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PROJECT SUCCESS

KEYWORDS
Project Success Factors • Project Performance • Quality Function Deployment (QFD)
Mean Square Error (MSE) • Decision Makingon

QFD Methodology for LINKING PROJECT SUCCESS FACTORS to Outcomes in a Specific Business Case

• ABSTRACT •

Defining Project Success (PS) outcomes and PS factors is not an easy task. A favorable outcome depends on the stakeholders' perspective, the project type, the project life cycle stage, and organizational characteristics. In the present study, focusing on an individual business case, we develop a procedure for quantitative evaluation of the relations between various PS factors and outcomes based on the quality function deployment (QFD) method.
A House of Project Success (HoPS) matrix is created using combined inputs from various managers and experts. This matrix summarizes the desired improvements in the PS outcomes and connect them to the relevant PS factors. Based on the HoPS matrix, outcomes and factors that maximize the desired results of the PS policy are chosen using the mean square error (MSE) criterion.
The paper describes the implementation of the above methodology in two organizations, and two project types, namely weapons development and an ERP implementation, demonstrating different project success causal structures.

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1. INTRODUCTION

The term project success (PS) factors refers to a set of components, as determined by an organization's management team, which are essential for this organization to reach its project objective.

The current study asserts that basic guidelines can reveal the vital PS outcomes and factors essential for the positive conclusion of an individual project. Our research question focuses on how to reveal the PS causal structure in a specific business case.

In the present study, we develop a procedure for quantitative evaluation of the relations between various project success factors and outcomes based on the quality function deployment (QFD) method. A QFD matrix is created using statistically combined inputs from various managers and experts. This matrix summarizes the desired improvements in the success outcomes and connects them to the relevant success factors.

Based on the QFD matrix, factors and outcomes that maximize the desired results of the project policy are chosen, using the mean square error (MSE) criterion.

Over the years, project management (PM) researchers have raised and tested several PS perspectives and, consequently, many PS factors and outcomes have been defined. In the next section, we explore several relevant papers selected from PM literature.

2. LITERATURE REVIEW

Anderson and Merna (2003) criticized PM theory, saying that it has some disadvantages and is not promising as it is thought to be. After analyzing unsuccessful (or partially successful) projects, these researchers concluded that poor management rather than bad execution is a major cause of failure. They claimed that an organization's business strategy is more important in achieving better project results than execution tools and techniques.

Christenson and Walker (2003) supported the importance of management as a major factor in PS. Accordingly, the project manager is considered a leader, and her leadership is a significant driver of project management success. As a leader, the project manager, has to build a project vision. The project's vision defines the expectations of the projects, focusing the organizational resources on it, to attain a positive result. The authors examined this theory on an IT project and they concluded that a vision and leadership are powerful PS factors.

Artto et al. (2008) defined the concept of a project strategy. They found that the project goals as well as the project management approaches of the different stakeholders may vary a lot. The firm's primary strategy must be aligned with its project strategy and take into consideration the business environment and stakeholders' interests. Hence, the project management leader has to examine the actual situation and the business environment, and not merely lean on top management.

Samset (2013) determined the main criteria for a project's success or failure. He ascertained that success is contingent on the realization of five important outcomes: (1) Efficiency; (2) effectiveness; (3) relevance; (4) impact; and (5) sustainability. These findings have inspired organizations to look for better ways to produce a project's outputs, manage projects, fit the project to the organization and its environment, and ensure long-term success.

Belassi and Tukel (1996) criticized the way project results are judged. They claimed that project management and clients interpret project results are differently: both have different points of view, so the accepted literature on projects, which describes seven acceptable success factors, is not "one size fits all". Consequently, they suggested a scheme that classifies critical success factors, and describes the impacts of these factors on project performance. They grouped various success factors, explaining the interaction between them. They asserted that grouping is better than isolating each factor and its possible relative positive impact. As many other researchers, they related project success to efficient and motivated management, effective team corporation and environmental factors.

