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Project characteristics, project management software utilization and project performance: an impact analysis based on real project data

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Scorecard and KPIs for monitoring software factories effectiveness in the financial sector

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A tale behind Mum Effect

Sakgasit Ramingwong
Lachana Ramingwong

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Editorial

It is our great pleasure to bring you the third number of the IJISPM - International Journal of Information Systems and Project Management. The mission of the IJISPM is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

In this issue, readers will find important contributions on project management tools and practices for improving project performance.

As Robert Pellerin, Nathalie Perrier, Xavier Guillot and Pierre-Majorique Léger state in their article "Project characteristics, project management software utilization and project performance: An impact analysis based on real project data", project management software packages are increasingly used by companies. These tools require a substantial financial investment, hence the importance of identifying the real contribution of project management software packages to the realization of projects. However, studies on the impacts of software packages on the performance of engineering project management are rare and mostly based on perceptions. The objective of the first article of the present edition of IJISPM is to investigate, from real project data, the level of utilization of a project management software package and its link with project performance and project characteristics. Results stemming from non-parametric tests and correlation analyses show that the level of use of the software, and some of its subsystems, appears to be linked to project performance. Project duration also seems to be the most critical project characteristic.

The second article "Scorecard and KPIs for monitoring software factories effectiveness in the financial sector" is co-authored by Vicente Rodríguez Montequín, César Álvarez Pérez, Francisco Ortega Fernández and Joaquín Villanueva Balsera. Although financial corporations have always paid a special interest to investing in management and organizational policies to improve their efficiency, there have being always an important lack regarding to the control and monitoring of the software projects. They do not have suitable tools for monitoring actual process effectiveness. Adapting scorecards to this environment could be a useful tool for monitoring and improvement the process. Scorecard could here be used both as a tool for internal effectiveness measurement as well as externally, presenting sustainability indicators for the shareholders. In this article, the authors identify and define a collection of Key Performance Indicators which permit effectiveness to be improved under this context, focusing in the specific supply-chain model given by owner (financial group), software factory and software developers.

Mum effect is a situation when one or more project stakeholders decide to withhold critical information for particular reasons. In software project where most of the production is intangible, the seriousness of this challenge increases exponentially. There have been reports indicating that mum effect can surface during any phase of development and ultimately lead to disaster in software projects. Mum effect can be influenced by several factors such as organizational and national cultures. Sakgasit Ramingwong and Lachana Ramingwong, in their paper "A tale behind Mum Effect", investigate potential mum effect scenarios and reveal specific reasons which induce this challenge among information technology practitioners.

We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work, for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

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The Editor-in-Chief,
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João Varajão is currently professor of information systems and software programming at the *University of Minho* and a visiting professor at the *University of Porto Business School*. He is also a researcher of the *Centro Algoritmi* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997) and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are in Information Systems Management and Project Management. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst and software developer, for private companies and public institutions. He has supervised more than 50 Masters and Doctoral dissertations in the Information Systems field. He has published over 250 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor and member of the editorial board for international journals and has served in numerous committees of international conferences and workshops. He is co-founder of CENTERIS - Conference on ENTERprise Information Systems and of ProjMAN – International Conference on Project MANagement.

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Project characteristics, project management software utilization and project performance: An impact analysis based on real project data

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Abstract:
Project management software packages are increasingly used by companies. These tools require a substantial financial investment, hence the importance of identifying the real contribution of project management software packages to the realization of projects. However, studies on the impacts of software packages on the performance of engineering project management are rare and mostly based on perceptions. The objective of this study is to investigate, from real project data, the level of utilization of a project management software package, developed by an engineering construction firm recognized internationally, and its link with project performance and project characteristics. Results stemming from non-parametric tests and correlation analyses show that the level of use of the software, and some of its subsystems, appears to be linked to project performance. Project duration also seems to be the most critical project characteristic.

Keywords:
project management software; information technology; information systems; systems utilization; project performance.

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1. Introduction

The impacts of information technologies (IT) and information systems (IS) on organizations are numerous. IT/IS involve new organizational structures [1]-[3] and result in an increase of the productivity of the individuals [4], so facilitating the increase of organizational productivity. IT/IS also allow to reduce the size of organizations [5] and to facilitate the coordination within organizations. Better coordination allows realizing more complex projects bringing together many actors [6]. Furthermore, IT/IS helps organizations in improving their detection capability and capacity for response, which confers them a certain agility [7],[8] as they enable the flow and access to information required for good operations [8],[9]. Finally, IT/IS stimulates the learning capacity in organizations.

However, the implementation of IT/IS does not always result in positive outcomes. This problem, called *paradox of productivity* [10],[11] results from several factors such as the time lag between the investment and the observed outcome in productivity, poor management of IT/IS, poor qualified workforce, or the way investments in IT assets are accounted for in financial statements [12]-[17].

During the last 20 years, the paradox of productivity thus motivated the researchers to measure the impacts of IT/IS on organizations. However, few studies exist on the impacts of IT/IS on the performance of engineering projects. Project management makes use of business processes (supply chain management, human resources management, inventory control, planning, etc.) and IT/IS plays nowadays an important role in efficient project management (i.e. project management software packages).

While project management systems are now used extensively for conducting engineering projects, the analysis of their impact on the performance of projects has been largely ignored in the literature. Moreover, studies on the impacts of IT/IS on engineering projects are rarely based on real project data. The originality of this paper relies on the use of primary sources of project data, obtained from an engineering construction firm, to investigate the impact of utilization of a project management software on project performance. Specifically, the objectives of this paper are:

- To examine the relationship between project characteristics and software utilization;
- To highlight the perceptions of system users that have an impact on the performance of projects; and
- To derive a software utilization profile for the best-performing projects from the firm.

The remainder of this article is organized as follows. Section 2 introduces the necessary background and definitions concerning project management software packages and presents a review of the studies performed, for the last decades, on the impacts of IT/IS on organizations and the performance of engineering projects. Section 3 describes the variables studied, the data collection process and the research methodology. Section 4 presents results and analyses on the level of use of project management software and its relationship with project performance and project characteristics. We conclude with limitations and call for future research.

2. Background and literature review

According to the standard ISO/IEC 2382-1:1993, a software package is a “complete and documented package of programs provided to several users, with the aim of the same application or function”. As such, project management software packages, commonly called Project Management Information System (PMIS), generally facilitate the integration of project data, the interaction with enterprise systems and the interoperability with new IT. Besides optimizing the productivity of the teams, the system allows to make better decisions, to maintain a competitive advantage and to implement effective project management practices. This type of software consists of subsystems developed to treat various aspects of project management: procurement, construction, cost control, planning, etc.

Table 1 presents the subsystems usually found in a project management software package.

Table 1. Project management software subsystems

Subsystems	Function
Project definition	Define project parameters (employees, classification codes, etc.) and project characteristics (person in charge, dates, contract type, etc.)
Activity planning	Schedule project activities via a specific professional software
Environment management	Manage environmental plans, preventions, training and follow-up actions on inspections and accidents
Health and safety management	Manage health and safety plans, preventive measures, education, preventions, inspections and follow-up actions on accidents and incidents
Estimating process management	Establish detailed estimate of project (project work breakdown structure, work packages, etc.)
Working hours management	Achieve follow-up on working hours provided by the firm according to the contract type defining the project
Document control	Control documents (internal and external) generated during the execution of the project
Document management	Manage processes related to the documents and archive documents
Engineering process management	Carry out recording, follow-up on equipment and materials resulting from engineering, allow purchase requisitions and give an interface with engineering tools
Procurement management	Manage procurement processes related to the project (purchasing, training, contract administration, logistics, procurement follow-up and inspection, material management on site)
Cost management	Carry out follow-up on the project budget, invoicing and payments
Construction activity management	Manage construction contracts, do a follow-up on the construction progress and manage implementation activities

The several interactions between the software subsystems enable the flow of information. Each subsystem thus becomes an information source for other subsystems. For example, the subsystem *Document management* receives information from the *Procurement management* and *Engineering process management* subsystems.

During the last decades, the impacts of IT/IS on organizations gave rise to a great deal of interest from the researchers. Besides allowing the implementation from an effective organizational management, IT/IS are innovation tools for organizational management [18],[19]. On the one hand, IT includes communication vehicles and tools (Internet, intranet, e-mail, videoconference, etc.) ensuring the linking between IS and individuals within organizations [13],[19]. On the other hand, IS includes software and databases used in organizational management processes (e.g., ERP system, project planning management system, etc.).

Many studies on the impacts of IT/IS on organizations concern the determination, analysis and quantizing of the impacts of IT/IS on productivity, improvement of processes and innovation [3],[5],[19]-[22]. Some studies only consider the impact of IT on organizations. For example, Boudreau et al. [8] showed that IT has an impact on the coordination, reactivity, effectiveness and learning capacities in organizations. Other studies consider the impact of IS on organizations. As an illustration, Vemuri and Palvia [23] and Velcu [24] showed that ERP systems allow organizations to achieve economies of scale, to reduce general and administrative costs, as well as the duration of organizational processes, and to insure a better inventory turnover.

However, there is a lack of studies on the impacts of IT/IS on the performance of engineering projects. Argyres [6] showed that the implementation of a communication channel between the designers and the use of databases, CAD and common software facilitate the coordination between the various companies involved in the realization of a complex project. More recently, Jones and Young [25] observed an increase in the number of multi-divisional projects in companies having implemented an ERP system. Also, Bardhan et al. [15] highlighted the importance to connect IT/IS to the characteristics of a project (project duration, cost, quality, and timeliness of work) to improve project performance. This study revealed that BCT (Basic Communication Technologies) are especially used for high-performance projects, EST (Enterprise Software Technologies), e.g., ERP systems and project management software packages, are desirable for projects where the environment is well structured, and the GCT (Group Collaboration Technologies) must be given special weight for projects where the environment is less structured, uncertain and volatile. Furthermore, Aral et al. [26] showed that the use of asynchronous tools (e-mail, databases) allows to simultaneously manage more projects and to reduce the duration of projects. The study of Bryde and Wright [27] revealed a significant correlation between the efficiency of the project management system and the expectations from the members of the project team and the customers. Raymond and Bergeron [28] showed that the quality and the frequency of use of PMIS have a positive impact on the performance of a project. Dostie and Jayaraman [3] observed that the employees who use computers are more productive than the non-users. Finally, Ali et al. [29] showed that information quality and project complexity have a positive impact on the use of PMIS. Ali et al. [29] also observed that the use of PMIS has a positive impact on the performance perceived by project managers.

Taken together, these studies reveals important observations, but are not quantifying the impacts of project management software packages on the performance of engineering projects. The objective of this paper is to study, based on primary sources of project data, the level of use of project management software and its link with the project performance, as well the impact of project characteristics on this relationship.

3. Research methodology

In this section, we first present the operationalization of research variables and then describe the project data and our approach to analyze the data.

3.1 Research variables

Data on project characteristics, system utilization and project performance were obtained by a large international engineering firm. Table 2 presents the variables considered in this study. The choice in research variables is consistent with measures used in the existing literature on the impacts of project management software packages [15],[29],[30].

System utilization is measured with two metrics: software usage time and subsystem intensity of use. The usage time of the software corresponds to the total time of usage of the system (in days) over the duration of the project. To measure the intensity of use of a subsystem, the following ratios are used: the number of times a user is connected to a subsystem, divided by:

- The project duration (working days);
- The budget of the project for activities executed by the firm (hours);
- The duration of use of the subsystem, for the duration of the project (days);
- The size of the project (number of work packages); and
- The number of persons in the project team.

To define if a subsystem is used or not, we used the subsystems utilization criteria of the firm. For example, the *Document Control* subsystem is used if documents are listed in the subsystem. Table 3 summarizes the criteria for using the subsystems of the project management software.

The subsystems *Activity planning* and *Document management* are not treated in this study because they were used independently from the software. Project performance is calculated using the earned value management method. This indicator, called *Cost Performance Index* (CPI), corresponds to the ratio of the budget cost of work performed to the actual cost of work performed (in working hours of the project team). Table 4 presents the threshold tests used by the firm in determining the performance of a project. The CPI threshold values *a* and *b* are fixed by the firm.

