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Maturity and performance conditions of IT projects

Renato de Oliveira Moraes, Isak Kruglianskas
Universidade de São Paulo
e-mails: remo@usp.br; ikruglia@gmail.com

Abstract: This article presents the result of an empirical study approaching interrelations between performance conditions, project management maturity, and the direct and indirect effects of each one on the performance of information technology (IT) projects. This study was based on the analysis of 131 IT projects. Data were collected through a self-administered questionnaire and submitted to a structural equations model in order to assess the interested relationships. Results showed that: i) the compliance with deadlines and budget (Project Efficiency) is directly affected by the maturity of internal processes in the project management area; ii) this maturity dimensions are affected by the support of the high administration; iii) project performance, in terms of project impact on users, is associated to individual elements of development – manager and team – and not to company elements represented here by the maturity in project management; and iv) the maturity in third-party management (suppliers) has no impact over projects performance.

Keywords: IT projects, project management maturity, IT projects performance, performance conditions.

1. Introduction

During recent decades, virtualization of activities and the new models of business that it has provided, as well as worldwide coordination of large supplies chains characterizes what many authors called as "New Economy" (GEREFFI, 2001). Still according Gereffi (2001), there is who calls this new configuration of economic activities as "digital economy", "innovation economy" "networks economy" or even as "electronic economy" (e-economy).

Information technology (IT) was the element that enabled this new scenario and also was the most visible factor from this huge transformations, Castells (1999) employs the expression "information society" to characterize these large impacts over society.

Therefore it is clear the huge IT importance to economic activities on worldwide markets, particularly to seek for innovations that enable companies to compete with success.

There is a relatively large literature about project's performance and its conditions (BAKER; MURPHY; FISHER, 1983; PINTO; SLEVIN, 1986, 1988; LIM and MOHAMED, 1999; COOKE-DAVIES, 2000; BACCARINI, 1999; MUNNS; MJEIRMI, 1997) that tries, in addition to study this relationship, to give elements for a more efficient projects' management. During this decade, a special attention was given to the concept of maturity in projects' management and its relationship with an improvement in projects' performance. This relationship was not always so clear and evident in terms of quantitative research (MORAES, 2004). This article presents a study of quantitative data collected through a survey that employed a structural equation model to simultaneously investigate relationships between: a) project's performance, b) project's performance conditions and c) maturity in projects' management in IT companies.

2. Theoretical review

This chapter discusses three concepts employed during work development: projects' performance, conditions of projects' performance and maturity in project management.

2.1. Project performance

Pinto and Slevin (1986) provide a definition regarding projects' performance that approaches both internal (cost, schedule and quality – meeting technical specifications) and external (use, satisfaction and effectiveness). Internal aspects are closer to manager and team and suffer less influence from clients and users. In contrast, external aspects are much more linked to clients' behavior. This division in projects' performance concept was taken to the extreme by other authors and differentiates two different concepts: project performance (project management) and project's product performance (LIM; MOHAMED, 1999; COOKE-DAVIES, 2000; BACCARINI, 1999; MUNNS; MJEIRMI, 1997). Shenhar et al. (2001) does not recognize the existence of two different concepts of success – project success and product success – and defends the idea that relative importance of projects' dimensions of success

changes over time. The dimensions identified by these authors are in Table 1.

The relative importance of each dimensions changes with time and technological uncertainty. In a short term, project's efficiency is the most important and also the only one that can be measured with reliable prediction. With the developed product, the assessment of other dimensions is possible and relevant (Figures 1 and 2).

In projects with low technological uncertainty, expectations about the project are more connected to marginal contributions where efficiency in development is a determining factor. For instance, when product's update is done, the objective is to maintain the product in compliance with market specifications and it is not expected that this will modify the product's life cycle. When you work with large innovations and large technological uncertainty, companies are more tolerant to a low project's efficiency. This may happen because there is an expectation that the project may eventually generate an internal concurrence against a new and emergent technology.

For this work, it was adopted a performance definition based in two first dimensions (Project's efficiency and Impact on the Client – purposed by Shenhar et al. (2001)). This choice was leaded by the nature of projects' type and companies studied according described in methodology chapter.

2.2. Performance conditions

Performance conditions are elements related to project, environment and its guidance that affects, determinates or constrain its performance.