Hyväri (2006) evaluated the critical success/failure factors in project management, looking at the organizational structure and its impact on project success. He also investigated the link between success factors and the organization's background. This study identified critical success factors, related to the organization, project size and project management. Some major success factors that were found are communication, project size, type of organization and management's work experience. Piyush et al. (2011) arrived at the same conclusion and gave the project manager significant weight among these factors. Blaskovics (2016) also asserted that the project manager makes a significant contribution to the project's success. He examined projects managers from a behavioral point of view – what type of leader they are, how strategy-oriented they are, and how planning-based and technocratic they are. He concluded that the project's success and the manager's skills are positively correlated.

Pinto and Prescott (1988) examined PS factors across four stages in the project life cycle and interviewed more than 400 project managers. This process enabled them to reduce the total number of critical PS factors to eight, which are based on life cycle stages.

Dvir et al. (1998) argued against the attitude of treating all projects the same: each project has its resources, necessities, goals, characteristics etc., so each project has its own success factors. They contended that it is almost impossible to assume that all projects should be treated the same and that the same success factors apply to each. To assess this theory, they employed a linear discriminant analysis methodology and demonstrated that different projects have different success factors.

Due to globalization, organizations are developing fast response abilities to changes. These abilities are focused on processes, technologies and adopting a projective attitude. Not all these abilities fit the organizational structure, so in addition to other challenges, managers must confront these also. Ozguler (2015) noted that project management can be a powerful tool in handling globalization well and she developed a seven-stage scheme for a multicultural project management process. The main stages are an assessment of the competence level of the firm and the creation of an improvement and control plan of the whole project focusing on the multicultural process.

Müller and Jugdev (2012) found that projects vary according to their definition and measurement of success, and as Dvir et al. (1998), Müller and Jugdev supported the idea that there is no single universal and unique theory that can explain every project's success. The success depends on the organization, its management, and the nationalities and culture involved in it.

Petro et al. (2015) examined the effectiveness of project portfolio management in project-based organizations. They looked at the factors that affect the success of project portfolios and the effectiveness of project portfolio management in the project-based organization – which combine to create an efficient business. The independent factors they inspected were the project manager's authority, responsibility and a steering committee level of involvement. The authors concluded that strategy and a dominant project manager, which translate into a well-defined project portfolio and staff commitment to the project's positive outcome, embody the most powerful contribution to the project's success.

Williams (2016) explored the many faces of a project's success. He found that there three factors have the most influence on the project's outcome: 1. Organizational culture. 2. Locality, i.e., the firm's ability to serve a small segment of clients, although it may be large. 3. A projective attitude on the part of the firm, which leads a continuous improvement culture.

Another study of the organization as a CSF was done by Cicmil (1997). The emergence of project management (PM) all as a global area of research and practice obligates managers, not only project managers, to learn and adopt PM techniques and assimilate them on all levels of the organization. This strategic attitude supports many aspects of TQM theory and team-work.

Koutsikuri et al. (2008) found 31 CSFs in interdisciplinary building design projects, which they divided into four groups: management factors, design team factors, competencies and resources factors and project enablers. They observed that the most effective success factors are enthusiasm, cooperation, creativity and innovation. They also mentioned that there are two more important contributors – the human factor and organizational support.

3. METHODOLOGY

---Quality Function Deployment (QFD) ---

Quality function deployment (QFD) was developed in Japan and has been effectively implemented by leadings firms around the world. QFD was originally developed as a product quality design methodology whose rationale was to assure that customers' needs or desires are translated into demands in technical product features, engineering parameters, and finally, in production systems (Akao and Mazur, 2003).

The original QFD methodology comprised four successive stages or matrices: (1) The product planning matrix (also known as the House of Quality (HOQ)), (2) the product design matrix, (3) the processes design matrix, and (4) the production design matrix. The HOQ maps the voice of the customer (what the customer wants) into final technical product features as understood by the research and development engineers; see Chan (2002) for a wide-ranging literature review on the QFD methodology.