Table 2. Research variables

Project characteristics	System utilization	Project performance
▪ Budget of the project for activities executed by the firm (hours) ▪ Budget of the project for activities executed by the key departments of the firm: project management, engineering, procurement and construction (hours) ▪ Duration of the project (working days) ▪ Project size (work packages) ▪ Number of persons in the project team	▪ Use (yes/no) of the subsystems ▪ Frequency of use of the software: o Number of hits on the software o Number of hits on the subsystems ▪ Duration of use of the subsystems (days)	▪ Project performance indicator, for activities executer by the firm (working hours)

Table 3. Criteria for use of the project management software subsystems

Subsystems	Subsystems utilization criteria
Project definition	This subsystem is always used in project management as it is the basis for the creation of projects in the software databases
Environment management	Management plans and training activities are present in the subsystem
Health and safety management	Management plans and activities are present in the subsystem
Estimating process management	Data concerning estimations are present in the subsystem
Working hours management	Tasks are defined in the subsystem
Document control	Documents are listed in the subsystem
Engineering process management	Data regarding engineering material are present in the subsystem
Procurement management	Procurement items associated with the material can be found in the subsystem
Cost management	Data concerning order forms or contracts can be found in the subsystem
Construction activity management	Construction activities are defined in the subsystem

Table 4. CPI performance levels

Performance levels	Description
CPI > a	Excellent performance
$a \geq$ CPI > 1	Good performance
CPI = 1	In accordance with the budget
$b \leq$ CPI < 1	Improvements required
CPI < b	Corrective measures needed

3.2 Project data

Aggregated data from 21 engineering projects executed (or being implemented) by the partner firm were collected. The data collection process was conducted between April and October 2012. Table 5 presents the data collected on the 21 projects and the statistics describing the sample data.

For all projects, the following subsystems were used: *Project definition*, *Working hours management*, *Document control*, *Procurement management*, *Cost management*, *Construction activity management* (contract definition). The following modules were used in some of the projects considered: *Estimating process management*, *Engineering process management*, and *Construction activity management* (contract follow-up). The subsystem *Document management* was not treated in this study because it was used independently from the project management system.

Table 5. Data collected and descriptive statistics

Project	**Project duration (working days)**	**Budget[1] (hours)**	**Project size (work packages)**	**Number of persons**	**CPI (working hours)**
1	547	445 732	227	297	0.83
2	1339	2 058 387	1092	414	0.91
3	947	97 233	144	79	1.02
4	1304	80 844	8	36	0.62
5	1531	342 277	1023	55	0.87
6	1022	27 949	99	71	0.78
7	1217	103 738	175	57	0.93
8	1329	127 446	420	62	0.99
9	2022	208 500	275	128	0.84
10	1819	292 425	407	57	1.03
11	1968	230 961	297	52	0.76
12	1217	99 471	254	143	0.94
13	674	467 879	21	35	0.88
14	1198	2 239 759	322	257	0.90
15	1803	91 019	105	40	0.85
16	3029	779 107	411	86	0.77
17	1041	206 295	189	80	0.76
18	2082	552 023	360	74	0.78
19	1534	37 453	61	45	1.04
20	2229	431 453	241	62	0.89
21	2217	760 818	682	101	0.97
Mean score	1527.1	460 989	324.43	106.24	0.88
Standard deviation	594.74	603 757.64	290.53	98.05	0.11

[1] Budgeted hours for activities executed by the firm.

3.3 *Data analysis*

Statistical tests were performed in SPSS using project data from an engineering construction firm recognized internationally. The analysis is based on the concept of ‘fit as profile deviation’ [30], which assumes that the degree of adherence (or fit) to an ideal profile is positively related to performance. We build upon a methodological approach developed by Lefebvre and Lefebvre [30] to identify a best-performing profile among a group or a sector. Based on their recommendation, we use the mean scores to establish a ‘calibration sample’, usually defined as the top 10 percent of a group [31]. Deviations from this ideal profile should impact performance. As highlighted by Lefebvre and Lefebvre [30], such an empirically derived profile is close to the concept of strategic benchmarking, rather straightforward and intuitively appealing.

In this study, in order to identify an ideal profile, the mean scores on system utilization are considered from a calibration sample, defined as the best-performing projects of the sample of 21 projects in terms of performance. Three subsamples are derived from the sample of projects. We considered the value of the CPI on all projects, and defined, based on the CPI threshold values determined by the firm, that the best-performing projects (CPI > a) represent the calibration sample (n1 = 6). Considering the sampling of the 21 projects, this is slightly more than the 25 top percent. The study sample consists of all the remaining projects with the exception of the less-performing projects (CPI < b), which corresponds to the bottom 25 percent. Removal of the less-performing projects is necessary to obtain an unbiased sample domain [30]. The study sample is therefore composed of 10 projects (n2 = 10), and the size of the less-performing group is five projects (n3 = 5).

4. Results

Statistical tests were conducted in four phases. First, the comparison of the mean scores on the software usage time of projects from the calibration sample allows for the identification of an ideal usage profile. In the second phase, we identify the core subsystems of the best projects. We also examine the relationships between the intensity of use of the subsystems and project performance. Significant positive correlation coefficients are expected since high usage levels would normally result in good performance. In the third phase, relationships between project characteristics and software utilization are analyzed. This provides a better understanding of the critical factors affecting project management software utilization. Finally, the last phase serves to highlight the perceptions of system users that appear to have a significant impact on the performance of projects.

4.1 *Phase I: Software usage time*

Table 6 presents the mean score from the level of use of the software package for each group (less, group of study and best), as well as levels of significance of bilateral tests for the differences in means. The Mann-Whitney test (non-parametric test of differences in means) is used here since the distribution of the population is unknown and the sizes of the three subsamples are small.

Table 6. Mean usage time per group

Mean scores			**Mann-Whitney**		
Less (1)	**Study (2)**	**Best (3)**	**1-3**	**2-3**	**1-2**
7.699	121.359	51.900	0.03**	NS	0.055*

NS - Not significant *p < 0.10 **p < 0.05

The results show that, at the significance level based on 0.05, the projects in the best-performing group display a significantly higher mean score from the level of use than the one of the less-performing group. Similarly, one can observe (at the significance level of 0.10) that there is a real difference between the level of use of the study group and that of the less-performing group. However, the mean score of the level of use of the study group is higher than that of the best group, although not significantly. We give a detailed explanation of this result in the next section.

We also examined the relationship between the level of use of the software and the CPI of the projects. As hypothesized, a significant positive correlation coefficient was obtained (Spearman correlation coefficient $r = 0.396$, $p < 0.05$): the more the usage time of the software increases, the better the CPI of the project is. This result is consistent under the observations made in the literature [28],[29],[32].

4.2 Phase II: Subsystems intensity of use

Table 7 presents, for each subsystem, the mean score on the intensity of use within each group (best, study and less-performing) as well as levels of significance of bilateral tests for the differences in means (Mann-Whitney). The ratio considered corresponds to the number of times a user is connected to a subsystem, divided by the project duration.

Table 7. Subsystems intensity of use: mean scores[1]

	Mean scores			**Mann-Whitney**		
Subsystems	**Less (1)**	**Study (2)**	**Best (3)**	**1-3**	**2-3**	**1-2**
Project definition	0.297	2.497	1.337	0.082*	NS	0.075*
Estimating process management	0.106	1.032	0.139	NS	NS	NS
Working hours management	0.339	5.356	1.778	NS	NS	0.028**
Document control	2.015	28.014	16.365	0.030**	NS	0.040**
Engineering process management	0.521	10.144	0.860	NS	NS	NS
Procurement management	1.456	25.084	3.032	NS	NS	0.075*
Cost management	2.428	33.850	17.230	0.030**	NS	0.040**
Construction activity management (contract follow-up)	0.480	3.012	10.094	NS	NS	NS
Construction activity management (contract definition)	0.522	15.139	10.517	0.030**	NS	0.008***

NS - Not significant   *$p < 0.10$ **$p < 0.05$ ***$p < 0.01$
[1] Ratio used to measure the intensity of use: number of hits on the subsystem, divided by project duration

Results show that projects in the calibration sample display significantly higher mean scores than projects in the less-performing group for almost half of the subsystems (4 out of 9). Also, for two thirds of the subsystems (6 out of 9), the intensity of use related to the less-performing group differs significantly from that of the study sample. Finally, we note that there is no real difference between the level of use of the *Estimating process management* subsystem by a group and that of another, this subsystem being sometimes maintained using other estimating software packages, independent of the project management software package developed by the firm.

Similar results were obtained with the following ratios:

- Number of connections to a subsystem, divided by the budget of the project for activities executed by the firm (Table 8);
- Number of connections to a subsystem, divided by the duration of use of the subsystem (Table 9).

Table 8. Subsystems intensity of use: mean scores[1]

	Mean scores			**Mann-Whitney**		
Subsystems	**Less (1)**	**Study (2)**	**Bes[t] (3)**	**1-3**	**2-3**	**1-2**
Project definition	0.003	0.010	0.018	NS	NS	NS
Estimating process management	0.001	0.002	0.002	NS	NS	NS
Working hours management	0.004	0.013	0.019	0.082*	NS	0.099*
Document control	0.016	0.092	0.186	0.052*	NS	0.099*
Engineering process management	0.003	0.013	0.008	0.082*	NS	NS
Procurement management	0.009	0.031	0.027	NS	NS	NS
Cost management	0.013	0.102	0.230	0.052*	NS	0.028**
Construction activity management (contract follow-up)	0.002	0.039	0.121	NS	NS	NS
Construction activity management (contract definition)	0.002	0.051	0.123	0.082*	NS	0.003***

NS - Not significant *p < 0.10 **p < 0.05 ***p < 0.01

[1] Ratio used to measure the intensity of use: number of connections to the subsystem, divided by the budget of the project

Table 9. Subsystems intensity of use: mean scores[1]

	Mean scores			**Mann-Whitney**		
Subsystems	**Less (1)**	**Study (2)**	**Best (3)**	**1-3**	**2-3**	**1-2**
Project definition	0.493	2.635	1.387	NS	NS	NS
Estimating process management	0.308	1.087	0.157	NS	NS	NS
Working hours management	0.471	5.730	1.921	NS	NS	0.019**
Document control	3.148	30.066	18.276	0.052*	NS	0.040**
Engineering process management	6.507	10.698	8.578	NS	NS	NS
Procurement management	5.271	27.164	3.577	NS	NS	NS
Cost management	3.830	35.209	18.170	0.052*	NS	0.040**
Construction activity management (contract follow-up)	0.642	3.279	10.940	NS	NS	NS
Construction activity management (contract definition)	0.741	16.357	11.750	0.052*	NS	0.005***

NS - Not significant *p < 0.10 **p < 0.05 ***p < 0.01

[1] Ratio used to measure the intensity of use: number of hits on the subsystem, divided by subsystem duration of use

A three-group analysis (best-performing n1 = 6; study sample n2 = 10; less-performing n3 = 5) also yields significant differences between the means on a three-group basis (Kruskal-Wallis test, Table 10).

Table 10. Three-group analysis

	Kruskal-Wallis		
Subsystems	**Ratio 1[a]**	**Ratio 2[b]**	**Ratio 3[c]**
Project definition	NS	NS	NS
Estimating process management	NS	NS	NS
Working hours management	0.067*	NS	0.062*
Document control	0.057*	0.080*	0.069*
Engineering process management	NS	NS	NS
Procurement management	NS	NS	NS
Cost management	0.057*	0.040*	0.069*
Construction activity management (contract follow-up)	0.099*	0.099*	0.099*
Construction activity management (contract definition)	0.024**	0.022*	0.024**

NS - Not significant *p < 0.10 **p < 0.05
[a] Number of connections to the subsystem, divided by project duration
[b] Number of connections to the subsystem, divided by the budget of the project
[c] Number of connections to the subsystem, divided by subsystem duration of use

However, the scores for all the subsystems, except for the *Construction activity management* (contract follow-up) subsystem, are higher in the study sample than in the ideal profile, although not significantly (see Table 7). This result strongly suggests that, above a certain performance level, system utilization does not allow for the distinction between the project groups and the development of an ideal profile.

We also verified whether the greater mean scores for projects in the study sample could be explained by the fact that the intensity of use of some subsystems is linked to a project's characteristic. Mann-Whitney bilateral tests however showed that the four project characteristic variables are not significantly different across the three subsamples (Table 11). Moreover, correlation analyses show that project characteristics do not seem to be related to project performance (the correlation coefficients are not significant, Table 12).

Table 11. Project characteristics

	Mean scores			**Mann-Whitney**		
Project characteristics	**Less (1)**	**Study (2)**	**Best (3)**	**1-3**	**2-3**	**1-2**
Project duration	1884.8	1358.2	1510.5	NS	NS	NS
Budget of the project for activities executed by the firm	369 846	641 669	235 808	NS	NS	NS
Project size	253	358	328	NS	NS	NS
Number of persons in the project team	65.60	141.60	81.17	NS	NS	NS

NS - Not significant

Table 12. Relationships between project characteristics and project performance

Project characteristics	**Correlation coefficients**[a]	**P**[b]
Project duration	- 0.036	NS
Budget of the project	- 0.057	NS
Project management budget	0.221	NS
Engineering budget	0.056	NS
Procurement budget	0.243	NS
Construction budget	- 0.114	NS
Project size	0.168	NS
Number of persons in the project team	0.057	NS

NS - Not significant
[a] Spearman correlation coefficients
[b] Levels of significance for unilateral tests

Table 13 sheds some additional light on the relationship between project performance and the intensity of use of the subsystems.

