I.6

Effectiveness Measures for Software Development Interests: Design and Validations

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SOFTWARE PROJECTS: STAKES AND PROBLEM AREAS

Software project stakes are still important and still remain problem areas. Software expenses will still continue because, firstly, software packages do not always expand over the whole business of a firm and, secondly, an information system that constitutes competitive advantage is specific to an organization. Meanwhile, software project management continues to worry data processing managers because previous deadlines and budgets are often not respected, earnings are difficult to evaluate, and user satisfaction is equivocal.

FRAGMENTED RESPONSES DUE TO PARTIAL FOCUS

Responses come from academics and professionals.

Academic Research

It focuses on structure (centralization versus decentralization, control versus autonomy, etc) and external operations such as transfer process management and interunit relations. The variables successes investigated are user satisfaction with the new system and effects on users' jobs. The more recent results demonstrate that the effects of MIS introduction cannot absolutely be known a priori. Technological, organizational, and individual factors interact with each other all along the project [3,13,20,23].

Professional Studies

Professional interests concern internal operations, which are activities carried out by MIS staff. Variables successes studied are costs, delays, productivity, and duration. Different methods have been developed to improve software project management. Estimation models relate to costs, duration, and time limit provisions. Comparative analyses of different models have dwelt on the problems and paradoxes of software measurement [1,5].

Methods of software development are used to improve product quality and/or to limit costs, duration, and delays. Depending on contingency factors, prototyping, the incremental model, self development by end-users, or package purchase constitute various alternatives to the waterfall model (sequential model with verification and validation at the end of each phase) [5,9,12,16].

Risk analysis makes it possible to avert many disasters by helping managers to make more informed and appropriate decisions. The chief determinants of risk are the size and structure of the project and the company's experience of the technology involved. Depending on risk profile, managers can choose various management tools; there is recognition that different projects require different managerial approaches.

These various studies have made it possible to obtain very interesting results: contingency approach to the problems of software development, dynamic interaction of the determinants of M.I.S. installation and success. Nevertheless, the topic's exploration has been fragmented, each investigation has focused on specific outcomes and partial determinants. Consolidation of progress is now necessary, and seems possible by resorting to some relevant paradigms of organizational theory.

USEFULNESS OF RE-USING SOME CONCEPTS

Two concepts were chosen to begin the software project research consolidation organizational effectiveness and rationality.

Organizational Effectiveness: Multidimensionality and Paradoxes

Despite the ambiguity and confusion surrounding it, the construct of organizational effectiveness is inherently tied to all theories of organization and constitutes the ultimate dependent variable in organizational research. Pragmatically, consumers, customers, suppliers, shareholders, managers, members, and other major stakeholders continually make judgments about effectiveness. Most current authors now share these common themes about organizational effectiveness, and it would be relevant to incorporate these consensual propositions in further research work [7].

multidimensionality

Effectiveness is a construct of various attributes encompassing in meaning both predictor and indicator variables. Often some confusion exists between the two categories of variables, inside the same research or between different research studies. Distinction between means and ends is also difficult to obtain because antecedence can change with inclusion of the time perspective. Outcomes are the dominant type of criteria used to assess effectiveness; in a broader societal context, effects of an organization's production can constitute other criteria. Nevertheless, the fact that effectiveness is a multidimensional concept is now widely acknowledged, and it has been proved by researchers [6,22].

Efficiency is the capacity for reducing the effort of inputs' transformation into acceptable products. Acceptance criteria may vary from different points of view. Economic efficiency is a relationship between inputs and outputs in terms of cost and outcome. Generally measurements focus on a restrictive set of costs, but effective measurement requires the development of various indices that identifies the contribution of each factor of (direct or indirect) production, and then tracks and combines them. The ratio: units of code instruction/(units of time/person spent) is often used as a productivity measure of software development projects. Social efficiency refers to individuals in organizations; members' implication and integration and realization of personnel goals constitute such attributes. Two major categories of personnel deal with software projects—data processing staff who realize the product (Was their work on the project an interesting experience that made it possible to learn new things?) and those who will use the system (Does use of the new system improve their work conditions?). Technical efficiency is the organizational capacity to produce goods and/or services in acceptable quantity and quality. Versatility and quality of information systems can be measured with indicators such as response time, accuracy completeness and richness of output information, and convenience of access.