Previous research utilized the QFD in the context of performance deployment. In that context, Killen et al. (2005) utilized QFD in the context of strategic planning. Barad and Gien (2001) developed a QFD procedure for defining the improvement priorities of SMEs through a method similar to the manufacturing policy creation.

Dror and Barad (2006) builds on the House of Quality by developing a House of Strategy (HOS) for translating the improvement needs of a company's business objectives into relative importance of its competitive priorities. A Mean Square Error (MSE) criterion, supporting the selection of vital competitive priorities to be improved, is suggested. It divides a group of items (a set of competitive priorities) into two groups: vital few and trivial many. The partition minimizes the overall MSE and by so doing delineates two homogeneous groups. The method was implemented in companies from three industry types. It reveals their different HOS structures and thus provides useful information on the vital competitive priorities to be improved as dictated by their respective business objectives and internal capabilities.

Dror and Sukenik (2011) described the development of a strategic service framework from a global perspective of the important components of the service system at different hierarchical levels.

--- The House of Project Success (HoPS) ---

We present the House of Project Success (HoPS) matrix method for project success (PS) factor selection in companies and apply it to two case studies. The essence of the HoPS is to extract the desired improvement in the PS outcomes (as viewed by managers and experts) and translate them into required PS factor improvements. Note that we have freely adapted the fundamental QFD matrix structure to fit the basic principles of our project success framework.

The general building sequence of the HoPS comprises the following five major steps:

1. PS outcomes (WHAT's) – Listen to the voice of the manager and classify his desires (the walls).
2. Importance and capability gap of the PS outcomes – Assign assessments observed from PS surveys, i.e., prioritization of PS outcomes.
3. PS factors (HOWs) – Select a structured set of relevant PS factors (the ceiling), i.e., create a list of the important PS factors.
4. Interrelationship matrix – Evaluate the relationship strengths between each HOW (j) and each WHAT (i). An appropriate scale is applied, illustrated by symbols.
5. PS factor priorities – Calculate the required improvement level of each PS factor.

The HoPS matrix determines the required improvement level of each PS factor. So in this context, we term it the House of Project Success (HoPS) and use it to translate the required improvement level of the PS outcomes (the WHATs) into the required improvement level of the PS factors (the HOWs). The required improvement level of each PS factor is calculated thus: Let $h=(h_1,\ldots h_p)$ be a vector of the required improvement levels of the PS factors, $w=(w_1,\ldots w_q)$ be a vector of required improvement levels of the PS outcomes, and R_{qxp} be a matrix expressing the relationship strengths between the PS outcomes and the PS factors. Namely, $h=w\cdot R$.

--- The Mean Square Error (MSE) criterion for selecting the PS outcomes/PS factors to be improved ---

Analysis of variance (ANOVA) is a statistical technique for splitting the entire variability of a group of a continuous variable data points, as calculated by the sum of the squares of these data points from the grand average, into sectional sums of the squares that are related to specific causes of the variation. In a one-way ANOVA, variation can be the result of two variations: the sum of the squares of the ranges between the group averages and the grand average – represented by the sum of the squares between the averages (SSB) – and the sum of the squares of the ranges between group data points and the group average – represented by the errors of the sum of the squares (SSE). The Mean Square Error (MSE) is an unbiased estimator of the population variance. (see, e.g., Montgomery, 2012).

In this work, we utilized the MSE criterion, defined by a one-way ANOVA, as a quantitative tool for selecting the vital PS outcomes/PS factors to be improved.

The algorithm for utilizing the MSE in this work runs as follows:

(1) Arrange the normalized required improvement levels of the PS outcomes/PS factors in descending order, where the first component represents the highest required improvement level and the last component represents the lowest required improvement level.