Table 13. Relationships between project performance and subsystems intensity of use[1]

Subsystems	**Correlation coefficients**	**P**
Project definition	0.295	$p < 0.1$
Estimating process management	- 0.037	NS
Working hours management	0.244	NS
Document control	0.331	$p < 0.1$
Engineering process management	0.191	NS
Procurement management	0.248	NS
Cost management	0.445	$p < 0.05$
Construction activity management (contract follow-up)	0.339	$p < 0.1$
Construction activity management (contract definition)	0.443	$p < 0.05$

NS - Not significant
[1] Ratio used to measure the intensity of use: number of hits on the subsystem, divided by project duration

As hypothesized (except for the *Estimating process management* subsystem), the correlation coefficients are positive and five are significant: the more the intensity of use of these subsystems increases, the better the CPI of the project is. Also, the correlation coefficients for the *Cost management* and the *Construction activity management* subsystems show stronger links to project performance than is observed for the *Project definition* and the *Document control* subsystems. The latter can be considered as a priori subsystems for project management. Once these are acquired, the *Cost management* and the *Construction activity management* subsystems may lead to superior project performance.

Therefore, project performance depends not only on the use of the *Project definition* and *Document control* subsystems, but also on *Cost management* and *Construction activity management* subsystems.

Similar results were obtained with the other four ratios used to measure the intensity of use of the subsystems (Table 14).

Table 14. Relationships between project performance and subsystems intensity of use

Subsystems	**Correlation coefficients**			
	Ratio 2[a]	**Ratio 3[b]**	**Ratio 4[c]**	**Ratio 5[d]**
Project definition	0.266[NS]	0.161[NS]	0.144[NS]	0.291[NS]
Estimating process management	- 0.060[NS]	- 0.043[NS]	- 0.049[NS]	- 0.043[NS]
Working hours management	0.227[NS]	0.217[NS]	0.158[NS]	0.210[NS]
Document control	0.314*	0.290[NS]	0.113[NS]	0.360*
Engineering process management	0.265[NS]	0.101[NS]	0.070[NS]	0.192[NS]
Procurement management	0.240[NS]	0.227[NS]	0.121[NS]	0.218[NS]
Cost management	0.494**	0.401**	0.366*	0.535***
Construction activity management (contract follow-up)	0.317*	0.342*	0.342*	0.328*
Construction activity management (contract definition)	0.466**	0.434**	0.425**	0.516**

[NS] NS - Not significant *p < 0.10 **p < 0.05 ***p < 0.01
[a] Ratio 2: number of connections to the subsystem, divided by the budget of the project
[b] Ratio 3: number of hits on the subsystem, divided by subsystem duration of use
[c] Ratio 4: number of hits on the subsystem, divided by project size
[d] Ratio 5: number of hits on the subsystem, divided by the number of persons in the project team

Finally, we also tested the impact of the nature of the subsystems used on the performance of projects. Correlation analyses show that an increasing statistical relationship exists between the use (yes/no) of the *Construction activity management* subsystem and the performance of the projects: when the subsystem *Construction activity management* is used, the CPI value seems to increase (Table 15). We note that only the *Estimating process management*, *Engineering process management* and *Construction activity management* subsystems were considered in the analysis, as these subsystems are the only ones presenting a variation in their use (yes/no). The other subsystems are not taken into account since they have always been used for the management of all projects (mean score = 1.0, standard deviation = 0).

Table 15. Relationships between project performance and use (yes/no) of three subsystems

Subsystems	**Correlation coefficients**
Estimating process management	- 0.079[NS]
Engineering process management	0.000[NS]
Construction activity management	0.300*

NS - Not significant *p < 0.10

Moreover, at the significance level of 0.01, results show that, for each subsystem, there is no real difference between the use (yes/no) of the subsystem by a group and that of another (Table 16).

Table 16. Use (yes/no) of three subsystems

Subsystems	**Mean scores**			**Mann-Whitney**		
	Less (1)	**Study (2)**	**Best (3)**	**1-3**	**2-3**	**1-2**
Estimating process management	0.600	0.600	0.500	NS	NS	NS
Engineering process management	0.800	1.000	0.833	NS	NS	NS
Construction activity management	0.200	0.200	0.667	NS	NS	NS

NS - Not significant

We also conducted Mann-Whitney tests for the difference in means on the following ratios:

- Ratio of number of users per subsystem;
- Ratio of number of persons who received training.

However, results show that there is no significant difference in means between the three groups.

4.3 Phase III: Project characteristics

Table 17, which summarizes the relationships between project characteristics and system usage time, on one hand, and the intensity of use for each subsystem, on the other hand, reveals some interesting results. First, project duration seems to be the most critical characteristic, as increase in project duration is related to lower system usage time. Similarly, negative correlation coefficients are observed between project duration and the intensity of use of the subsystems and most of them are statistically significant (6 out of 9). Moreover, the budget of the project for activities executed by the engineering department seems to have a significant positive impact on the usage time of the software and the intensity of use of its subsystems. In fact, the larger the budget of the engineering department, the more the project management software and nearly all subsystems (7 out of 9) appear to be used. The number of persons involved in the project management team also seems to have a significant positive impact on system utilization: the more the number of persons increases in the project team, the more the software, as well as four of its subsystems, appear to be utilized.

- Although the other project characteristics variables (budget of the project for activities executed by the firm, budget for activities executed by the project management, procurement and construction departments, project size) do not appear to be linked with system usage time (the correlation coefficients are not significant), results stemming from Table 17 nevertheless show that these characteristics can actually be related to the intensity of use of the subsystems. Indeed, for these characteristics, the following results are observed:
- The larger the budget of the project, for activities executed by the firm, the more the *Engineering process management* and *Procurement management* subsystems appear to be utilized (the correlation coefficients are positive and significant);
- The more the budget of the project is substantial, for activities executed by the project management, procurement and construction departments, the more the *Estimating process management* subsystem seems to be used;

- The more the budget of the project increases (for activities executed by the firm and by the project management, procurement and construction departments), the less the *Construction* (contract definition) subsystem appears to be used (the correlation coefficients are negative and significant);
- The larger the budget for activities executed by the construction department, the less the *Project definition* and *Working hours management* subsystems seem to be utilized;
- The more the number of project work packages increases, the more the *Estimating process management*, *Engineering process management* and *Procurement management* subsystems appear to be used.

Table 17. Relationships[1] between project characteristics and system utilization

	Project duration	**Budget of the project [2]**	**Budget project management**	**Budget engineering**	**Budget procurement**	**Budget construction**	**Project size**	**Number of persons**
System usage time	- 0.501**	NS	NS	0.460**	NS	NS	NS	0.379**
Subsystems intensity of use[3]								
Project definition	- 0.683**	NS	NS	0.325*	NS	- 0.391*	NS	NS
Estimating process management	NS	NS	0.642**	NS	0.590**	0.411*	0.362*	0.391**
Working hours management	- 0.685**	NS	NS	0.421**	NS	- 0.477**	NS	NS
Document control	- 0.486**	NS	NS	0.444**	NS	NS	NS	0.441**
Engineering process management	NS	0.456**	NS	0.658**	NS	NS	0.387**	NS
Procurement management	- 0.325*	0.431**	NS	0.597**	NS	NS	0.384**	NS
Cost management	- 0.479**	NS	NS	0.391**	NS	NS	NS	0.350*
Construction activity management (contract follow-up)	NS	- 0.420**	- 0.408*	NS	- 0.432*	- 0.432*	NS	NS
Construction activity management (contract definition)	- 0.503**	NS	NS	0.323*	NS	NS	NS	0.429**

NS - Not significant   *$p < 0.10$ **$p < 0.05$
[1] Spearman correlation coefficients
[2] Budget of the project for activities executed by the firm
[3] Ratio used to measure the intensity of use: number of hits on the subsystem, divided by project duration

Similar results on the relationships between project characteristics and subsystems intensity of use were obtained from the following four ratios:

- Number of connections to the subsystem, divided by the budget of the project (Table 18);
- Number of connections, divided by the duration of use of the subsystem (Table 19);
- Number of connections, divided by the size of the project (Table 20);
- Number of connections, divided by the number of persons in the project team (Table 21).

Table 18. Relationships between project characteristics and subsystems intensity of use[1]

Subsystems	Project duration	Budget of the project	Budget project management	Budget engineering	Budget procurement	Budget construction	Project size	Number of persons
Project definition	- 0.563**	- 0.627**	- 0.584**	- 0.325*	- 0.615**	- 0.704**	- 0.383**	NS
Estimating process management	NS	NS	0.545**	NS	0.473**	NS	NS	0.307*
Working hours management	- 0.666**	- 0.495**	- 0.469**	NS	- 0.479**	- 0.718**	- 0.294*	NS
Document control	- 0.446**	- 0.522**	- 0.531**	NS	- 0.477**	- 0.656**	NS	NS
Engineering process management	NS	NS	NS	0.365*	NS	- 0.579**	0.395**	NS
Procurement management	NS	NS	NS	0.395**	NS	- 0.511**	0.378**	NS
Cost management	- 0.445**	- 0.361*	NS	NS	NS	- 0.395*	NS	NS
Construction activity management (contract follow-up)	NS	- 0.499**	- 0.408*	- 0.337*	- 0.432*	- 0.432*	NS	NS
Construction activity management (contract definition)	- 0.437**	- 0.313*	NS	NS	NS	NS	NS	NS

NS - Not significant *p < 0.10 **p < 0.05
[1] Ratio used to measure the intensity of use: number of connections to the subsystem, divided by the budget of the project for activities executed by the firm

Table 19. Relationships between project characteristics and subsystems intensity of use[1]

Subsystems	Project duration	Budget of the project	Budget project management	Budget engineering	Budget procurement	Budget construction	Project size	Number of persons
Project definition	- 0.709**	NS	NS	0.297*	NS	NS	NS	NS
Estimating process management	0.317*	0.314*	0.672**	NS	0.626**	0.477**	0.383**	0.377**
Working hours management	- 0.677**	NS	NS	0.396**	NS	- 0.441**	NS	NS
Document control	- 0.452**	NS	NS	0.412**	NS	NS	NS	0.431**
Engineering process management	NS	NS	NS	0.352*	NS	- 0.388*	NS	NS
Procurement management	NS	0.456**	NS	0.595**	NS	NS	0.416**	NS
Cost management	- 0.418**	NS	NS	0.371**	NS	NS	NS	0.321*
Construction activity management (contract follow-up)	NS	- 0.417**	- 0.408*	NS	- 0.432*	- 0.432*	NS	NS
Construction activity management (contract definition)	- 0.376**	NS	NS	0.353*	NS	NS	0.299*	0.485**

NS - Not significant *p < 0.10 **p < 0.05
[1] Ratio used to measure the intensity of use: number of connections divided by the duration of use of the subsystem

Table 20. Relationships between project characteristics and subsystems intensity of use[1]

Subsystems	**Project duration**	**Budget of the project**	**Budget project management**	**Budget engineering**	**Budget procurement**	**Budget construction**	**Project size**	**Number of persons**
Project definition	- 0.681**	- 0.352*	NS	NS	NS	- 0.375*	- 0.566**	NS
Estimating process management	NS	NS	0.600**	NS	0.557**	0.422*	0.312*	0.381**
Working hours management	- 0.748**	NS	NS	NS	NS	- 0.495**	- 0.438**	NS
Document control	- 0.655**	NS	NS	NS	NS	- 0.454**	- 0.390**	NS
Engineering process management	- 0.321*	0.391**	NS	0.588**	NS	NS	NS	NS
Procurement management	- 0.340*	0.394**	NS	0.562**	NS	NS	NS	NS
Cost management	- 0.632**	NS	NS	NS	NS	NS	- 0.297*	NS
Construction activity management (contract follow-up)	NS	- 0.502**	- 0.408*	- 0.343*	- 0.432*	- 0.432*	NS	NS
Construction activity management (contract definition)	- 0.601**	NS	NS	NS	NS	NS	NS	NS

NS - Not significant *p < 0.10 **p < 0.05
[1] Ratio used to measure the intensity of use: number of connections divided by the project size

Table 21. Relationships between project characteristics and subsystems intensity of use[1]

Subsystems	**Project duration**	**Budget of the project**	**Budget project management**	**Budget engineering**	**Budget procurement**	**Budget construction**	**Project size**	**Number of persons**
Project definition	- 0.498**	NS	NS	NS	NS	- 0.563**	NS	NS
Estimating process management	0.324*	NS	0.624**	NS	0.572**	0.393*	0.371**	0.325*
Working hours management	- 0.608**	NS	NS	NS	NS	- 0.552**	NS	NS
Document control	- 0.451**	NS	NS	NS	NS	- 0.424*	NS	NS
Engineering process management	NS	0.414**	NS	0.604**	NS	- 0.416*	0.432**	NS
Procurement management	NS	0.442**	NS	0.569**	NS	NS	0.426**	NS
Cost management	NS	NS	NS	NS	NS	NS	NS	NS
Construction activity management (contract follow-up)	NS	- 0.405**	- 0.408*	NS	- 0.432*	- 0.432*	NS	NS
Construction activity management (contract definition)	- 0.295*	NS	NS	NS	NS	NS	NS	NS

NS - Not significant *p < 0.10 **p < 0.05
[1] Ratio used to measure the intensity of use: number of connections divided by the number of persons in the project team

Table 22 provides similar results on the relationships between project characteristics and the use (yes/no) of three subsystems.