Baker, Murphy and Fisher (1983), who worked with the concept of perceived performance (success / failure) noticed that success conditions are not the failure conditions. That is, those elements which by their presence increased the project's success perception by stakeholders are not identical to the ones that increase failure perception. Other authors (KERZNER, 2000; PINTO; SLEVIN, 1986) also studied the theme purposing lists of condition elements from project performance.

Gemuenden and Lechler (1997) related through structural equations the performance conditions and projects' success. The model employed to represent the relations between conditions and performance is in Figure 3. The eight dimensions of conditions were joined in three categories and success is represented through 3 different dimensions (Table 2).

Table 1. Projects' dimensions of success, according Shenhar et al.

Project success dimensions	Metrics/variables used
Project efficiency	Time goal Budget goal
Impact on the client	Functional performance Conformity to technical specifications Attendance of client needs Client's problem solution Utilization of project products by the client Client satisfaction
Business success	Commercial success Market share increase
Preparation for the future	Creation of a new market Creation of a new product line Development of a new technology

Source: Shenhar et al. (2001).

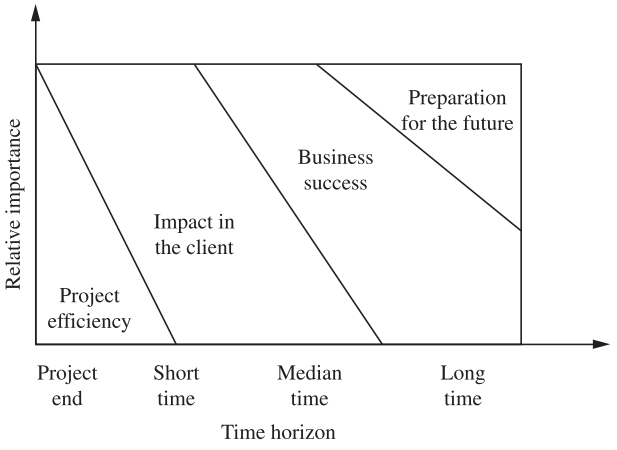

Figure 1. Relative importance of success x time dimensions. Source: Shenhar et al. (2001).

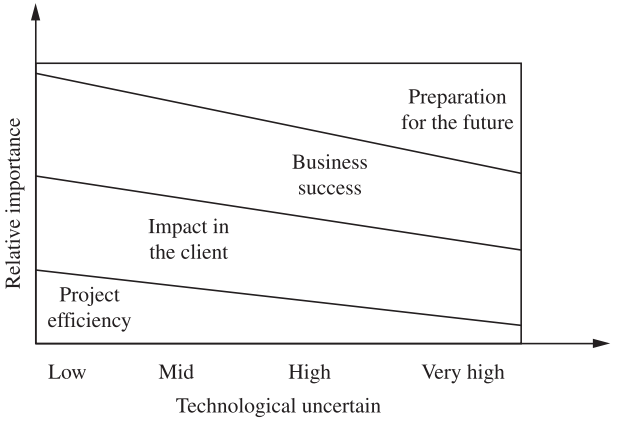

Figure 2. Relative importance of success dimensions x technological uncertain. Source: Shenhar et al. (2001).

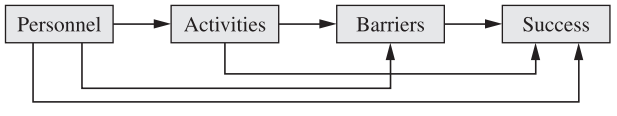

Figure 3. Relation between success conditions. Source: Gemuenden and Lechler (1997).

Table 2. Success conditions used by Gemueden and Lechler.

Categories	Dimensions	Description
Personnel	High administration	Includes direct support and interest in an individual project
	Project manager	Refers to the formal authority of project manager
	Project team	Refers to technical training and social profile of team
Activities	Participation	Refers to the involvement of project team in decision making
	Information/ Communication	Describes the formal system of information and efficacy in communication.
	Planning and Control	Refers to efficacy in planning and control
Barriers	Conflict	It concerns both intensity and the type of conflict
	Changes on project's goals	Refers to extension, importance and frequency of changes
Success	Efficiency	Rational use of resources
	Efficacy	Compliance of established goals
	Social success	Impact of project results over society

Source: Gemuenden and Lechler (1997).

