necessary reason to consider the entire project as a success or a failure. As such, the PMD analysis differs from the classical regression approach in two important aspects: First, unlike classical regression it uses a binary criterion (i.e. perceived success or failure of a project) as a dependent variable. Secondly, the model is non-linear in nature because it focuses on the necessity or sufficiency of a certain criterion in order to predict the success of the entire project. However, in this paper a restricted variant of the model is used, which expresses the log of the success probability as a linear function of parameters that pertain to the different parties that were used to judge the projects.

In the following paragraph, the unrestricted variant of PMD models is discussed more in detail. Secondly, the restricted variant is presented that is used to model the data of the present article. Thirdly, the application of the model to the data and its results are discussed.

4.2 Probability matrix decomposition models

PMD models may be used for the analysis of binary three-way three-mode or two-way three-mode data. An example of three-way three-mode data is the case in which persons are asked to judge whether or not objects have each of a number of attributes. An example of two-way three-mode data is the case in which persons who are nested in a certain group judge a number of items. The data that are analysed in this paper are of the latter type, that is, persons i (i=1,..,I) of a certain party j (j=1,..,J) (e.g. user; projectteam members, both benefactors and no benefactors; management) judge the success or failure of each of a number of ICT projects k (k=1,..,K). The observations, denoted as D_{ijk}, equal 1 if person i of party j judges project k to be a success, and 0 otherwise. To explain the observed data, PMD models assume a *twofold process*:

First, it is assumed that, when judging the success of a certain project, persons covertly classify projects with respect to a number of latent features f (f=1,..,F) which are perceived as relevant for the project's success. In the present context, the features might refer to *specific* success criteria such as finishing the project within the specified time limits, keeping the costs within budget, and so on. On the other hand, persons are also covertly classified as to whether they find a particular specific criterion important for their global judgement of the project. An important assumption of the model is that persons of the same party have the same probability to judge a specific criterion as important whereas persons of different parties might have different probabilities. In other words the model focuses on the differences that exist between parties in judging the success of ICT projects.

Formally, the two types of latent classifications are represented as the realizations of Bernoulli variables $X_{jf.ik} \sim \text{Bern}(\sigma_{jf})$ and $Y_{kf.ij} \sim \text{Bern}(\rho_{kf})$ (f=1,..F), which are realized when person i of party j judges project k. That is, $X_{jf.ik}$ equals 1 if person i of party j, when judging project k, perceives criterion f as important for the success of the ICT project (ex. management may perceive “on time” as an important criterion to judge a certain project). In the same way, $Y_{kf.ij}$ equals 1 if, in judging project

[2] The expert, who belongs to a group, rates the success of a project, based on criteria presented to him or her.

k, person i of party j perceives criterion f to be fulfilled in project k (e.g. the project is finished in time).

Note that, when applying PMD models, the number of features is usually to be determined by the researcher. Similarly as with for example factor analysis, one should determine the number of features on the basis of a balance between parsimony and goodness of fit, on the one hand, and the interpretability of the obtained solution, on the other hand.

Second, it is assumed that the observed global judgement of a person on a project depends on the specific criteria that are perceived as fulfilled in a project and on the specific criteria that are judged to be important by the person. In other words, it is assumed that the global judgement D_{ijk} is a function of covert classifications $X_{jf.ik}$

and $Y_{kf.ij}$ (f=1,..F). This function is denoted as the *mapping rule*. When applying PMD models to real data, two mapping rules are especially useful:

A first rule reads that a person will judge the entire project as a success if at least one specific criterion is fulfilled that the person judges to be important. Stated otherwise, satisfying one specific criterion is regarded as ***sufficient*** for the success of the entire project. This rule is referred to as the disjunctive rule.

A second rule states that the entire project is a success if all the specific criteria that are judged to be important by the person are fulfilled in the project. Hence, this rule states that fulfilling certain specific criteria is ***necessary*** for the success of the entire project. This rule is referred to as the conjunctive rule.

From the above assumptions one may derive, for each of the mapping rules, the probability that a person of a certain party judges a project to be successful. It turns out that this probability is a non-linear function of parameters (σ_{jf}) associated to each of the parties and project parameters (ρ_{kf}). Note that the model does not include any individual differences within parties as persons of the same party have the same probability to perceive a project as a success. Meulders, De Boeck and Van Mechelen (2002) extended PMD models to include individual differences between persons within the same group (e.g. party). However, these models are not applied in the present paper because they require a larger number of persons within each group in order to have reliable estimates of the parameters associated to the groups.