Table 22. Relationships between project characteristics and use (yes/no) of three subsystems

Subsystems	**Project duration**	**Budget of the project**	**Budget project management**	**Budget engineering**	**Budget procurement**	**Budget construction**	**Project size**	**Number of persons**
Estimating process management	0.580**	0.334*	0.617**	NS	0.622**	0.590**	0.397**	0.350*
Engineering process management	NS	0.455**	NS	0.402**	NS	NS	0.482**	0.429**
Construction activity management	NS	- 0.417**	- 0.365*	NS	- 0.386*	- 0.386*	NS	NS

NS - Not significant *p < 0.10 **p < 0.05

4.4 Phase IV: Users' perception of the project management software

The perceptions of the users of the project management software were collected from eleven project managers by means of a questionnaire. The results shown in Table 23 indicate that, for the best-performing projects, the users appear to have a better perception of the system in terms of the quality of information provided by the system and its ease of use.

Table 23. Users' perception of the project management software

Perceptual factors	**Mean scores**[1]		
	Less (n_1 = 1)	**Study (n_2 = 7)**	**Best (n_3 = 3)**
Perceived impact of system utilization on project performance	5,2	5,6	5,6
Functionality of the system	4,8	4,8	4,7
Information quality	3,9	5,1	**5,6**
Ease of use of the system	3,7	4,1	**4,8**

[1] Mean values of the responses on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree)

Furthermore, as regards the quality of information provided by the system and its ease of use, the analysis of the questionnaire replies revealed that, for the less-performing projects, project managers seem to perceive that the system does not necessarily provide simple information free of errors, that the system is not very user-friendly and that the use of the system is quite time consuming. Table 24 provides additional results on the relationships between perceptual factors and project performance.

Table 24. Relationships between perceptual factors and project performance

Perceptual factors	**Correlation coefficients**[1]	**P**[2]
Perceived impact of system utilization on project performance	0.179	NS
Functionality of the system	0.092	NS
Information quality	0.516*	0.05
Ease of use of the system	0.562**	0.04

NS - Not significant *p < 0.10 **p < 0.05
[1] Spearman correlation coefficients
[2] Levels of significance for unilateral tests

Two correlation coefficients are significant: the better the perception of the users of the project management software is, in terms of information quality and ease of use of the system, the more the value of the cost performance index of the project seems to increase.

However, correlation analyses between perceptual factors and system utilization show that the perception of the users of the project management software does not appear to be linked to the level of use of the system or the intensity of use of the subsystems.

5. Discussion and concluding remarks

This paper focuses on level of use of a project management software package, developed by an engineering construction firm, and its relationship with project performance and project characteristics. Statistical tests were performed on the basis of quantified data resulting from 21 large engineering projects executed by the firm.

Overall, the results suggest that the less-performing projects present significantly lower system utilization levels than the other projects. This finding corroborates the findings of Raymond and Bergeron [28]. However, system utilization for the best-performing projects is not significantly different from projects in the study sample. This result can be explained by the fact that, above a certain performance level, system utilization does not allow for the development of a distinct profile from the best-performing projects.

Also, the performance of the projects appears to be linked to the usage time of the software: the more the software usage time increases, the better the CPI of the project is. Similarly, project performance also seems to be related to the intensity of use of four software subsystems: *Project definition*, *Document control*, *Cost management* and *Construction activity management*. The more intensively one or the other of these subsystems is used, the better the CPI of the project is. These subsystems are used to support project management processes requiring an important effort from the project management team, due to the amount of data required by these processes. These subsystems interact intensively with each other and are designed to be used together. This result seems to demonstrate the need to use a minimal subset of subsystems which can be referred as the core elements of integrated project management software. This result is consistent with findings related to the use of other integrated software, such as ERP system, where some key modules (e.g., finance and logistic modules) are tightly integrated, which provide in return the most important benefits for the organization. Key modules are often implemented first, while the other peripheral modules can be discarded or implemented in subsequent phases.

In addition, project duration seems to be the most critical characteristic, as increase in project duration seems to be related to lower system utilization.

Finally, the perception of the users of the project management software does not seem to be related to the level of use of the system or the intensity of use of the subsystems. However, for the best-performing projects, which present significantly high system utilization levels (see Sections 4.1 and 4.2), users seem to have a better perception of the system in terms of information quality and ease of use of the system. This finding is consistent with the observations made in the literature: the more the information provided by the system is perceived as being of high quality, the more users intend to use the system [27],[29],[32]. Also, the ease of use of the system appears to be related to the intention to use the software [29].

For project management practitioners, these findings provide four broad insights for in the initial phases of engineering projects. First, the selection of subsystems to be used for supporting one project should be guided by business process integration objectives and not decided based on function requirements. Second, the selection of subsystems to be used must favour the support of data intensive processes. Third, when monitoring projects, project managers should ensure that core subsystems are used at a high level (not necessarily the highest level as displayed in Table 7) to maintain good performance. Fourth, the use of parallel software or databases for conducting similar activities should be avoided. Training and monitoring activities should therefore be planned with care in the initial phases of projects in order to maximize the use of the core subsystems. Our observations show that lack of training is a common reason for bringing users to work with parallel systems.

Although this study provides insight into the use of project management software and its relationship with project performance and project characteristics, it has limitations and results may be interpreted with caution. First, the sample size is small (n = 21). A project is "a temporary endeavor undertaken to create a unique product, service, or result" [33]. As each project is unique with its own characteristics, a larger sample would be required to generalize our findings on all projects. Also, only one project performance indicator is considered in this study: the Cost Performance Index (CPI) for the working hours of the firm. However, project performance is often defined in terms of schedule, scope and cost. Thus, we may have obtained different results with other project performance indicators. Some subsystems could offer a higher control of the baseline which could be consistent with a better performance of project duration. Other project performance indicators should therefore be considered in future studies.

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Scorecard and KPIs for monitoring software factories effectiveness in the financial sector

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Abstract:
Financial corporations and especially banking institutions have important needs concerning to the development of software around their business core. The software, that traditionally had been developed in house by the IT departments, is now usually outsourced to IT firms. These firms work under the software factories model. An important feature within this sector is that usually the financial groups keep the ownership of these firms because the strategic value of the software for the core business. These firms work almost exclusively for the owner financial group developing their software, but they have to demonstrate that they are so profitable and competitive like any other firm. The organizational structure of these firms has some differential features. Top level tasks (software design and project management) are usually performed by the IT firm but the development is usually subcontracted to other software companies. Although financial corporations have always paid a special interest to investing in management and organizational policies to improve their efficiency, there have being always an important lack regarding to the control and monitoring of the software projects. They do not have suitable tools for monitoring actual process effectiveness. Adapting scorecards to this environment could be a useful tool for monitoring and improvement the process. Scorecard could here be used both as a tool for internal effectiveness measurement as well as externally, presenting sustainability indicators for the shareholders, the financial institutions. This paper aims to identify and define a collection of Key Performance Indicators which permit effectiveness to be improved under this context, focusing in the specific supply-chain model given by owner (financial group), software factory and software developers (subcontracted).

Keywords:
Software Factory; financial software development; Balanced Scorecard; KPIs; efficiency.

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1. Introduction

Financial corporations and especially banking institutions require a great deal of software development. The development of business applications represents more than 50% of the IT budget [1]. Traditionally, banking is the sector which not only requires the highest level of software development, but which also has a higher tendency to externalize the development of projects of that type. They had large IT departments where the business software was developed, but following the modern managerial trends, now it is outsourced to external firms. Most of these firms were created by the financial groups in the beginning of the two thousand and usually they have kept the ownership and control because the extreme importance of the software for the core business. So these firms work also exclusively for the matrix financial group, but they have to demonstrate to be more competitive than other firms. In addition, financial institutions have pushed these firms to reduce cost, which has obliged them to search for new productive models in order to remain competitive. Most of them have followed the “software factory” model. A software factory applies manufacturing techniques and principles to software development to mimic the benefits of traditional manufacturing.

Financial sector have always paid a special interest to investing in management and organizational policies to improve their efficiency. Finance and banking are one of the sectors in which more effort has been applied for measuring productivity in all of their departments. However, their weakest point is still the measurement and monitoring of the productivity of the development of the software projects that support its main core activity. One of the reasons why this productivity is not being suitable analyzed is due to the software nature of intangible. This lack has been also transferred to the software firms. The firms pay according to the estimated effort it takes to be produced and not according to the quantity and quality of the actual software produced. This model eventually involves a further increase in costs for the project.

Usually these firms perform the top level design and control of the projects, but the development is usually subcontracted to other companies specialized in software development. This structure appears as a natural reaction from the financial groups for keeping the control of their software. Subcontracting the development is the usual strategy for minimizing costs. Nowadays, the financial groups are pushing their software firms to cut cost, who are also pressing their subcontractors to reduce costs. As reaction of this context, the subcontractors have explored several strategies for cutting costs, some of them lying in a loss of quality. For instance, they have created offshore software factories. The creation of these software factories is justified as a way of increase productivity and efficiency. However, the reality could not be more different. Realistically, the truth of the matter is that there are evidences which tell us that there is a reduction in costs by employing a cheaper workforce but with a loss of quality in most cases. These facts remark the need of controlling and monitoring systems from the side of the contractor, the software factories of the financial groups.

The explored way in this work for improving this process is based on scorecard approach. Key Performance Indicators (KPIs) accommodated in scorecards is an usual tool within the strategic management, but is rarely used effectively in the field of software projects, which are more commonly evaluated by productivity assessment metrics linked to the generation of code as the "number of lines of code" or "function points" [2]. This work aims to identify and define a collection of Key Performance Indicators which permit effectiveness to be measured in these types of organizations in this supply-chain context. The different key indicators are conveniently set in a specific scorecard that allows decision-making associated with top level project portfolio management.

The context where we study was carried out is introduced in the background section. Special consideration is done regarding to the structure of these kind of Software Factories and their features. The basis of the Balanced Scorecard is also introduced. Then the suggested model is described in section 3, grouping the identified KPIs in six perspectives: financial; customer; human resources and growth; productivity; software quality-quality in use; software quality-product quality. Each perspective is summarized in a table including the KPI formulation. Finally conclusions and future work is described in the final section.

2. Background

The Software Factory is generally defined as the workplace where software is developed using techniques and principles associated with traditional industrial production. The Software Industry needs to become similar to the industrialized software manufacturing process in order that it is able to provide everything the market expects today related to efficiency, fast delivery and quality in all industrial products. Such transformation requires significant changes in the industry, but the sooner they are carried out, them the actors will gain larger competitive advantages [3]. Software engineering seems not to have made use of the latest technological advanced in software production [4].

Although the term Software factory was first introduced in 1968, it is due to the recent social, economic and technological circumstances that the term Software factory becomes notorious again among the software sector [5]. Authors like Greenfield et al. [6], from Microsoft, use the concept of the Software factory as a structured collection of related software assets that assists in producing computer software applications or software components according to specific, externally-defined end-user requirements through an assembly process. The aim of a Software factory is the improvement of productivity and quality, scale production and the maintenance of software development control [7]. The Software Industry is turning into a new business model, where the different centers work together to achieve objectives and developments.

The term software factory had already been used by 1975 when Harvey Bratman and Terry Court, from the System Development Corporation, described in one of their papers the challenge of developing an integrated set of software development tools to support a disciplined and repetitive approach to software development. This effort was a part of a large program to increase software reliability and control software production cost using standard engineering techniques. This study, which attempted in part to correlate program productivity and experience, identified the lack of a methodical and well founded body of knowledge on the software development process. The most significant problems that contributed to this shortcoming were:

- Lack of discipline and repetitiveness;
- Lack of development visibility;
- Lack of design and verification tools;
- Lack of software reusability.

Despite the introduction and use of new techniques and methodologies about software development, the fact is that for more than 30 years after the introduction of software factory concept, and even today, many of the initial issues and other problems associated with them (systematic reuse, assembly development, model-driven development and process frameworks) cannot been resolved yet [6].