The unique approach from these authors allowed a better understanding from relations of projects' performance conditions. Its structure emphasizes the independence between conditions and the fieldwork allowed to explicit the direct influence of high administration about success and its indirect influence because affects the project manager, the participation degree and the project team which together will affect the information/communication in the project that will affect success.

With specific regard to IT projects, it was also developed several studies approaching performance conditions (YEO, 2002; POON; WAGNER, 2001; JIANG; KLEIN; BALLOUN, 1996; JIANG; KLEIN, 1999; TEO; ANG, 1999; ROBIC; SBRAGIA, 1995; PINTO, 2002).

Belassi and Tukel (1996) proposed a structure to evaluate project's success conditions when they assessed studies approaching success conditions. This proposes is based on gathering of conditions in four categories: i) conditions related to project; ii) conditions related to project manager and team members; iii) conditions related to the company where the project is developed (performing company); and iv) conditions related to external environment. Figure 4 shows the relation between these factors according Belassi and Tukel (1996).

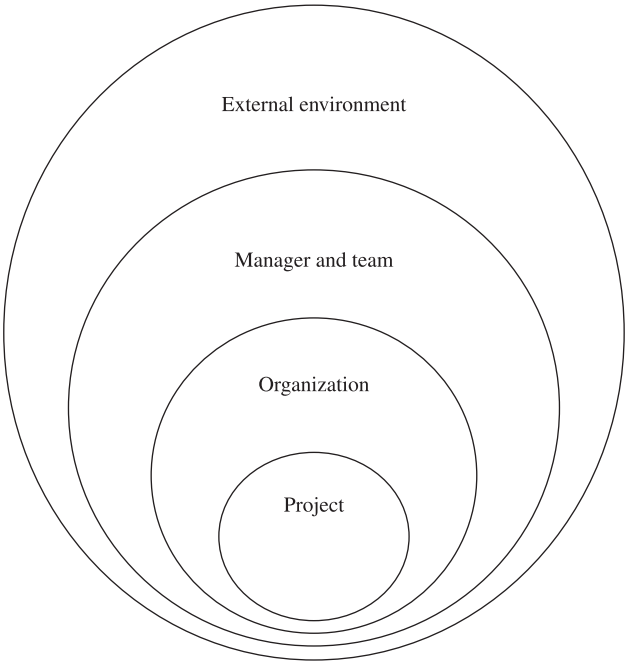

Figure 4. Group of success conditions. Source: adapted from Belassi and Tukel (1996).

2.3. Maturity in project management

The maturity concept in project management comes with the proposition, which was made by different authors, of maturity models in project management. Goldsmith (1997) tries with CMM/Project Maturity Model to conciliate PMBoK (Project Management Body of Knowledge) and CMM (Capability Maturity Model). It is a specific model for software projects and it is directed to preparation for professional certification in Project Management Institute (PMI) environment.

Ibbs and Kwak (1997, 2000) developed the *Project Management Process Maturity Model* (PM_2), also influenced by CMM – it uses five levels of maturity – and divides the concept of maturity in function of eight areas of PMBoK knowledge (Integration Management, the ninth area is excluded) and phases from the development cycle.

Also influenced by CMM, the *Project Management Maturity Model* (PM3) (Fincher; Levin, 1997; REMY, 1997), unlike the others, supports the idea that is not necessary that all companies seek the highest level of maturity to be effective. This model suggests that each organization must find the better combination of competencies related to its objectives.

Hartman and Skulmoski (1997), when examined the maturity models in project management, highlighted the

need of one framework for the development of universal model of maturity. This structure should contemplate technical, business and social issues.

The *Organizational Project Management Maturity Model* (OPM3) probably is the one that will have most acceptability by professionals of project management. This is because its development has been sponsored by PMI and therefore has the support of this institution. The developing group identified a number of elements that must be assessed during the determination of company's maturity in Schlichter projects management (2001).

Maturity models are influenced by CMM and PMBoK. CMM has provided a structured based on maturity levels determined by implanted processes. PMBoK brings a characterization of processes from project management. The combination of these two references have led to different proposes of maturity models from processes management.