4.3 A restricted variant of the PMD model

To model the data in the present paper a specific restricted variant of the PMD model is considered. This restricted model is obtained by assuming that the relevant specific criteria are the criteria that were used to construct the project descriptions, that is, “on time”, “within budget”, “to specifications”, “users happiness”, “projectteam happiness”, “management happiness” and “financial success”. More formally, we assume that F = 7 and that *the variables $Y_{kf.ij}$ are not random, but constants determined by the design of the study*. As a result, the only parameters involved are the parameters associated to the parties that indicate whether members of a party find a specific criterion of importance for the success of the entire project. As shown by Meulders, De Boeck, & Van Mechelen (2001) this restricted variant may formally be regarded as a generalized linear model with a binomially distributed random component and a log link. This means that the logarithm of the probability of success is modelled as a linear function of the parameters associated to the parties.

4.4 Applying the restricted PMD model

The parameters of the model are estimated using a Markov chain Monte Carlo method such as the Gibbs sampler (Gelfand & Smith, 1990). This method allows computing a sample of the posterior distribution of the model's parameters, which can serve as a basis to compute point estimates and 95% posterior intervals (comparable to 95% confidence intervals of a classical approach) of the parameters.

Meulders et al. (2001) implemented the Gibbs sampler for the PMD model. Their algorithm could be easily modified to implement the restricted variant of the model that is used in the present paper.

Table 1 presents the posterior median (point estimate) and the 95% posterior interval of the party parameters for the conjunctive model. The parameters in Table 1 indicate the probability that a certain criterion is necessary for the success of the entire project.

Before discussing the results in detail, a general remarks should be made: on the basis of the 95% posterior intervals of the estimated probabilities, one can conclude that differences in the perceived necessity of different criteria for the same party are generally larger than the differences in the perceived necessity of a the same criterion for different parties. In other words, the main-effect of the different criteria is rather clear whereas there exists less evidence for the differences between the parties.

	users		projectteam - no benefactors		projectteam - benefactors		management	
	median	PI	median	PI	median	PI	median	PI
on time	.45	(.21,.62)	.28	(.02,.52)	.32	(.04,.52)	.53	(.25,.71)
within budget	.18	(.01,.45)	.25	(.03,.51)	.12	(.01,.39)	.06	(.00,.30)
to specifications	.06	(.00,.29)	.09	(.01,.31)	.12	(.01,.37)	.06	(.00,.25)
management happiness	.17	(.02,.41)	.15	(.01,.39)	.12	(.01,.35)	.18	(.01,.47)
projectteam happiness	.04	(.00,.17)	.12	(.00,.38)	.05	(.00,.21)	.06	(.00,.24)
user happiness	.24	(.09,.41)	.43	(.26,.59)	.42	(.24,.57)	.50	(.29,.68)
fin/com success	.48	(.27,.67)	.28	(.05,.53)	.43	(.20,.61)	.41	(.12,.65)

Table 1: Posterior median and 95 % posterior intervals (PI) for the conjunctive model

4.5 Interpretation

The figures in table 1 represent a distribution of the estimated probabilities. For example: the chance that criterion “on time” is judged as being necessary for success by the users lies between 21 and 62% with a 95% certainty. The median is 45%, indicating that the most likely chance that the users judge this criterion as important is 0.45.

The higher the median, the more important the criterion is. The smaller the interval PI, the more the distribution is concentrated around the median, i.e. the smaller the interval the better.

For users, especially the criteria “on time”, “fin / com success” and “user happiness” are important. The criterion “fin / com success” has the highest median, e.g. is the most important criteria. As Wateridge indicated (see supra), “user happiness” is an issue. But it is judged as being of less importance compared with long-term gains (i.e. fin/com success).

Satisfying the users is the prime criterion for the projectteam members – no benefactors. Long-term gains (e.g. fin / com success) are importance as well, but are placed at the same level as the criteria “on time” and “within budget”. This indicates that this party focuses more on short-term criteria.