Nowadays, there is a great deal of pressure on software delivery organizations to produce more software at a faster rate in the context of extreme cost pressure and growing globalization of the software delivery organization. The concept of a software factory is beginning to emerge as one way to address these challenges. The principles of software factory are necessary for enterprise software delivery to propose faster deliveries, reduce cost and increase software quality [8].

Many companies have experienced a great deal of change over the past few years due to evolution of the business environment, financial upheavals, societal changes and technical advancement. The key to addressing these changes has been analysis of the core business processes to see how they can be refined and optimized, followed by a restructure of those business processes to better meet the new context.

At the same time, IT groups have been forced to lower operating costs across the organization. The direct implication is that they must not only minimize waste and inefficiency, but increase productivity and relevance to the businesses they serve.

This combination of business process restructuring and close focus on delivery efficiency have been seen in many business domains, and has resulted in techniques such as *lean manufacturing*, *supply-chain management*, and *product line engineering*. The application of these ideas in software delivery is what we refer to here as a *software factory approach* to enterprise software delivery [9],[10].

Although there are different development standards to measure in-house development, there is little standardization in evaluating supply-chains and software factories. Standard approaches such as function point analysis and defect density can be applied, but in practice they appear inadequate. With more complex supply-chain delivery models becoming more common, we need metrics that help us address different questions:

- Which software factory is more productive and efficient?
- Which software factory experiences a delay when delivering their products?
- What is the quality of the software delivered?

These and other many other measures need to be defined and an automatic mechanism to collect these metrics must be implemented to help compare results across external providers in real time [8].
This paper works about the presented questions, and its objective is to develop a scorecard and a set of suitable indicators to provide managers answers about the productivity and efficiency in a software factory oriented towards financial sector.

2.1 The software factory architecture, according the software factory processes

The main features of software factories for financial software development are usually the next:

- They work almost exclusively for the owner group;
- These usually have a greater demand of requests;
- The software development process is usually subcontracted to several software companies. However, due to strategic reasons, this does not apply to top level processes such as functional specifications and project management;
- Usually the payments to subcontractors are made according to the number of hours budgeted, and not by the number of hours actually performed.

The usual organizational structure for software factory orientated financial software should not differ substantially from what is presented below, which include the following processes:

- Demand Management, which aims to collect top level user requirements and establish methods for prioritizing demands;
- Functional Analysis, which transforms the identified top level user requirements into functional requirements;
- Technical Analysis, which is responsible for the technical details of the functional specifications which must be implemented;
- Development, which performs the development, construction and assembling of the requested requirements;
- Testing, which has to validate everything that has been implemented;
- Production, which performs the customer deployment;
- Quality, which assesses the global system quality.

In the proposed schema, the development process is subcontracted to several software development firms. On the other hand, the rest of the processes are under the software factory control. Fig. 1 illustrates the usual process followed in this scheme of operation, which is similar as [4].

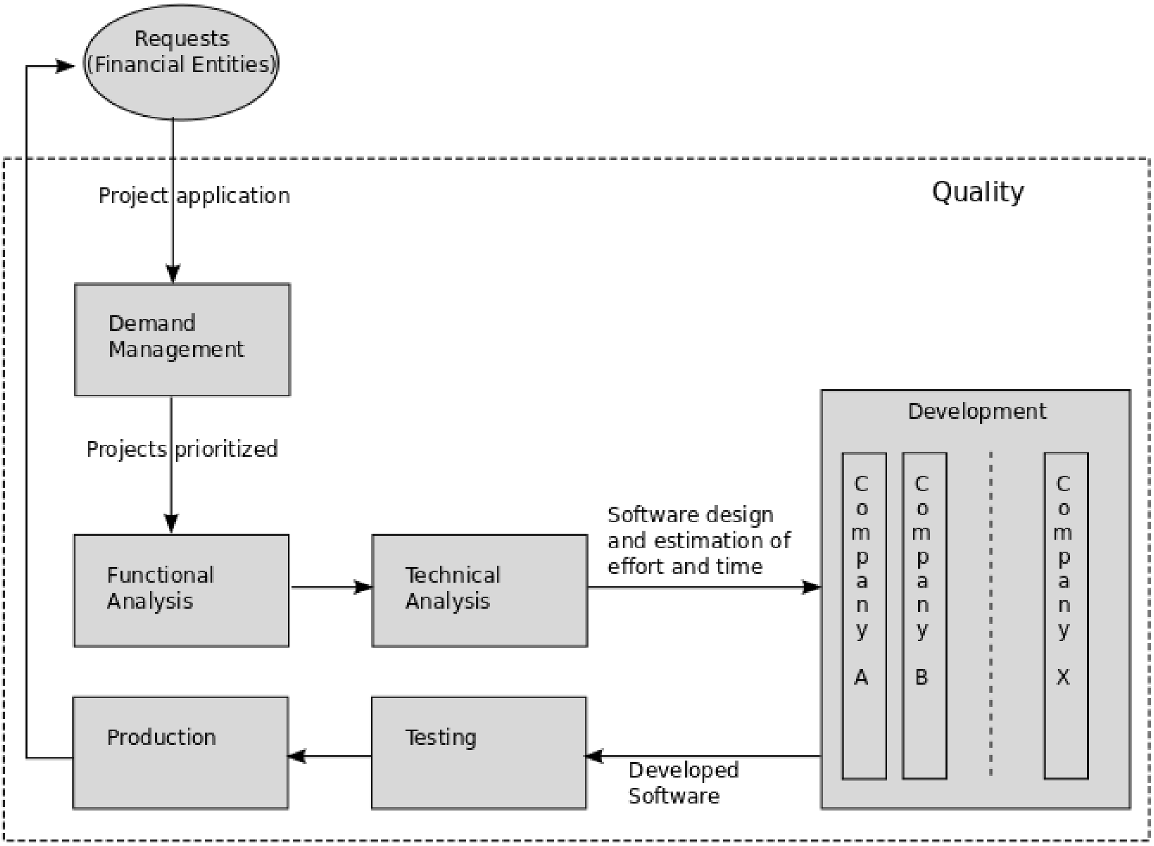

Fig. 1. Map of processes of model for software factory oriented financial sector

The system described involves several different levels of control to evaluate the efficiency. The measuring productivity of the development process is based on metrics as function points, number of defects, etc. All of these methods have been widely studied in the literature, though it is the work of Fenton [11] that most of these practices are based on. These controls are made into development software areas by the outsourced firms.

The proposed scorecard presented here does not incorporate this level, since within the presented context it is the measurement in the top level that is much more interesting. At this level we need to focus on the overall project portfolio and productivity ratios of the whole system. Some of the questions that the scorecard must find and provide answers for are as follows:

- What is the software factory Performance?
- What are the cost and time deviations compared to the estimations?
- What is the employees’ productivity?
- What is the level of customer satisfaction?
- What is the value provided by developers and the rest of the human capital?

2.2 Using scorecard for the efficiency measurement

Organizations have used systems consisting of a mix of financial and non-financial measures to track progress for quite some time. In the mid-1990s, a new method emerged. In the new method, measures are selected based on a set of “strategic objectives” plotted on a “strategic linkage model” or “strategy map”. With this new approach, the strategic objectives are distributed across the four measurement perspectives to form a visual presentation of strategy and measures. This method was named “Balanced Scorecard”. The Balanced Scorecard is a strategy performance management tool - a semi-standard structured report, supported by design methods and automation tools, which can be used by managers to keep track of the execution of activities by the staff within their control and to monitor the consequences arising from these actions. The Harvard Business Review, in its 75th Anniversary issue, cites the Balanced Scorecard as being one of the 15 most important management concepts to have been introduced via articles in the magazine. Since its introduction in 1992, the Balanced Scorecard has featured in a wealth of academic and practitioner papers, and has been the subject of several bestselling books.

The Balanced Scorecard was originally proposed as an approach to performance measurement that combined traditional financial measures with non-financial measures to provide managers with richer and more relevant information about organizational performance, particularly with regard to key strategic goals [12].

By encouraging managers to focus on a limited number of measures drawn from four “perspectives”, the original Balanced Scorecard aimed to encourage clarity and utility. Over time Balanced Scorecard has developed to form the center-piece of a strategic communication and performance measurement framework that helps management teams articulate, communicate and monitor the implementation of strategy using a system interlinked with the long-term destination of the organization. More recent insights suggest that a successful Balanced Scorecard implementation will require adjustments to be made to other management processes used by the enterprise. Only in so doing will the Balanced Scorecard be able to become a central part of a “strategic management framework” [13].

Some of the benefits of using the Balanced Scorecard are:

- It improves the bottom line by reducing process cost and improving productivity and mission effectiveness;
- Measurement of process efficiency provides a rational basis for selecting what business process improvements to make first;
- It allows managers to identify best practices in an organization and expand their usage elsewhere;
- The visibility provided by a measurement system supports better and faster budget decisions and control of processes in the organization. This means it can reduce risk;
- Visibility provides accountability and incentives based on real data, not anecdotes and subjective judgments. This serves for reinforcement and the motivation that comes from competition.

The Balanced Scorecard allows manager to look at the business from four important perspectives: Financial; Customer; Internal Business; and Innovation and Learning. It provides answers to four basic questions:

- How do customers see us?
- What must we excel at?
- Can we continue to improve and create value?
- How do we look to shareholders?

Each question requires a set of indicators to be measured and analyzed to answer these questions.

Since the Balanced Scorecard was popularized in the early 1990s, a large number of alternatives to the original “four box” balanced scorecard promoted by Kaplan and Norton in their various articles and books have emerged and new variations appeared for specific sectors, like pharmaceutical, technology, engineering, and software companies. But, in general, a specific set of indicators have to be chosen for each specific organization.

2.3 KPIs, a metric of performance measurement

Key Performance Indicators (KPIs) help organizations understand how well they are performing in relation to their strategic goals and objectives. In the broadest sense, a KPI provides the most important performance information that enables organizations or their stakeholders to understand whether the organization is on track or not. KPIs serve to reduce the complex nature of organizational performance to a small number of key indicators in order to make it more manageable [14].

KPIs or Key Performance Indicators are the selected measures that provide visibility into the performance of a business and enable decision makers to take action in achieving the desired outcomes. Organizations that measure performance identity the handful of critical success factors that comprise every strategic objective [15].

Typically, KPIs are monitored and distributed in dashboards or scorecards to provide everyone in the organization with an understanding of the strategy implementation progress. KPI utilization enables learning and improvement on critical operations, capabilities and processes across business areas [16].

In order to be evaluated, KPIs are linked to target values, so that the value of the measure can be assessed as meeting expectations or not.

3. Model description

This work shows a set of KPIs in order to establish into the Balanced Scorecard here proposed.

KPIs are distributed according the four perspectives of the Balanced Scorecard. KPIs about Financial, Customers and Innovation and Learning perspective are usual and commonly used. KPIs about Internal Business are distributed in Productivity and Software Quality sub-perspectives.

3.1 Perspectives

3.1.1 Financial perspective KPIs

In the private sector, these measures have typically focused on profit and market share. Managers must answer the question: How do satisfy the financial expectations of our stakeholders?

The set of proposed KPIs are:

- ROI;
- Added Value;
- Efficiency;
- % Development Software Cost;
- % External / Internal Client Sales Revenue.

Table 1 shows the financial KPIs into the proposed balanced scorecard.

3.1.2 Customer perspective KPIs

Managers must know if their organization is satisfying customer needs. They must determine the answer to the question: How do customers perceive us?

The set of proposed KPIs are:

- Customer Satisfaction Index;
- Service Level Agreements.

Table 2 shows the customer KPIs into the proposed balanced scorecard.

3.1.3 Innovation and learning perspective KPIs

An organization's ability to innovate, improve and learn ties directly to its value as an organization. Managers must answer the question: Can we continue to improve and create value for our services?

The set of proposed KPIs are:

- Staff turnover;
- Outsourcing firms turnover;
- Human Capital.

Table 3 shows the innovation and learning KPIs into the proposed balanced scorecard.

3.1.4 Internal business perspective KPIs

Managers need to focus on those critical internal operations that enable them to deliver their work program. They must answer the question: What must we excel at? This Perspective is the largest and more important in this work, and it is subdivided in other two perspectives: Productivity and Software Quality perspectives.

3.1.4.1 Productivity sub-perspective KPIs

Productivity is the ratio of output to inputs in production; it is a measure of the efficiency of production. Productivity growth is important to all the organizations because more real income means that the organization can meet its (perhaps growing) obligations to customers, suppliers, workers, shareholders, taxes and still remain competitive or even improve its competitiveness in the market place.

Furthermore, it is necessary to measure cost and time deviation. Earned Value is a technique for measuring project performance and progress. It has the ability to combine measurements of scope, schedule and cost.