The idea of processes maturity is associated to the concept of processes stability. Stable processes are processes free of changes that are consistently and homogeneous carried out. The processes formalization reflects this stability on ISO 9.000 staff "[…] do what you write and write what you do" (ANTONIONI; ROSA, 1995).

In this vision, the quality of a product is determined by the quality of the process that generated it. So, the quality of the development process of a software project will determinate the quality from the software generated. This is the same idea behind the models of quality assurance, such as ISO 9.000-3, CMM and ISO 15.504. In these models, the quality of process is obtained by the stability of processes.

Unlike the proposed models of maturity in projects management, in this work it is not relevant a preliminary characterization of maturity levels. If here was adopted any model, there would be a concern in build a sample to take a meaningful amount of individuals in each level of maturity. In addition to this practical issue, there is other conceptual one related to the very validity of proposed models. They still are extremely recent, were not satisfactorily tested and also development.

Here, on this work, what matters is the use of procedures that allows separating the sample elements in homogeneous groups of maturity. Therefore, the preliminary characterization of these groups – which might be achieved by the adoption of one maturity model – it is not necessary.

The characterization of these groups was made after its formation – through statistical procedures. Then, the relevant question becomes the identification of processes from project management that are relevant for the assessment of maturity in samples' companies. PMBok, due its international importance, is the answer to this question. It brings, grouped in knowledge areas, the main processes in projects management. So, the processes described on PMBoK were used in the assessment of companies' maturity in this work. This procedure, which is to use the PMBoK processes as base for the maturity measurement in projects management, is the same employed by Ibbs and Kwak (2000).

3. Methodology

The population considered in this work is composed by projects of software development with the following characteristics:

- Initial cost not inferior to R$ 20 thousand
- Had concluded between 1999 and 2003

The sample used was composed by a group of mailing lists with professionals from Information Technology (IT) area. The option of a convenience sample limited the generalization possibilities of findings statistically meaningful found in sample. But this option allowed obtaining a sufficient number of answers to amplify the statistical techniques used.

The sample elements were notified by e-mail and invited to join the research. They could answer the questionnaire through e-mail or directly through a site built for this purpose. The answer rate was between 2% and 3%. This can be considered as reasonable for this type of research.

The original questionnaire was composed by 51 questions distributed in 3 parts:

1) Interviewed: one identification and qualification of interviewed.
2) Company: the project's main company. Also includes information related to maturity in management of company projects.
3) Project: the questions of this part are divided into two groups:
   a) Project's development environment: contain questions about the project and the conditions under which was developed

1) Project: questions from this part are divided into two groups:
   a) Project's development environment: contain questions about the project and conditions under which it was developed.
   b) Project's development: contain questions related to project's performance and relative importance from different criteria of performance.

In order to reach the aim of this work, the data collected on the sample were studied according some following orientations:

- One first analyze was made for each completed questionnaire, in order to verify mistakes/ filling problems that could be identified and corrected even before the tabulation of answers.

a) Each one of variables quantitative (ordinal variables assumed as intervals) was evaluated separately to verify whether the assumptions for application of

multivariate methods were satisfactorily met.

b) A group of factorial studies was done approaching the following groups of variables:
   i) Performance variables used for project assessment
   ii) Maturity of projects' administration processes
   iii) Projects' performance conditions

Thus, it was obtained a meaningful reduction in the problem's number of dimensions.

a) Structural Equations Model – where we tried to simultaneously verify the relationship between maturity and conditions, and between performance, maturity and conditions

Performance ← fç (Maturity, Conditions)

Maturity ← fç (Conditions)

For this work it was adopted the performance concept of Shenhar et al. (2001) – a unique concept of performance – on the ground that provides a temporal perspective about

Table 3. Processes of project management choose as representatives in PMBoK knowledge areas.

Areas	Representative processes
Integration management	Integrate control of changes
Scope management	Control of scope changes
Time management	Estimative of duration of activities
	Chronogram control
Cost management	Costs estimative
	Costs control
Quality management	Quality assurance
Human resources management	Development of team
Communications management	Planning of communications
	Distribution of information
Risks management	Planning of risks management
	Control and monitoring of risks
Acquisitions management	Suppliers selection
	Administration of contracts

Table 4. Constructs (latent variables) and indicators (manifest variables).