(2) While keeping this order, divide the k components into two groups – (a) vital few and (b) trivial many. Assuming that each group includes at least one component, there are k-1 possibilities for splitting the items into two groups.

(3) Calculate $MSE(m)$, $m=1,\ldots,k-1$.

(4) Find, $MSE(m^*) = \underset{1\le m\le k-1}{Min}\left[MSE(m)\right]$.

4. WEAPONS DEVELOPMENT CASE STUDY

This section describes the implementation of the above methodology in a project involving a large group of engineers from a military weapons production company. These engineers are responsible for the design, development and installation all of weapon systems on combat platforms.

To obtain the required inputs for building the HoPS matrix, we interviewed three senior engineers (the systems engineer, the head of the algorithm team and the project manager) from this company. They provided the qualitative and quantitative data detailed in **Table 1**. The qualitative data are the project success indicators and the quantitative data are their respective importance and capability gaps. The possible values of the importance and capability gaps were based on a Likert scale ranging from 1 to 5. The values in **Table 1** symbolize the median score among those assigned by the three interviewees. Usually, for measuring the mid-point of a sample, an average value is calculated. Here, the mid-point is measured by means of a median value. The median is less sensitive to extremely large or small values than is the average and this makes it a better measure than the average for our case study, particularly since our sample was small.

Clearly, effectiveness and relevance are the most important PS outcome (5), followed by efficiency, impact and sustainability (4). On the other hand, sustainability had the highest capability gap (5), followed by effectiveness and efficiency (3), relevance and impact (2). The required improvement level of the project success outcomes was calculated as the multiple of the importance and capability gap. The final column, representing the normalized required improvement level, is the input to the HoPS matrix. It emphasizes the firm's need to improve its sustainability (0.31).

Project Success Outcomes	Importance	Capability gap	Required improvement level	HOS input (normalized)
Efficiency	4	3	12	0.18
Effectiveness	5	3	15	0.23
Relevance	5	2	10	0.15
Impact	4	2	8	0.12
Sustainability	4	5	20	0.31
All objectives			65	1

TABLE 01. Required improvement level of the PS outcome (HoPS input)

Once identified, the five PS outcomes must be separated into two groups (vital and less vital). The group of important PS outcomes (to be promoted) was identified by means of the MSE technique. pj, j=1,2,……5 . These are the required improvement levels of the PS outcomes arranged in descending order, as follows:

P1	P2	P3	P4	P5
.31	.23	.18	.15	.12

Recall that MSE(m) is calculated as the sum of the internal variances of the two groups, with the first m components in group A and the remaining 5-m components in group B. Following are the results of calculating the MSE(m):

MSE(1)	MSE(2)	MSE(3)	MSE(4)
0.0063	0.0049	0.0082	0.0134

It is seen that the lowest MSE(m) is obtained for MSE(2)=0.0049. Therefore, the vital few PS outcomes to be improved are the first two on the list: 'sustainability' and 'effectiveness'.

Sustainability (Will the positive impacts of the project continue over a longer term?) and effectiveness (Were the goals achieved? Did the output meet the goals?) are perceived as being the most important indices of the project. Sustainability can be defined as the ability of a project to maintain its operations, services and benefits during its projected lifetime. Embedding sustainability into the DNA of a security enterprise is a complicated task. Adversaries continually increase their attack capabilities and the rate at which new threats arrive in the arena is high. Weapons smuggling and new risks to strategic assets and combat platforms oblige arms project development to be a race against time. The arms race means that engineering teams have to come up with innovative ideas and/or effective solutions to new threats within a reasonable period. If not, they might find that by the time their systems have matured, the threats have changed, rendering their systems irrelevant. Therefore, development projects must be fast-tracked. One way of doing this is by using existing building blocks – components of systems that already exist, currently serving other combat platforms, and adapting them to the new platform. This includes new command and control systems, based on older ones but adjusted and upgraded for the newer systems.