The set of proposed KPIs are:

- Performance;
- In/Out Request Rate;
- Time Deviation (scheduled error);
- Cost Deviation;
- Employee Productivity;
- % Calls to Reuse Software Components;
- % Error.

Table 4 shows the productivity KPIs into the proposed balanced scorecard.

3.1.4.2 Software quality sub-perspective KPIs

The ISO/IEC 25000:2005 provides guidance for the use of the new series of International Standards named Software product Quality Requirements and Evaluation (SQuaRE). The purpose of this guide is to provide a general overview of SQuaRE contents, common reference models and definitions, as well as the relationship among the documents, allowing users of this guide a good understanding of those series of International Standards, according to their purpose of use.

The international standard SQuaRE provides [17]:

- Terms and definitions;
- Reference models;
- General guide;
- Individual division guides;
- Standards for requirements specification, planning and management, measurement and evaluation purposes;
- The cost and time deviations compared to the estimations.

Furthermore, the ISO/IEC 25010 defines characteristics and sub characteristics that provide a consistent terminology for specifying, measuring and evaluating system and software product quality. Also a set of quality characteristics against which stated quality requirements can be compared for completeness. In combination with other standards the ISO 25010 can be used as framework to support different processes, e.g. requirements definition or software quality evaluation[18].

The standard ISO/IEC 25010 defines two different models:

- A quality in use model composed of five characteristics (some of which are further subdivided into sub characteristics) that relate to the outcome of interaction when a product is used in a particular context of use. This system model is applicable to the complete human-computer system, including both computer systems in use and software products in use. Table 5 shows the quality in use KPIs into the proposed balanced scorecard;
- A product quality model composed of eight characteristics (which are further subdivided into sub characteristics) that relate to static properties of software and dynamic properties of the computer system. The model is applicable to both computer systems and software products. Table 6 shows the product quality model KPIs into the proposed balanced scorecard.

The characteristics defined by both models are relevant to all software products and computer systems. The characteristics and sub characteristics provide consistent terminology for specifying, measuring and evaluating system and software product quality. They also provide a set of quality characteristics against which stated quality requirements can be compared for completeness.

It is important that the quality characteristics are specified, measured, and evaluated whenever possible using validated or widely accepted measures and measurement methods. The quality models in this International Standard can be used to identify relevant quality characteristics that can be further used to establish requirements, their criteria for satisfaction and the corresponding measures.

Quality in use is the degree to which a product or system can be used by specific users to meet their needs to achieve specific goals with effectiveness, efficiency, freedom from risk and satisfaction in specific contexts of use. The properties of quality in use are categorized into five characteristics: effectiveness; efficiency; satisfaction; freedom from risk; and context coverage.

The product quality model categorizes product quality properties into eight characteristics (functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability and portability). Each characteristic is composed of a set of related sub characteristics.

3.2 Proposed Scorecard and KPIs

The following is the proposed scorecard objective of this work, and it includes a specific set of KPIs. The KPIs are categorized according to four different approaches or perspectives: financial; customer; human resources and growth; and internal processes (productivity and quality). The proposed scorecard is linked to the new work processes scheme in this software factory, and it includes specific and nonspecific KPIs for its use. The model here presented is aimed to assess the project management portfolios and it is only applied to software factories for financial institutions.

Table 1. Financial perspective for the proposed scorecard

Financial Perspective		
ROI (Return of Investment)	What is the return of investment?	$\mathrm{ROI} := \left(\frac{\text{Net Profit}}{\text{Shareholders Investment}}\right) \text{ x } 100$
Added Value	What is the added value provided by the human capital?	$\mathrm{A.V.} := \frac{\text{Sales Revenue} - (\text{Total Cost} - \text{Staff Cost})}{\text{Number of Staff}}$
Efficiency	What is the efficiency of the activity?	$\text{Efficiency} := \left(\frac{\text{Structure Cost}}{\text{Income}}\right) \text{ x } 100$
% SW Development Cost	What is the ratio between SW development cost and total cost?	$\%\ \mathrm{SW.D.C.} := \left(\frac{\text{Software Development Cost}}{\text{Total Cost}}\right) \text{ x } 100$
% External / Internal Client Sales Revenue	What is the ratio between external and internal sales revenue?	$\%\ \frac{\mathrm{E}}{\mathrm{I}}\mathrm{S.R.} := \left(\frac{\text{Software Development Cost}}{\text{Total Cost}}\right) \text{ x } 100$

Table 2. Customer perspective for the proposed scorecard

Customer Perspective		
Customer Satisfaction Index	What is the level of customer satisfaction?	$\mathrm{CSI} := \sum \left(\frac{\text{Indicator Value}}{\text{Maximum Value Indicator}} \text{ x Weight}\right)$
Service Level Agreements	What is the level of compliance with the SLA?	$\mathrm{SLA} := \sum \left[\left(\frac{\text{SLA Value}}{\text{Operative Level Agreed for SLA}}\right) \text{x Weight}\right]$

Table 3. Human resources and growth perspective for the proposed scorecard

Human Resources and Growth Perspective		
Staff Turnover	What is the level of stability?	$\text{Staff Turnover} := \frac{\left(\frac{\text{Recruitments} + \text{Layoffs}}{2}\right)}{\text{Average Employee}} \text{ x } 100$
Outsourcing firms Turnover	What is the level of outsourcing firms' stability?	$\mathrm{O.F.Turnover} := \frac{\left(\frac{\text{Recruitments outsourcing firms} + \text{Layoffs outsourcing firms}}{2}\right)}{\text{Average Outsourced Firms}} \text{ x } 100$
Human Capital	What is the most optimal task for the employees?	$\mathrm{H.C.} := \mathrm{MAX}\left(\sum_{\text{Employee}=1}^{\text{Employee}=\mathrm{N}} \text{Training x Position in SF x Personal Factors}\right)$

Table 4. Internal business perspective - Productivity for the proposed scorecard

Internal Business Perspective – Productivity		
Performance	Performance	$\text{Performance} := \left(\frac{\sum \text{Working Hours Budgeted by Request}}{\sum \text{Working Hours Performed by Request}}\right) \text{x } 100$
In/Out Requests Rate	Increase in hours of Requests over the previous year	$\frac{\text{In}}{\text{Out}}\text{Requests} := \left(\frac{\sum \text{Working Hours Completed by Request}}{\sum \text{Working Hours Required by Request}}\right) \text{x } 100$
Time Deviation (Scheduled Error)	What is the time deviation error?	$\text{T. D.} := \sum(\text{Working Hours Performed} - \text{Working Hours Budgeted})$
Cost Deviation	What would be the minimum cost for the work performed?	$\text{C. D.} := \sum_{\text{Si}>0}(\text{Working Hours Budgeted} - \text{Working Hours Performed})$
Employee Productivity	What is the average number of hours allocated to each employee in a year?	$\text{E. P.} := \left(\frac{\sum \text{Working Hours Budgeted by Request}}{\text{Number of Employee}}\right)$
Calls to Reuse Software Components	What is the level of Software Components Reused?	$\text{SW Reuse} := \left(\frac{\sum \text{Calls to Reuse SW Components by Request}}{\sum \text{Calls to SW Components by Request}}\right) \text{x } 100$
% Error	Errors detected in testing process	$\% \text{ Error} := \left(\frac{\sum \text{Increased Working Hours for Errors by Request}}{\sum \text{Working Hours Charged by Request}}\right) \text{x } 100$

Table 5. Internal business perspective - Software quality – Quality in use

Internal Business Perspective – Software Quality - Quality in Use (ISO/IEC 25010:2011)		
Effectiveness	Accuracy and completeness with which users achieve specified goals	Effectiveness
Efficiency	Resources expended in relation to the accuracy and completeness with which users achieve goals	Efficiency
Satisfaction	Degree to which user needs are satisfied when a product or system is used in a specific context of use	Usefulness; Trust; Pleasure; Comfort
Freedom from risk	Degree to which a product or system mitigates the potential risk to economic status, human life, health, or the environment	Economic risk mitigation; Health and safety risk mitigation; Environmental risk mitigation
Context Coverage	Degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in both specified context of use and in contexts beyond those initially explicitly identified	Context completeness; Flexibility

Table 6. Internal business perspective - Software quality – Product quality model

Internal Business Perspective – Software Quality – Product Quality Model (ISO/IEC 25010:2011)		
Functional Suitability	Degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions	Functional completeness; Functional correctness; Functional appropriateness
Performance efficiency	Performance relative to the amount of resources used under stated conditions	Time-behavior; Resource utilization; Capacity
Compatibility	Degree to which a product, system or component can exchange information with other products, systems or components, and/or perform its required functions, while sharing the same hardware or software environment	Co-existence, Interoperability
Usability	Degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use	Appropriateness; recognizability; Learnability; Operability; User error protection; User interface aesthetics; Accessibility
Reliability	Degree to which a system, product or component performs specified functions under specified conditions for a specified period of time	Maturity; Availability; Fault tolerance; Recoverability
Security	Degree to which a product or system protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization	Confidentiality; Integrity; Non-repudiation; Accountability; Authenticity
Maintainability	Degree of effectiveness and efficiency with which a product or system can be modified by the intended maintainers	Modularity; Reusability; Analyzability; Modifiability; Testability
Portability	Degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another	Adaptability; Installability; Replaceability

3.3 Application of the scorecard to a specific case study

The presented model is being currently implemented in a software factory associated to an important Spanish Banking Group. Due to terms of confidentiality, its name cannot be published here. The organization follows the scheme described in Figure 1, outsourcing to several suppliers for the software development process. They have a maturity level 3 according to the standard CMMI-DEV. This is an organization that has suffered a major transformation in the past two years, due to former traditional projects the company functions by adopting a closed process management approach. The proposed scorecard serves as a comparison of the performance of the new model and the former one. Due to its recent application, there is only data available for a few indicators, but an evaluation of some internal processes KPIs showed that performance increases when there are several different companies working in competition and when the cost of the projects is linked to budgeted time and it is not linked to performed time. The software factory productivity increased from 92% to 107%, decreasing the project duration by 7% on average in the last year and a half.

4. Conclusion

This paper presents a scorecard for a software factory suitable for the financial sector. This sector has externalized the development process, but they have kept the top level processes due to strategic reasons. This kind of organizations has usually two different wok lines: providing services and developing projects. This study is coped only to the project side, considering the project portfolio of the organization. The scorecard is intended for the analysis by management levels, allowing the top managers to take the appropriate decisions. The proposed scorecard does not incorporate the traditional software engineering metrics, since within the presented context the measurement in the top level is much more interesting. Considering that the proposed model is aimed at the Software Factory top level managers, global view indicators have been prioritized rather than low level traditional software engineering quality indicators. The use of this Scorecard does not exclude the use of additional Scorecards designed for other specific areas, like developing or testing. According to this, four different approaches were identified: financial; customers; innovation and learning; and internal processes. The model is being tested in a real context in a Spanish Software Factory. Although the gathered experience is being very positive, it is anticipated that an evolution of the model will take place according to the feedback and the results provided. The adoption of the model is still very recent so no definitive conclusions can be drawn. It is possible that in a short period of time the management of this factory will make changes in other departments as it has done in the development processes. It should be also considered the limitation that the model is being tested only in one organization, so the proposed model could be biased to the internal operative of this organization. In addition, the model could be also affected by the local business culture. After this initial experience, the model will be extended to other Software Factories as further work.

The results provided by this work will constitute the bases for a further study detecting process weakness in this kind of organizations and looking for a new model that could improve their efficiency. The new model could establish a new process standard that brings them closer to the Software Factory paradigm.

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A tale behind Mum Effect

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Abstract:
Mum effect is a situation when one or more project stakeholders decide to withhold critical information for particular reasons. In software project where most of the production is intangible, the seriousness of this challenge increases exponentially. There have been reports indicating that mum effect can surface during any phase of development and ultimately lead to disaster in software projects. Mum effect can be influenced by several factors such as organizational and national cultures. This research investigates potential mum effect scenarios and reveals specific reasons which induce this challenge among information technology practitioners.

Keywords:
project management; outsourcing risk management; culture; mum effect; interview.

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1. Introduction

Software projects are indeed different from projects of other engineering disciplines. The entire development cycle of software projects highly involves design. Moreover, the products, especially during development, are mostly intangible. This makes project monitoring particularly difficult. The development of software projects highly depends on human generated ideas. This leads to unique risks and different degree of challenges, especially those which are related to human factors.