Type of construct	Construct	Variables used
Project performance	Project efficiency	Term goal Budge goal
	Impact on the client	Functional performance Compliance with technical specifications Filling of customer needs Resolution of customer issues Use of product by customer Satisfaction of customer
Maturity in project management	Maturity (internal) in project management	Estimative of duration Control of chronograms Estimative of cost Costs control Quality assurance Planning of risks Control and monitoring of risks Control of scope changes Teams development Distribution of information Integrate control of changes Planning of communications
	Maturity (external) in suppliers management	Suppliers' selection Administration of contracts
Conditions of projects' development	Project team	Team experience Team competence Experience of GP Conflicts in the team
	Project manager	Knowledge of users by GP Knowledge of company by GP Commitment of GP
	Project size	Size of team Size of software (in KLoC)
	Profile of project users	Commitment of users Participation of users Familiarized users Experience of users
	Support of high administration	Variable directly measured
	Technological uncertain	Variable directly measured

Table 5. Model of structural equations.

Dependable variables	Independent variables			
	Project efficiency	Impact on the client	Internal maturity	External maturity
(Internal) Maturity in project management	X	X		
(External) Maturity in suppliers management	X	X		
Project team	X	X	X	X
Project manager	X	X	X	X
Size of project	X	X		
Profile of project users	X	X		
Support of high administration	X	X	X	X
Technological uncertain	X	X		

the performance of the most interesting projects. The choice for Shenhar propose is the one that stands out as the most embracing and adherent to multidimensional representation of success of software projects.

However, some adaptations were necessary. The dimension of "Preparation for future" performance is more clearly manifested just after a long term, and once that the sample elements refer to projects that were recently concluded, this dimension was removed. Another dimension – "Business success" – was omitted since it was expected that within the sample there were many projects developed in companies that does not have IT in its core product, a fact that actually happened. In these companies, the development area has as clients other functional areas from the same company; this would prevent the correct interpretation of this dimension that approaches business impacts from the product developed by the project. Therefore, two dimensions from the original model of Shenhar were used: 1) Project's efficiency and 2) Impact on the Client.

For the questionnaire would not be so long, what would compromise the response rate from direct mail, we only worked with a cluster of processes described on PMBoK – just the most representatives from each one of the nine areas of knowledge described. Table 3 shows these processes selected.

4. Data analysis

Firstly was made a set of factorial studies in order to measure certain construct aspects from the studied model. There are three types of constructs: performance dimensions of IT project, maturity dimension in project management and performance conditions. Table 4 shows the relationship between constructs (latent variables) and indicators used in survey (manifest variables). It was used the two first performance dimensions proposed by Shenhar et al. (2001). The first dimension – Project's Efficiency – refers to compliance to schedule goals and cost of project. The second dimension – Impact on the Clients – is attached to the way that the result of project affects the environment where it will be used. Regarding the maturity of projects

Table 6. Indicators of model adjustment.

Chi-square = 38,999
Degrees of freedom = 17
Probability level = 0,002
RMSEA = 0,0971892
p = 0,0296629
Parsimony ratio = 0,3090909
Parsimony-adjusted NFI = 0,2937701
Parsimony- adjusted CFI = 0,2997990

management, its measuring resulted in the formalization degree of some management projects described in PMBoK (MORAES, 2004). Two dimensions of this maturity were taken into account: the maturity in the management of third parties, which refers to process related to management of PMBoK acquirements, and maturity of internal management that refers to other processes of project management. Six conditions were used. Two of those – Technological Uncertain of Project and Support of High Administration to Project – were directly measured. The other ones used a group of indicators in its assessment, which were: Project Team, Project Manager, Size of Project and Profile of Project Users.

During the construction of structural equations model, the relations were specified according review of literature. The project performance (each one of its dimensions) was described in function of its conditions and maturity in the management of projects from performing company. The maturity in projects management was described in relation to company's characteristics that also are conditions for the performance of project. Therefore, every variable that explains maturity is a condition for project development, but not every condition of performance is an explicative variable of maturity in project management. The conditions that are specific for each project (Size, Users and Technological Uncertain) cannot be considered as variables that determinate the company maturity in project management.