A more systematic approach to improving development projects outcomes is by using the HoPS methodology.

		HOS Input	PS Factors												
		Required improve-ment level	IS/IT	Recourse flexibility	Recourse capacity	Clear targets	Plans approved by interested parties	Clear descrip-tion of the tasks	Commun-ication with end user	Team-work	Com-munica-tion between employ-yees	Emplo-yee involve-ment	Emplo-yees skill	Manage-ment support	Structured approach
PS outcomes	Efficiency	0.185	1	3	9	3	3	9	1	9	1	3	3	3	3
	Effective-ness	0.231	0	1	3	9	9	9	1	3	9	9	9	9	3
	Relevance	0.154	0	1	3	9	9	9	9	3	9	9	9	3	9
	Impact	0.123	1	1	1	3	3	1	3	1	1	3	1	9	3
	Sustain-ability	0.308	9	9	3	3	3	3	9	1	1	3	1	1	3
HOS output	Required improve-ment level		3.08	3.83	3.86	5.31	5.31	6.17	4.94	3.25	4.08	5.31	4.45	4.51	3.92
	Normalized		0.053	0.066	0.067	0.092	0.092	0.106	0.085	0.056	0.070	0.092	0.077	0.078	0.068

TABLE 02. HoPS of the weapon development project

The core of the HoPS matrix (**Table 2**) explores the relationships between all PS outcomes and all success factors, enabling us to translate the normalized required improvement level of the PS outcomes into the normalized required improvement levels of the success factors. In this step, the interview systematically answers the equation: "What is the relationship between this specific PS factor and this specific PS outcome?" The interviewees assigned the relationship levels on a four-point scale (none, high, medium, low, none), which were, respectively, replaced by the typical numerical values (0, 1, 3, 9). This nonlinear scale stresses high relationships. Again, the values appearing in the HoPS matrix are the median of the interviewees' answers.

The interviewees pointed out that 'IS/IT', 'Recourse flexibility' and 'Communication with the end user' may have a strong influence on the 'Sustainability' indicator. Communication between employees influences 'Effectiveness' and 'Relevance'.

Effective communication between people from diverse organizational units can facilitate such an innovative process. Communication involves the transfer of information, ideas, thoughts or feelings via different channels: verbal communication (face-to-face, telephone, and other media), written communication (letters and emails), and visualizations (graph and charts). This transfer gains special significance in interdisciplinary teams, especially in system development processes since in the company we examined, the engineers from different engineering disciplines interact with other employees (communicate). In any sustainable design, communication between workers from a variety of disciplines, i.e., engineers, programmers, operators, plays a vital role and can help ensure that a team not only learns how to work well together, but increases efficiency and productive workflow for future projects.

Typically, information systems (IS) and information technology (IT) enable effective knowledge management processes to operate at the multiple organizational levels at which knowledge is deployed. In relation to sustainability, IS/IT is often seen as an enabler of knowledge retention and technical data collection about performance and contributes to engineering improvement based on failures analysis. To achieve these goals, the IS/IT infrastructure must be enhanced. The base for any such infrastructure is the capability to store and manage information and obtain the technology that supports the flow of information with the aim of making a positive impact on sustainability.

Again, the MSE criterion was utilized to identify the vital few PS factors. There were 13 success factors from which we had to deduce the vital few, pj, j=1,2,……13. Accordingly, the required improvement levels of the PS factors were arranged in descending order, as follows,

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
.106	.092	.092	.092	.085	0.078	0.077	0.070	0.068	0.067	0.066	0.056	0.053

After applying the MSE(m), we see:

MSE(1)	MSE(2)	MSE(3)	MSE(4)	MSE(5)	MSE(6)
0.0020	0.0018	0.0014	0.0010	0.0007	0.0008
MSE(7)	MSE(8)	MSE(9)	MSE(10)	MSE(11)	MSE(12)
0.0009	0.0011	0.00136	0.00159	0.0018	0.0023

The lowest MSE(m) was obtained for MSE(5)=0.0007. Therefore, the vital few PS factors to be improved are the first five on the list: 'Clear description of the tasks', 'Clear Targets', 'Plans approved by interested parties', 'Employees' involvement' and 'Communication with the end user'.