"Mum effect" or "code of silence" is defined as a phenomenon when one or more persons decide to hide the problems [1]. Hiding problems in general engineering projects is not easy and may not result in extreme situations. For example, in a construction project, a delay of works-in-progress can be almost immediately noticed due to the visibility of the product. Additionally, overall progress of physical products such as a house or a car can be inspected with minimal technical knowledge. In the same way, customer satisfaction can also be assessed early. Thus, any delays or misconception can be promptly detected and managed. However, this could be vastly different in software projects. It is rather impossible to inspect software product during the development, especially for those who have little technical knowledge. Ironically, even for a software engineer, it is difficult enough to understand a code written by others. Problems from misunderstanding of requirements could surface at the later phase of development, such as the acceptance testing or, even worse, the deployment. The problem could be worsened if the staff encounter problems but decide not to report or attempt to hide them. In this way, such problems would be extremely difficult to detect and subsequently tackle. This suggests that the abstract nature of software development matches perfectly with the subtleness of mum effect. People with different background may have different perception towards mum effect. Some might claim that keeping silence would have minimal effect to certain software projects, especially the ones with agile development environments. In contrast, others might argue that code of silence can surface even from staffs who have the most experiences and responsibilities. As for evidences, this risk caused substantial damages to software projects in the past [2],[3],[4]. Mum effect shares several similar traits to another risk called "deaf effect" which surfaces when at least one stakeholder decides not to acknowledge problems.

Several factors are hypothesized as mum effect factors. These include fear of consequences, information asymmetry, fault responsibility, time urgency and culture [5],[6],[7]. Firstly, fear of consequence directly depicts situations which an individual choose silence rather than uncertain consequences if the information is revealed. Secondly, information asymmetry indicates a project environment where stakeholders hold different information. This factor can be extended to communication gap which involve lack of sufficient information channel or other communication barriers. Both factors encourage mum effect. In contrast, the third and fourth factors, fault responsibility and time urgency, are negative factors of this risk. Fault responsibility, the third hypothesized factor, describes scenarios when there is a sophisticate chain of responsibilities. This encourages stakeholders to report problems if they could blame others. Fourthly, time urgency indicates that the closer the deadline is, the more likely the negative issues are reported. The final mum effect factor, culture, is arguably the most sophisticate aspect. Culture is a sensitive issue and cannot be easily controlled. Studies report that effects of these factors vary. Some factors appear to have strong connection to the risk while no significant proof is yet found for other factors.

This research does not attempt to investigate the factors of mum effect, however. On the contrary, it explores reasons of being silence on certain situation from a group of samples. Yet, the findings can be used as guidelines for practitioners to mitigate this risk.

The second section of this paper describes literature reviews on mum effect. The third section depicts interesting case studies on mum effect. This includes several business and educational cases. Then, the fourth section defines research methodology, the participants and other research settings. Findings are discussed in the fifth section. Finally, the sixth section concludes this paper.

2. Literature review

Mum effect is an interesting risk. It surfaces when at least one stakeholder determine to withhold critical information, generally to avoid negative consequences. This risk could become a serious issue in software projects where progresses are generally intangible. The lack of product visibility makes project tracking difficult. The situation could get worse with inaccurate information or concealed negative issues. Different levels of mum effect could lead to minor delay, significant conflicts, or project breakdown.

Researchers have suggested that there are several potential factors which influence mum effect. One of these factors is culture [6]. Based on Hofstede's landmark research, culture can be classified into five major dimensions [8]. Certain cultural dimensions such as power distance index and individualism are expected to have influence on mum effect. People with higher power distance index, which indicates a perception of large gap in societal equity, is expected to be more vulnerable to mum effect. An example scenario of this case is when young engineers feel reluctant to communicate with their superiors. This obviously facilitates mum effect. Individualism, on the other hand, designates different values between personal and group objectives. People with low individualism tend to prioritize group benefits over their own goals. They are likely to cover their colleagues' mistakes in order to keep positive relationship. Although this could strengthen the team, it could also result in irrational defensive culture. Mum effect can indeed surface from such situation. Interestingly, cultural scores from a number of countries, especially those in Asia, seem to be suitable for facilitating this risk.

Studies report that collective behavior is one of the most dominant traits of Asian culture [9]. The characteristic of the collectivist society is shared among Asian countries such as China, Vietnam, Singapore, Korea and Japan. The collectivist nature of Asian people reflects one of the key Confucius principles, which perceives that a person is not a mere individual but an important member of a family [10]. An example to illustrate this principle in practice is the case that students are keener to express their ideas as a group rather than an individual [11]. If their opinions are wrong, the blame is shared between team members. In this way, no matter the group decision makes sense or not, students who have different opinion than the majority of the group would usually keep mum. This may not be the case in Western culture where the individualism is high. As a result, every individual are more likely to oppose the group consensus if they think the majority are wrong.

With these hypotheses, researchers attempt to study relationships between this risk and cultural dimensions based on local and multinational recipients [12],[13]. International graduate students are reported to share a similar obligation to report critical issues to their immediate supervisor. Yet, they are not likely to pursue the result if their report is ignored. No significant differences are found between students from different cultural background [12]. Another study finds that there are strong connection between cultural dimensions and mum effect scenarios. For examples, IT professionals who have high power distance index tend to be reluctant to make a straightforward estimation. Additionally, collective respondents are unlikely to decline customer's requests, even unnecessary ones. However, surprisingly, their relationships are found to be not as significant as expected [13].

Fear of consequences and information asymmetry are other proposed factors for mum effect [1]. Indeed, in order to avoid immediate bad consequences, a person might choose withholding of negative information. This is especially true in an organization which has a record of staff punishment. Information asymmetry also facilitates mum effect. This factor arises from several issues such as a large gap of communication, language barriers, lack of communication channel, inadequate information circulation and inefficient communication. In an organization with serious information asymmetry, the staff might feel that reporting bad news is complicate and ultimately determine to keep mum. This mum effect factor is extended to communication gap in order to cope with other issues regarding inefficiency of communication [5]. The influence of these factors could be lessened by improving the quality of communication and building a strong organizational culture.

Team solidarity is another potential source of mum effect [5]. Generally, team solidarity is beneficial for a project. However, if such bond is too strong, it is possible that team members become protective. As a result, they might fail to report information which could negatively affect their colleagues or team relationship. This factor is sensitive and needs to be managed carefully.

Other factors of mum effect are defined as fault responsibility and time urgency [7]. Fault responsibility occurs when at least two stakeholders take part in a project. It is not unusual for an organization to blame external vendor if problems arise from the project development. It is found that if the fault responsibility can be placed on the external vendor, mum effect is less likely to happen. Another factor, time urgency, involves with the project life cycle and time-to-market. It is reported that high urgency negatively influences mum effect. In other words, a higher urgency increases a person’s willingness to tell the bad news.

3. Case Studies of Mum Effect

There have been reports that a number of software projects were affected by mum effect. In most case, this risk created delay and many undesirable problems to the project. However, there were several cases which mum effect ultimately led to major disasters.

3.1 CONFIRM

One of the most devastating cases involving mum effect was the CONFIRM system development. Major international organizations such as Budget Rent-A-Car, Marriot Corporation and Hilton Hotels invested in this project [2]. All stakeholders expected that CONFIRM will be a very successful project. However, instead of a new and complete global reservation system, $165 million was lost. A report indicated that this project suffered from extreme technical complexity. Serious scope creep and sophisticated system integration were also accounted for the problems.

Although technical difficulties were blamed as the main reasons of this disaster, the mitigation was actually likely to be possible if an immediate action was taken. However, the project staffs decided not to report this critical problem at an early stage of development in order to prevent the team from punishment against high expectation from stakeholders. While the project kept going, the problem continually intensified. It was already late before the stakeholder realized the situation and acted correspondingly. Resources were pushed in attempt to solve the problems. Unfortunately, all effort was wasted and CONFIRM was never completed.

3.2 LAMP

The License Application Mitigation Project (LAMP) project is another excellent example of IT projects failure which stemmed from mum effect. The project was planned to offer an automated process for renewal of vehicle license and registration for the state of Washington, USA [4]. Unfortunately, this five year promising project of $16 million turned out to be a seven year mediocre project of $67 million [CIO Staff, 1998]. The main problems of LAMP project were identified as poor scope management, poor project coordination and poor project management.

In this case, several problems were actually found in an early stage of development. However, the problems fell into deaf ears. The LAMP management team fails to admit their seriousness. Instead of reporting to the stakeholders, the project staffs reluctantly continued their work. For some reasons, the technical staffs also did not attempt to report these problems to external parties. This later resulted in more serious problems and a major increase of budget. It is arguable that if the team halted their production and reported the difficulties to the stakeholders, even though the project might still fail, it would cost much less budget and resources.

3.3 ADMIN

Another interesting case study on mum effect is the ADMIN project. This project was to develop an information system for administrative tasks for a mid-sized company [3]. The project manager was freshly promoted and immediately assigned to this project. This one-year project progressed smoothly in the perspective of the stakeholders until the testing phase. Then, major problems regrettably surfaced during the testing. After the first mistake was encountered, numerous other defects appeared. The project consequently suffered from a major delay and was ultimately scrapped after two years of implementation.

It was later revealed that these problems were actually earlier acknowledged by the project manager. One major problem stemmed from miscommunication between the manager and a project member. However, the project manager was confident that the problem would be mitigated and therefore chose not to report to higher stakeholders. Unfortunately, the problem turned out to be serious. Not only he was unable to solve the cases, it also grew to the scale that affected the entire project.

3.4 Mum effect in education

Mum effect often surface in education. It is normal to find that at least a few students fail to feedback or participate in in-class activities. This leads to inefficiency of the classrooms. Culture and language capability are usually blamed for this behavior [14]. However, as aforementioned, a study amongst international IT students found that the connection between cultural dimensions and mum effect are not as significant as expected [12]. Also, mum effect can be generally found in local East Asian universities where the students' first languages are used. Thus, it is not entirely logical to accuse that language barrier is the main source of mum effect either.

There have been reports on mum effect as one of the most dominant the in-class behavior of Asian students [14]. They are reported as quiet and inactive in opposed to Australian, American and European students [15]. The silence of Asian students is known to be a sign of respect for their teachers [14],[11]. This behavior is found to be common among Asian students, for example in China [11]. The silence is considered to be the better alternative than speaking in front of their seniors that is perceived as showing off in Asian tradition. This mindset shapes up the students' public behaviors, and, therefore, provides challenges to faculties and the education system.

Another common issue that contributes as one of the factors is the fear of "losing face", which can lead to a loss of self-esteem and reputation in community [16]. Asking questions during class can be perceived as lacking of understanding, and thus shows a sign of disgracefulness in some cultures. In even more serious cases, students would say "yes" in response to a teacher's question if asked whether they understood what explained in class, even though they did not. This is because answering "no" would be seen as an insult to the teacher.

The first three business cases suggest that mum effect, although subtle, can be extremely dangerous to projects. This is especially critical in software projects where the actual progresses are not entirely visible for stakeholders. It can be seen that several aforementioned factors influenced mum effect in those case studies. Mum effect in the CONFIRM and LAMP projects was clearly caused by fear of punishment and pressure from high expectation. On the other hand, mum effect in the ADMIN project was slightly different since it involved over self-confidence and expectation of achievement. Then, the final case indicates that mum effect exist from the level of undergraduates. Students from certain regions appear to be more vulnerable from others. Culture, although perceived as the main source of this case, was found to have no significant correlation to this risk. Indeed, there could be many more elements which influence mum effect. Additional empirical studies which focus on identifying its source could help improving the overall knowledge for tackling this challenge.

4. Research Methodology

This research performed a short but insightful survey to the participants in July 2013. The sample group involved 38 senior computer engineering undergraduate students from Chiang Mai University, Thailand who attended the software engineering class. Two questions as follows were asked to the students:

- Have you ever keep silence in certain situations?
- If yes, what were your most frequent reasons on that action?

After that, the students wrote their answer in their card and submitted them anonymously. The participation was entirely voluntarily. This simple setting reflects a viewpoint towards mum effect from a perspective of fresh graduates, before being affected by organizational culture.

The first question was a probe question to investigate whether the students are vulnerable to mum effect. The students are given a 7-scale Likert of answers, i.e., never, very rarely, rarely, occasionally, very frequently, and always [17]. On the other hand, the main interest of this research focuses on the second question. Although simple, this second question was an open end question which directly inquires for the reasons behind mum effect scenarios. The students were allowed to give more than one reasons if they want. Their anonymity encouraged them to provide sincere answers.

After the participant submitted their answers, the data was then analyzed. Basic descriptive statistical analysis is performed on the results of the first questions in order to investigate general trend of this phenomenon. Then, the answers of the second questions are normalized, grouped and interpret.

5. Results and Discussions

Fig. 1 summarizes information gathered from the first question. Although most of the students experienced mum effect, the majority of them (33 out of 38) stated that this risk only happened rarely or occasionally. Almost 10% of the students even stated that they very rarely or never keep mum in any situations. This can be a positive sign for the industry that these future workers, in spite of their young ages, do not have a nature of silence. They can keep mum at times, but not always. An appropriate environment could encourage these young talents to speak and participate.