It were also included the correlations between success dimensions of projects – Project Efficiency and Impact on the Client – and also between maturity dimensions in project

Table 7. Coefficients and significances of correlations specified on structural equations model.

Dependable variables	Undependable Variables			
	Project efficiency	**Impact on the client**	**Internal maturity**	**External maturity**
(Internal) Maturity in project management	**0,297** **0,49%****	0,048 65,02%		
(External) Maturity in suppliers management	–0,141 17,1%	–0,04 70,08%		
Project team	0,026 83,78%	**0,31** **0,87%****	0,164 16,16%	0,099 42,23%
Project manager	0,035 77,44%	**0,394** **0,06%****	0,106 34,08%	**0,299** **0,93%****
Size of project	0,167 14,2%	–0,038 72,8%		
Profile of project users	**0,275** **1,3%***	0,111 30,34%		
Support of high administration	0,135 19,55%	0,088 39,23%	**0,291** **0,23%****	–0,008 93,47%
Technological uncertain	0,031 72,36%	–0,099 24,55%		

**Statistically meaningful at level of 1%. *Statistically meaningful at level of 5.

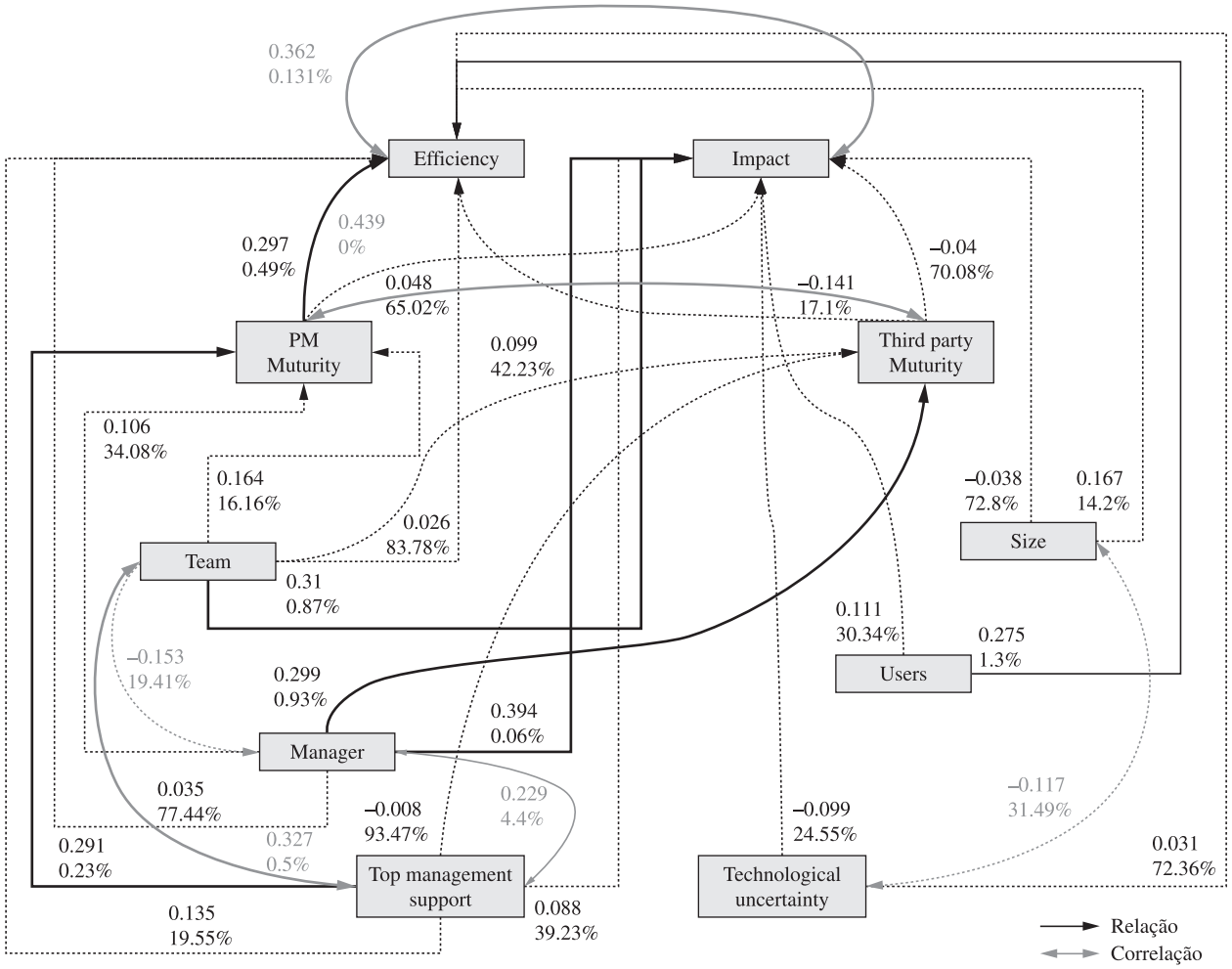

Figure 5. Model of structural equations.

management – (internal) Maturity in Project Management and (external) Maturity in Suppliers Management. Table 5 shows the relationships approached by the model of structural equations.

The study of structural equations model was made using AMOS software. The adjustment indications of model provided by software are on Table 6 and the estimate coefficients are in Table 7 and Figure 5.

As expected, significant correlations were observed between performance dimensions of projects and maturity dimensions in project management. Between the performance conditions of projects, it was observed meaningful correlations between High Administration Support and Profile of Project Manager and between High Administration Support and Profile of Project Team. These lasts correlations showed a characterization of organizational environment were the maturity in project management is built and where the development of projects is done.

"Project Size" and "Technological Uncertain" conditions did not present a relation with performance dimensions nor maturity dimensions in project management. The lack of evidences in these relations should not be interpreted as an evidence of absence of such relations.

High administration, on this model, is the one responsible for internal maturity in project management and this maturity dimensions give conditions for project performance in terms of its efficiency. This reinforces the idea that is high administration that creates organizational conditions where maturity in project management is developed. Internal maturity in project management that excludes the processes in acquirement management determinates the project performance in terms of its efficiency, but not in terms of impact over users. This performance dimension – impact over users – is not related with maturity in project management, just to Profile of Project Manager and Profile of Project Team conditions. This suggests that this performance dimension – impact over users – is much more connected to personal aspects of development (manager and team) than to organizational aspects (maturity in project management).