When an engineer knows what needs to be accomplished and what is expected, he does not need to be constantly supervised. Clear goals and objectives allow engineers to monitor their own progress in all project rounds and correct their activities as necessary. Moreover, when engineers know what they need to accomplish, they can look at their results as they reach project milestones and identify barriers to achieving those goals. Also, when engineers understand how their individual work contributes to the overall project goals, they can more easily decide on their own on what to focus their work time so that their work is consistent with the project priorities. The consequences are that engineers know what they must do, how well they must do it, and why they are doing it. In general, therefore, a development team that understands this will accomplish its goals with much less effort and supervision.

--- ERP implementation case study ---

We now present the implementation of the methodology in a private manufacturer of electronic systems for the military market. The project's target was to improve the understanding and usage of the Enterprises Resource Planning (ERP) information system.

ERP is a business-management software that allows business process tasks to be performed by means of software modules. Typically, ERP software comprises modules for material purchasing, inventory control, product planning, finance, distribution, and HR. The ERP shares data across various functions and facilitates information flow between business functions. For instance, when a customer service department takes an order from a customer, the ERP supplies all the necessary information to complete the order. Every employee in the relevant department in the firm sees the same information on her computer screen and has access to the file that holds the customer's original order. When a business function completes its work on an order, it is automatically routed via the ERP system to the next business function for the next business process.

Fiona et al. (2001) conducted a wide-ranging literature review on critical SFs when adopting enterprise resource systems. The authors demonstrated that 11 factors were found to be vital to the success of ERP implementation – top management support; a management program for a company-wide cultural change; ERP teamwork and composition; business process reengineering with minimum customization; a business plan and vision; monitoring and evaluation of performance; project management; effective communication; testing and troubleshooting; software development; IT legacy systems; appropriate business and project champion. The authors classified these factors into five elements (project, shakedown, chartering, onward and upward) in an ERP life cycle, showing their significance.

In our case, after using the ERP system for some years, only half of the users we interviewed admitted understanding the features they were using in their ERP operation. Most new employees only learned a portion of what the previous employee training them knew. Many users were using functions in the system without knowing why. This fact is amazing considering the amount of money the firm spent on their ERP system. By not utilizing most of the modules, the firm was losing opportunities to computerize business processes, run transactions faster, and meet operation objectives efficiently. Enrichments, upgrades and maintenance were more expensive, and less expected to be successful.

The results of the HoPS are presented in **Table 3**. The group of vital PS outcomes ('Effectiveness', 'Efficiency', and 'Sustainability') and the group of vital PS factors ('Communication between employees', 'Employees' involvement', 'Employees' skill', 'Clear targets', 'Clear description of the tasks', and 'Teamwork') were identified by means of the MSE criterion.

Pinto and Pinto (1990) conducted a research study among hospitals project teams responsible for developing new programs. They evaluated the relationship strength of two domains of communication in project teamwork (formal and informal types and motivation for communication) in terms of the level of cross-functional collaboration. 262 hospital project team participants were surveyed from 72 teams. The results demonstrated that high collaboration teams differed from low collaboration teams, both in terms of their increased use of informal communication channels as well as their motivations for communicating. Finally, cross-functional collaboration was found to be a strong predictor of project performance.

Welikala and Sohal (2008) conducted a comprehensive case study of a firm that is known as outstanding and presented several issues connected to employee involvement. The case study revealed that employee involvement was a key subject in the firm when total quality management (TQM) was first adopted. When the firm shifted its focus outward, however, this disappeared. The lack of continuing employee involvement at the ground level was identified as a major cause for the non-sustainability of TQM in the firm.