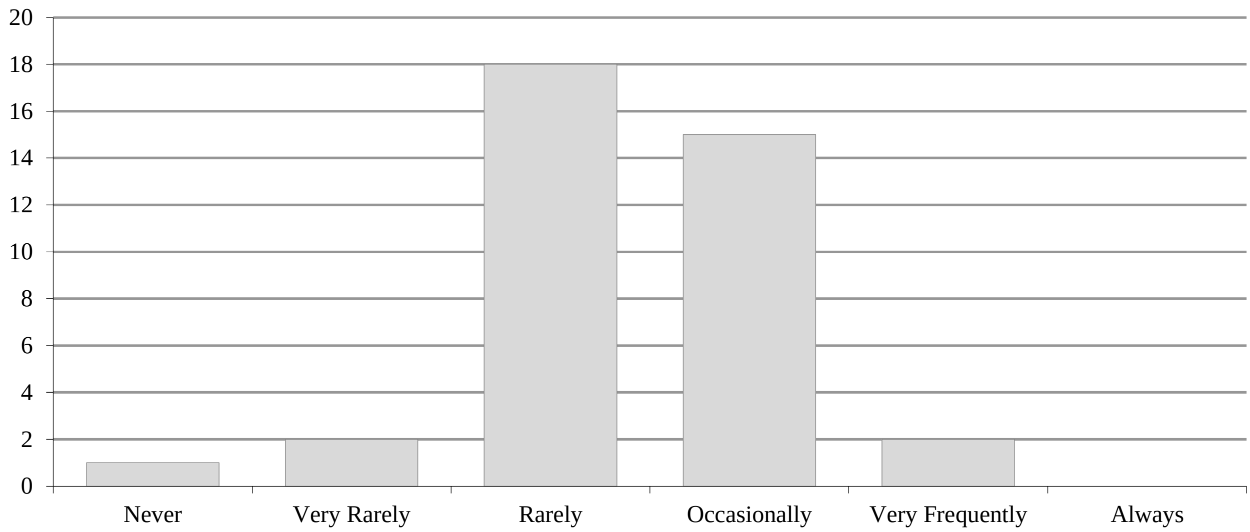

Fig. 1. Ratio of students who kept silence in certain situations

Fifty five various responses were retrieved from the second question. Samples of these answers are listed as follows:

- I keep mum when I think my idea could exacerbate the scenario;
- I keep mum when I do not have any idea on that issue;
- I keep mum when I am not confident;
- I keep mum when I am uncertain that what will be the result of my idea;
- I keep mum when I do not understand the question;

- I keep mum when my adversary is present in the group;
- I keep mum when I need to use English;
- I keep mum because I never refuse my boss/lecturer's command;
- I keep mum because I am shy;
- I keep mum because I want to give other people a chance to speak;
- I keep mum because I prefer a private discussion over public speaking.

These answers were then moderated and organized. Similar responses such as having conflict with the interlocutor, having conflict with another stakeholder, or avoiding conflicts amongst team members were grouped together. Table 1 exhibits the result of these responses.

Table 1. Reasons behind mum effect

Group	**Subtotal**	**Frequency**
Team solidarity	*15*	
Relationship maintaining		7
Avoiding conflict		5
Command from superior		3
Fear and uncertainty	*14*	
Fear of consequences		6
Uncertainty of ideas		8
Characteristics of the participant	*8*	
Shyness		3
Preferred communication style		3
Courtesy		1
Selfishness		1
Miscellaneous	*18*	
Complication in communication		10
Culture		1
Language barriers		1
Other		6

Major reasons behind mum effect found in this research can be divided into five categories, i.e., fear and uncertainty, team perception, characteristics of the participant and miscellaneous. Several interesting feedbacks were discovered.

5.1 Team solidarity

Team solidarity involves situations when the participants attempt to maintain team relationship by any means. This includes keeping mum if the idea can offend other team members. Several students admit that they rather keep silence if their expression can cause problems within the team. This displays a strong collectivism culture of the students. Yet, perception towards team relationship can be dangerous. It has been reports on several occasions that a strong team can become overprotective and lead to deceptive vision [18]. Therefore, it is important to keep the balance of the team relationship. Additionally, based on Hofstede's cultural research, it appears that many countries in Asia and South America such as China, Indonesia, Malaysia, Thailand, Colombia, Venezuela and Peru are collectivists [8]. General population in these countries is likely to prioritize team relationship over individual objectives. This is different from most North America and European countries where people tend to sacrifice team relationship if it conflicts with their personal goals. As a result, different approaches might be needed for these different cultures.

Conflict amongst stakeholders also facilitates mum effect. Students reveal that they are unwilling to talk if their adversary is presented in the conversation. This is regardless whether he or she represents as a moderator, superior or another team member. This is actually a rather serious scenario since it is not always easy to allocate conflicts amongst team members. In order to tackle this problem, an organization should establish a conflict management system as well as a mechanism which can help identifying conflicts between both internal and external stakeholders.

Another mum effect scenario surfaces when the participants receive orders from their superiors. In this case, superiors could mean their lecturers, advisors, bosses or even group leaders. A few students indicate that they always accept their orders or assignments, regardless of they are confident they can finish it or not. This is actually not a positive sign since it could lead to major problems as described in previous case studies. Indeed, in order to overcome this case, the superiors need to understand the capability of their subordinates as well as encourage them to sincerely feedback on their orders. Likewise, there should be certain mechanisms which encourage the subordinates to negotiate without any potential punishment. Frequent tracking of work-in-progress, such as in agile software development, would be another efficient strategy for this setting.

5.2 Fear and uncertainty

As hypothesized as a major factor for mum effect, fear of consequences is reported to be one of the top reasons of the students' silence. Students indicate that if they feel fear that their talk can result in bad consequences they are obliged to keep mum. This is especially true when the students predict that the outcome would be undesirable and would directly affect them. The bad consequences distinctively noted by this sample group involve fear of punishment and fear of causing conflict. Fear of punishment is found to be the dominant reason behind mum effect in this study.

Uncertainty is another main reason of silence. Several students reveal that whenever they are uncertain of the outcomes, they are not likely to speak. This situation could be worsened if they are not familiar with their immediate supervisor. Uncertainties could be a complex situation since removing them from a working environment is not a simple task.

Arguably the best strategy to tackle mum effect from fear and uncertainty for the industry is building a sincere working environment and culture where the staff can at least feel that they will be safe even if their idea are different from others. Records of previous decisions based on certain action could help reducing the uncertainties. For example, if the staffs recognize that their current boss is open to public discussion and never keep grudge against the critics, they would be more likely to create an open argument on such basis. Improving relationship between staffs in the same line of command is also another promising mitigation strategy. It is obvious that if the staffs feel that they will be protected by their supervisors, they would feel more obliged to report negative issues.

5.3 Characteristics of the participants

Shyness is one main reason behind mum effect. The students who admit that they have a shy nature are likely to be nervous talking in public. In some cases, shy students could have problems even when they need to communicate in person, either with their colleagues or supervisors. Shyness usually reduces when the people get more confident or are more familiarize with their counterparts. Indeed, practicing and experiences could gradually help easing this matter. Furthermore, the supervisors should attempt to encourage their staff to speak, especially the ones who usually keep silence. The stronger the bond between the team grows, the less the shyness is likely to emerge.

Several students indicate that they are likely to keep mum whenever they are in public. However, they are more than willing to converse in person. This suggests that an organization needs to have more than one channel of communication. Apart from public and personal options, an anonymous channel would be an efficient solution to this problem. Also, similar to the strategy to tackle shyness, building up relationship between staffs could help lessening this situation.

Courtesy is reported as a source of mum effect from one student. An interesting scenario emerges when this student attempts to keep mum in order to encourage other members to speak. Although this could be perceived as a mere excuse from another shy student, it is not entirely illogical. Again, improving communication channel could be an excellent strategy to tackle this unfortunate case. With increased options of communication, ideas could be expressed more easily.

One response from the students states that he or she keep mum when having a decent idea. Instead of telling the idea to others, he or she choose to keep this for own sake. This indeed sounds selfish and would be undesirable for any level of organizations. Tacking mum effect emerged from this situation could be sophisticated. The best strategy to handle this case could be a building of strong professionalism within the organization and improve the attitude towards the good of the organization.

5.4 Miscellaneous

Complication in communication is an extension of a previously proposed factor, the communication gap. This source of mum effect involves a number of complex situations in communication. The survey results reveal that mum effect can happen when the participant could not clearly understand the question. It also occurs when they has no idea how to answer the questions. It could even happen when the staffs think that there are a sufficient amount of enough ideas expressed. A few students indicate that they are not likely to speak if they think other people’s ideas are good enough to concur. Other feedbacks involve when the idea is extremely difficult to do or the idea is difficult to express. In fact, all of these reasons are not necessarily true. Certain ideas which one person perceive as difficult might be easy in the viewpoint of others. Moreover, everyone should be given at least an opportunity to express their idea, no matter how similar they are. Indeed, the staffs should be advised that more number of similar ideas can actually highlight their importance. A strong organizational culture which encourages information exchanges could dampen this mum effect setting.

Culture and language are also regarded as sources of mum effect from one student. The student signifies that he or she cannot express ideas sincerely in front of seniors or superiors since it is considered not polite. Although similar to the aforementioned scenario described in previous case studies, this might be another misinterpretation towards cultural politeness. Yet, it is undeniable that culture is usually a sensitive issue. The best method to mitigate this could be to set an example in an organization level. An organizational culture which subordinates are encouraged to discuss with their supervisors should help minimizing this mum effect scenario.

Other feedbacks describe random situation which encourage mum effect. For example, a few students indicate that if they are depressed or they feel not in the mood, they would not participate in any kind of discussion. One student even note that he or she personally hates meetings and believes that keeping silence could help the conversations to end as soon as possible.

6. Conclusion

Mum effect involves a scenario when one or more person decides to withhold certain information for some reasons. This risk might be considered as a trivial one in many engineering projects. However, it can lead to serious problems in software projects. This is due to the high dependency on human resource and abstract nature of software products. Reports indicate that mum effect led to a number of software project failure in the past.

Fear of consequences, information asymmetry, culture, language barriers, fault responsibility and time urgency are proposed as factors which influence mum effect. Several experimental studies report that some of these hypothesized factors have connections to the risk. This study attempts to explore other potential source of mum effect. The anonymous survey was conducted to a group of senior undergraduate students to investigate on this matter.

Several reasons of mum effect are identified. Unsurprisingly, team solidarity, fear of consequences and complication in communication are the most frequently stated factors. The students choose to keep mum if they think that it can help avoid conflicts with their associates. The result also revealed that several participants would never refuse or negotiate when they receive assignments from superiors. Also, they are likely to withhold their information when they feel that the result of the idea is uncertain or will lead them to undesirable consequences. Complication in communication also facilitates mum effect. The participants indicate that various settings cause mum effect. This includes when they do not clearly understand their interlocutors, or they are not sure how to properly express their ideas. Some additional interesting elements are also found in this study. Several characteristics of participants such as shyness and preferred communication styles are reported to be potential sources of mum effect.

Based on the findings, two major implications can be applied in any organization in order to mitigate mum effect. Firstly, at least three options of communication channels need to be represented and accessible. This includes not only public and personal, but also anonymous communication. In this way, the staffs are allowed to choose their most preferable channels, thus the mum effect could be reduced. The second implication involves building a strong organizational culture. A working environment which the team encourages discussion and treats each ideas equally is highly likely to help lessening mum effect.

Other strategies based on implications from this study include promoting of professionalism within the team. Every staff should prioritize the benefits of the organization over their personal interests. Problems and concerned should be discussed constructively. The person who raises issues should be rewarded, not punished or blamed. Relationship between staffs should be built up to a high level. This is to encourage frequent and sincere information exchange, either officially or informally.

The major limitation of this study is the monotonous background of the participants. Since they are all Thai undergraduate students from the same class, they are likely to experience similar environment. Yet, from another perspective, this limitation is a genuine reflection from fresh workforces who have been minimally influenced by actual organizational cultures. As a result, the findings are especially beneficial for tackling mum effect in such bodies.

This research could be extended in the future by collecting the data from experienced IT professionals. To maximize the profit from the study, the participants should have various ethnographical backgrounds, educational levels, positions and professional experiences. The data collection could be performed in a form of interview in order to thoroughly investigate the phenomenon as well as their solutions.

Another potential research based on this study is the evaluation of the proposed mitigation strategies. Results of a controlled experimental research which investigates the effectiveness of organizational culture, increased communication channel, and other strategies on mum effect would definitely benefit software project management community.

As there are a number of potential source for mum effect, the management team needs to carefully monitor the status of their human resources. Mitigating mum effect is not difficult. However, it needs to be performed as early as possible.

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