Another important element to highlight is that maturity in suppliers' management does not have implication over any dimension of project performance. One interpretation for this fact is that the use of sub-contraction is very uncommon in this type of project. This also could explain, once that sub-contraction is something unusual, the fact of why it is not related to Support of High Administration.

5. Final considerations

The article presented a study about the relations between: i) project performance, ii) conditions of project performance and iii) maturity in project management in IT companies. The data obtained through a survey were studied through a model of structural equations that basically used the following relations:

Performance ← fç (Maturity, Conditions)

Maturity ← fç (Conditions)

In summary, the study of structural equations reveled that, in elements of this sample:

i) The compliance to terms and budget (Project Efficiency) is conditioned by the maturity in project management, which is a characteristic of company's environment.

ii) This organizational characteristic –maturity in project management – is conditioned by the support of high administration.

iii) The project performance, in terms of impact of project over the users, is connected to personal elements of development – manager and team – and no to company elements, here represented by maturity in project management.

iv) The maturity in third-parties management (suppliers) does not have impact over the project performance, probably because the sub-contraction practice is not common in this type of project.

The sample characteristics not allow the generalization of results founded, and must be analyzed under this perspective. These results, which showed to be very consistently with project management's literature, presented maturity in project management as an intervening variable from the relation between project performance and condition elements of its performance, according previously suggested already (MORAES, 2004; KRUGLIANKAS; MORAES, 2004; MORAES; KRUGLIANKAS, 2005, 2006; MORAES; KRUGLIANKAS; PEREIRA, 2006). The study enabled a better understanding of the way in which maturity can contribute with the performance of IT projects. For professionals in this field, we can recommend that the maturity wished for a company must considered the dimensions of performance wanted. In other words, a suitable maturity may have a specific profile according the characteristic of environment where the projects are developed. For scholars and researchers it is suggested that this type of study be developed in other contexts and eventually including the characterization and the indicators of performance and maturity the larger than the ones used here.

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