Effectiveness focuses on the realization of organizational goals and concerns the capacity to maximize outcomes in different ways. It includes efficiency, and also flexibility, that is, adaptation to and/or manipulation of the organizational environment. Many authors call managers' attention to the competitive advantages that can be procured by appropriate utilization of information technology (17,24,26). The value of an information system comes from different benefits, tangible benefits like cost reduction, or intangible benefits (benefits difficult and/or too long to quantify exactly) like communications improvement or change in organizational procedures.

paradoxes of effectiveness

There are different models of organizational effectiveness (goal, system resource, internal processes, strategic, etc) arising from different conceptualization of organizations. These models are not congruent but compete with one another because organizational effectiveness is inherently paradoxical. To be effective an organization must possess attributes that are simultaneously contradictory, or even mutually exclusive. Paradox arises also because judgments of effectiveness are based on the values and preferences an individual holds, and they are sometimes difficult for that person to identify. Another problem with these preferences is that they vary and are often contradictory among different constituencies. Also the preferences of individuals change over time, and contradictory preferences are held by individuals and pursued by organizations simultaneously.

The result is that effectiveness of software projects is assessed differently by users, data processing professionals, and managers; indicators vary from feasibility until the installation of the system. Indicators such as time limit, quality and social efficiency can compete. The same predictor can play a contradictory role (positive versus negative) on different indicators.

Rationality in Social Actions

Cognitive rationality has two dimensions—instrumentality and communication[11]. Instrumental rationality is the application of knowledge to actions directed towards success. Communicative rationality concerns social actions; it is a constructive argument between different participants oriented towards obtaining common values or shared convictions.

These rationalities in action can fail when the desired result or consensus does not happen. More often the two forms of rationality are melded. A programmer coding and testing a program realizes an instrumental activity; the same working with others during the integration phase will realize instrumental and communicative activities. Strategic activity occurs when the goal is instrumental (success) and power over other participants is used (social means but not constructive argument). Confusion can appear between actions directed towards success and actions directed towards mutual comprehension. In such situations strategic acting is dissimulated, consciously (illusion is consciously generated by manipulation), or unconsciously (illusion is unconsciously produced).

Software project activities are varied, instrumental, and social. Every constituency has its point of view about the project (goals, means, expected benefits) and can try to rise above its subjectivity to create consensus or adopt a strategic behavior by imposing, directly or indirectly, its values.

Software projects will be studied in this research paper from both prior research results on the question, and paradigms related to the constructs of organizational effectiveness and rationality.

SCOPE OF THE PRESENT RESEARCH

The theoretical framework adopted has been put through empirical validation.

Theoretical Constituents

Three basic elements constitute the theoretic framework of this research: processes and conflict resolution as predictors of effectiveness, and multiple indices as indicators of effectiveness/efficiency.

processes predictors of effectiveness

To achieve their goals, organizations have to resolve problems derived from their characteristics as open social systems: division of labor, teleological operationality, interaction with the environment [8]. Problems square with these characteristics: resource acquisition with division of labor and environment, integration problems with teleological operationality, adaptation to the environment, etc. Effectiveness depends on problem resolution in different areas. Two categories of processes have been investigated: project processes and immediate environment processes.

The internal process concerns the activities carried out by project staff members only. The external process makes interface with all the other constituencies (users, managers, etc).

Project environment consists of temporal and functional environments. The preliminary project study constitutes the temporal environment. Processes of data processing departments and the quality of pre-existent information systems in the users department refer to functional environment.

conflict resolution as effectiveness-reducing and effectiveness-conducting

Software project realization needs different skills and coordination of the various constituencies. This organizational differentiation, social or horizontal line, and hierarchical or line of command encourages conflict emergence. Task interdependence is important for these project activities and can also generate conflicts, such as the share of scarce resources. Lastly, because they concern information and communication systems, because information detention constitutes an element of power, and also because they can drive strategic organizational changes, software projects constitute by nature a nest of discord fertilization in organizations. Conflicts are inevitable, but different mechanisms of conflict resolution turn into positive (focus on problems, focus on shared values, creativity, motivation, etc) or negative (hostility, alienation, obstruction, wasting energy, etc) orientation [10]. In a conflict situation, interaction orientation determines the mode of conflict resolution.

Detached orientation occurs when conflicts exist but are not explicitly revealed because one party, with weak power and/or weak interest, stays in the background. Conflict ignorance leads to catastrophic dilemmas, which often appear when people use the new system.

Cooperative orientation refers to constructive argument by the constituencies. Confronting points of view needs conviction, permits selective integration and consensus, and finally favors effectiveness.

Competitive orientation happens when at least one constituency tries to impose its aspirations to the detriment of others. Conflicts are open, attempts to reach consensus can have occurred and failed. The hierarchy has to resolve conflict, and the issue is ambivalent: either the compromise found satisfies all constituencies or a clear-cut decision taken does not agree with at least one party.

Accommodating orientation consists in minimizing open conflicts and in smoothing over issues by playing down the differences and emphasizing common interests; often issues that might cause divisions or hurt feelings are not discussed. The result of this mode is also ambivalent for effectiveness because important issues may have been treated or ignored.