		HOS Input	PS Factors												
		Required improve-ment level	IS/IT	Recourse flexibility	Recourse capacity	Clear targets	Plans approved by interested parties	Clear descript-tion of the tasks	Commun-ication with end user	Team-work	Com-munica-tion between employ-yees	Emplo-yee involve-ment	Emplo-yees skill	Manage-ment support	Structured approach
PS outcomes	Efficiency	0.22	3	9	3	9	3	9	3	9	9	9	9	9	9
	Effective-ness	0.28	3	3	9	9	3	9	3	3	9	9	9	9	9
	Relevance	0.11	3	3	3	3	3	1	1	9	9	9	9	3	3
	Impact	0.17	3	3	9	9	1	9	3	9	9	9	9	3	3
	Sustain-ability	0.22	9	3	3	9	3	9	3	9	9	9	9	9	3
HOS output	Required improve-ment level		4.33	4.33	5.67	8.33	2.67	8.11	2.78	7.33	9.00	9.00	9.00	7.33	6.00
	Normalized		0.052	0.052	0.068	0.099	0.032	0.097	0.033	0.087	0.107	0.107	0.107	0.072	0.068

TABLE 03. HoPS of the ERP implementation project

5. CONCLUSION

In the literature, project success is shown as having two components: PS factors, which are similar independent variables that contribute to the likelihood of success and PS outcomes. Beyond theoretical attempts at creating a classification of settings, however, it is important to elicit the reasons the success or failure of projects within their specific settings. In specific settings, the literature has little to say about why some projects succeed and others fail.

In the current work, the QFD method is utilized as a mechanism for revealing the specific PS framework of a specific organization. A House of Project Success (HoPS) matrix was created using combined input from various managers and experts. This matrix summarizes the desired improvements in the PS outcomes and connects them to the relevant PS factors. Based on the HoPS matrix, outcomes and factors that maximize the desired results of the PS policy in an individual project were chosen using the mean square error (MSE) criterion.

This paper presents the application of the above methodology in two organizations, involved in different project types, namely weapons development and information system implementation, revealing their different HoPS structures. In the weapons development case, the vital project success factors, 'Clear description of the tasks', 'Clear Targets', 'Plans approved by interested parties', 'Employees' involvement' and 'Communication with the end user', were the drivers of 'Sustainability' and 'effectiveness', the PS outcomes to be improved. In the information system project, 'Communication between employees', 'Employees' involvement', 'Employees' skill', 'Clear targets', 'Clear description of the tasks', and 'Teamwork' were found to be the best PS factors for improving the 'Effectiveness', 'Efficiency', and 'Sustainability' PS outcomes.

We find that the QFD based approach successfully quantified PS initiatives related to PS priorities.

The QFD matrix ensures that every PS outcome defined by the project management is linked to a set of PS factors in the relevant domain that may, ultimately, influence its future performance. The QFD systematic methodology contributes to organizing the PS planning, thus enhancing continuous improvement for attaining project management goals.

The methodology was implemented in two organizations, and has three important practical implications:

(1) The QFD based approach offers a good way to define the most important PS factors related to PS outcomes.

(2) The applied approach is a scientific/engineering method for identifying a subset of vital PS factors necessary to achieve the best PS outcomes for all types of projects at any stage of development.

(3) Following the main objective of the study, we confirm the high level of interest of management personnel in the effective direction of project development in terms of PS. The project managers may well use the purposed methodology as a measurement framework of the PS initiatives for project development evaluation.

Limitation of the current study: A disadvantage of our PS QFD based methodology is the assumption that PS outcomes can be captured, documented and remain stable over the long term. The required improvement level of the PS outcomes may change unexpectedly. Therefore, the QFD tool could complicate the issue since adapting to dynamic needs can be complex, confusing and costly. ◆

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