The criteria used by the projectteam members – benefactors and the management both resemble the criteria applied by the users, but the proportions differ. Being on time is of less concern to the projectteam members – benefactors compared to the other criteria, while the mean of the criterion “fin/com success” is slightly less than the mean of the criteria “on time” and “user happiness” for the managers.

Overall this model indicates that the projectteam members – no benefactors use a different set of criteria, compared to the other parties involved.

Furthermore, fin /com success is a prime criterion for the users, projectteam members – benefactors and the management, while it is of less concern for the projectteam members – no benefactors. This seems to indicate that the latter are focussed more on short-term goals, while the other parties are more concerned about the long-term results.

Note that satisfying the predetermined specifications is of little importance to all the parties involved. Apparently, as long as the users are happy, the application is delivered on time and there is fin / com success, it does not matter if the application is not constructed following the specifications.

5 ADDITIONAL QUESTIONS

The experts were asked if, besides the seven criteria, there were other criteria of importance to them. The aim of this question was to verify if the selected criteria were sufficient to base a judgement upon.

Seven experts extended the list. Three noted that sufficient documentation and knowledge transfer is a criterion for them, two noted that a smooth aftermath of the implementation is a criterion. The remarks made by the two other experts are perceived by the authors as success factors rather than criteria, and thus neglected in this part of the research.

The fact that a broad majority of the experts did not enlarge the list indicates that they agree with the selection of criteria used in this research.

6 CONCLUSIONS

In this research, seven possible criteria to judge the success of intra-organisational ICT projects were examined. The aim was to indicate which criteria were used by each of the groups involved in the implementation of ICT projects.

- First, there is no such thing as a set of criteria that is uniform for all the parties involved in intra-organisational ICT projects. The different parties use different sets of criteria to rate the success of an ICT project.
- Second, none of the parties examined based their judgement solely on the triple constraints. In other words, fulfilling the triple constraints is no guaranty that a project is perceived as successful.
- Third, for all parties examined, financial or commercial success is an important criterion. It is a prime criterion for the users, the projectteam members – no benefactors and the management, but for the projectteam – no benefactors, the weight of this criterion is exceeded by the weight of other criteria. This indicates that the latter are interested more in short-term gains. The statement posed by Turner (see supra) that projectteam members primarily use short-term criteria could thus only be confirmed for the projectteam members – no benefactors. This does not hold for projectteam – benefactors.
- Fourth, as literature indicated, the management focuses on the long-term gains (financial or commercial success). But “on time” and “user happiness” are important criteria as well. This can be explained by the fact that both criteria contribute to the long-term gains the application generates.

7 MANAGEMENT GUIDELINES

Based on the findings of this research, some management guidelines are constructed:

- The selection of the project manager and the projectteam members should be based upon the characteristics of the project. If the aim of the ICT project is to generate long-term gains, management should mainly recruit people that benefit from the project after handover (projectteam

– benefactors). Long-term gains prevail over short-term criteria. If the characteristics of the project are such that the short-term criteria prevail (examples: upgrade an application, apply to changed regulations…), one should select people whose involvement ceases after handover.

- Moreover, if consultants or other people whose involvement ceases after handover are working on a project that should deliver long-term gains, they should be able to profit from the long-term gains the application generates (for example by using bonuses). This will shift their attention from short-term criteria (the application has to look good at the handover stage) towards long-term criteria (does the application deliver gains).
- Management should be aware that the criteria that are used to judge ICT projects vary for every group involved. Consequently, depending on the groups the management wants to satisfy, emphasis should be on different criteria.
- Do not use the triple constraints as success criteria. Since no group bases his judgement solely on these constraints, fulfilling them does not guaranty that the project is perceived as a success.
- Knowing the success criteria the different groups use is a powerful tool for the project manager. It enables him or her to evaluate trade-offs. For example, if a trade-off needs to be made between satisfying all predefined specifications or delivering on time, the project manager should select the latter since the weight of the criterion 'to specification' is lower than the weight of the criterion 'on time' for the most groups examined. Another example is the trade-off between budget and fin / com success. Three out of the four groups do not mind that the budget is exceeded, provided that it results in a higher fin / com success.
- In short: knowing which success criteria are applied enables the (project) manager to focus on those criteria that are really important.

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