To improve confrontation, interfaces are often created, which have to help the weak parties' argument.

Conflicts will have, through their resolution modes (constructive and/or destructive), effects on project results. For example, a project failed after installation of the system because the points of view of operational units were always systematically ignored (fear of loss of power, more control from the technostructure, no resources to initialize database from voluminous paper notebooks, etc). These units had to initialize and update the new database; after installation of the system, initialization procedures were found inappropriate and were not applied. The new system, without sufficient historical data, was not usable by the strongest constituency (functional unit of the technostructure).

multiple indices of effectiveness

The model includes the different efficiency-effectiveness indicators. For each indicator, multiple indices were created (figure 1).

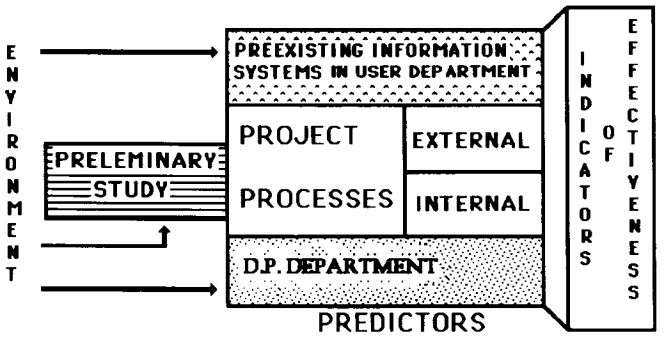

Figure 1—Diagram of Theoretical Constituents

VALIDATION TECHNIQUES AND RESULTS

Because measurements of organizational and human behavior are not error-free, instruments validation is needed.

Psychometric Procedures Used

Validity was evaluated from two perspectives that are equally important—intrinsic and extrinsic validity [25].

Empirical Field

Paradigms have been tested in France with 24 real software projects. The sample concerns business software (CAM and OA systems excluded).

To avoid halo effects, the study was longitudinal. From 1987 to 1990, three soundings were taken: first, at the end of the feasibility phase (project environment and expected benefits measures taken); second, at the system installation (project process measures taken); and third, after operational utilization by users (effectiveness-efficiency measures taken) (figure 2).

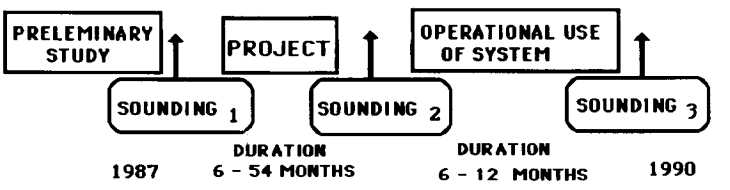

Figure 2—Diagram of Longitudinal Study

The intrinsic validity of an instrument refers to how well it measures what it is intended to measure in a consistent way. The procedures used to evaluate intrinsic validity of this research instrument are: factor analysis, indices of internal validity (alpha Cronbach coefficient), discriminant validity (median correlations), and correlations of selected dimensions with parallel measures. For each measure, recognition of intrinsic validity is adopted when three of these four techniques are positive, having regard to the standards generally adopted.

Extrinsic validity focuses on the practical usefulness of the instrument in testing paradigms. The procedures used to assess extrinsic validity are bi-dimensional correlation (one predictor/one indicator), multiple and stepwise regression (n predictors/one indicator).

Validations and Hypotheses Results

intrinsic validity

Sixteen measures have been intrinsically validated. One instrument, "staff skills," concerning aptitudes shown by project members, could not be validated. The 15 items have not been aggregated and were kept isolated for extrinsic validation.

extrinsic validity

Seventy-eight predictors are significantly related to at least one indicator. Nine predictors were not significantly related, but the power of the test is insufficient to invalidate relation. The percentage of variance in performance explained varies from 0.37 to 0.90. The results of the extrinsic validation permits the conclusion that the theoretical approach is relevant.

hypotheses

All the hypotheses can be considered as validated [18].

- hypotheses related to organizational effectiveness:

H1 significant predictors vary according to performance indicators,

H2 the same predictor can be involved in contradictory ways in different performance indicators,

H3 perception of performance predictors varies according to different constituencies;

- hypotheses related to conflict resolution:

H4 resolution by "avoidance or ignorance" is negatively correlated to performance,

H5 resolution by confrontation is positively correlated to performance,

H6 resolution by "resorting to higher authority" and by "smoothing over conflict" is contradictory, correlated to performance,

H7 coordinating is positively related to performance.

variables investigated

Process Predictors	Validations intrinsic	Results extrinsic
Legend: column intrinsic validation	V = Validated I = Invalidated	
column extrinsic validation	P = positive N = negative C = contradictory	
Internal operations		
Coordination with project manager (1 item)		P
Coordination with members (1 item)		P

Coordination with others (1 item)		P
Project manager's actions (5 items)	V	C
Others' actions (5 items)	V	C
Members' (as individuals) actions (5 items)	V	C
Members' (as a group) actions (5 items)	V	C
Behavior extremely directed towards success (1 item)		C
Behavior moderately directed towards success (2 items)	V	N
Behavior weakly directed towards success (2 items)	V	N
Conflict volume with project manager (1 item)		
Conflict volume with others (1 item)		N
Conflict volume with members (1 item)		N
Conflict resolution "avoidance" (1 item)		N
Conflict resolution "smoothing over issues" (1 item)		C
Conflict resolution "confrontation" (1 item)		P
Conflict resolution by "hierarchy" (1 item)		C
Aptitudes shown by members (15 items)	I	C
Autonomy (4 items)	V	P
Work pressures (2 items)	V	N
Control of job pressures (2 items)	V	N
Work feedback (1 item)		P
Colleagues' feedback (1 item)		C
Supervisors' feedback (1 item)		
Job accountability (3 items)	V	C
Task variety (1 item)		P

External operations

Members' role (4 items)	V	C
Data processing managers' role(4 items)	V	C
Data processing experts' role (4 items)	V	C
User managers' role (4 items)	V	C
Users' role (4 items)	V	C
Others, coordinating role (4 items)	V	P
Supervisory attention (1 item)		C
Frequency and importance of modifications (1 item)		C
Conflict volume (1 item)		C
Conflict resolution "avoidance" (1 item)		N
Conflict resolution "smoothing over issues" (1 item)		C
Conflict resolution "confrontation" (1 item)		P
Conflict resolution by "hierarchy" (1 item)		C
Conflict object "functional" (1 item)		C
Conflict object "technical"(1 item)		C
Conflict object "user department's organization " (1 item)		C
Conflict object "new system validation" (1 item)		C
Conflict object "design of user job" (1 item)		P

Project environment

Preliminary study

Members' role (4 items)	V	N
Data processing managers' role (4 items)	V	
Data processing experts' role (4 items)	V	C
User managers' role (4 items)	V	N
Users' role (4 items)	V	
Others' coordinating role (4 items)	V	P

Conflict volume (1 item)		N
Conflict resolution "avoidance" (1 item)		
Conflict resolution "smoothing over issues" (1 item)		P
Conflict resolution "confrontation" (1 item)		
Conflict resolution by "hierarchy (1 item)		N
Conflict object "cost and duration" (1 item)		N
Conflict object "technical" (1 item)		C
Conflict object "functional" (1 item)		P
Data processing department		
Job-contingent rewards (2 items)	V	N
Job-contingent sanctions (2 items)	V	P
Conflict volume (1 item)		C
Conflict resolution "avoidance" (1 item)		
Conflict resolution "smoothing over issues" (1 item)		
Conflict resolution "confrontation" (1 item)		
Conflict resolution by "hierarchy" (1 item)		P
Users' department		
Satisfaction with pre-existing information systems (32 items)	V	P
Indicators of efficiency-effectiveness		
Economic efficiency		
- Perceptual ratio cost/outcome (1 item)		
- Productivity		
Technical efficiency		
- Global quality (1 item)		
- Precise quality (26 items, 14 indicators)		V
Social efficiency		
- Social effects of project (2 items)		V
- Global social effect of new system (1 item)		
- Precise social effects of new system (11 items)		V
Effectiveness		
- Support decision (6 items)		V
- Obtained benefits (sum of scores)		
- Difference of obtained benefits and expected benefits		
- % of expected benefits obtained		
- Lag time (-)		

WHAT PROJECT FOR SOFTWARE PROJECTS: PREDICTIVE AND/OR COMPREHENSIVE APPROACH?

These exploratory research results permit provisional conclusions. The principles adopted have been productive. Significant predictive processes of software projects have been identified. Consolidation with two previously and reasonably selected paradigms would concern French data processing managers because the survey results indicate that they pay weak attention to external processes and to "confrontation" conflict resolution.

Further data investigation by projects, and not by respondent, would permit a rough shape of the predictor grid. This grid would be modulable and malleable. It would be modulable according to the different effectiveness-efficiency indicators, according to project characteristics (complexity, structure, size, etc), and also according to particular objectives (constituencies using the grid). Ductility would be reached by imaginative integration and rigorous application of heuristically collected paradigms, even if comprehensive malleability would be exerted to the detriment of prediction.

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