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Modeling of Project Dynamics in IT Sector: A System Dynamics Approach for Resource Optimization from a Risk Perspective

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ABSTRACT
This paper focuses on contingent approach to Dynamic-risk factors, which influence the 'Project Success' in an IT sector. The objective is to promote strategic thinking by helping managers to recognize, design and use flexible alternatives to manage dynamic uncertainty. System Dynamics and Cybernetics approach has been used to develop causal loop diagrams and flow diagrams by considering the impacts of underlying uncertainties on performance of the firm. The effects of critical success factors such as Time- independent training and Scope Management are incorporated in the model and dynamic simulation has been carried out. The results thus obtained are analyzed so as to obtain alternatives to capitalize on the opportunities and improve the firm's competitiveness.

INTRODUCTION
In the Globalized Information Technology (IT) economy, competitive forces such as intense competition, fragmented & demanding markets, and diverse & rapidly changing technologies cause companies to view improved product development as a competitive imperative (Wheelwright and Clark, 1992). The success of the IT industry lies wholly on the way they transform into Learning Organization and the rate at which they learn to develop the product with regard to time, cost, quality and customer satisfaction.

The IT industry has recognized the importance of Project Management (PM) and restructured itself to project-oriented organizations. But traditional project management concepts do not offer effective mechanisms to facilitate the qualitative and quantitative learning. That is why, many researchers place continuous learning and improvement in the highest level of project management maturity, in an organization (Kerzner, 2000).

System Dynamics (SD) in PM focuses on how performance evolves in response to interactions between managerial decision-making and development processes. SD has been applied to software development process in-order to improve the situation (Abdel-Hamid and Madnick, 1986; 1991; Abdel-Hamid, 1989; Abdel-Hamid, Sengupta, and Ronan, 1993; Abdel-Hamid, Sengupta, and Hardebeck, 1994), mostly focused on impacts of schedule pressure, increasing productivity aspects of project staff via improvements in technology or management. Although these aspects do have an influence on the project success, closer examination shows that these efforts address only a part of the problem. A project gets overtime or over-budget if actual performance does not match estimates and its inability to evolve itself. This paper aims at a solution to the impacts of competence loss and productivity & schedule pressure related aspects when there is change in the scope of the project, as it is the major dynamic risk factor in IT related projects.

OBJECTIVE
The overall goal of this research is to increase the knowledge and understanding of the IT Projects. This is achieved by applying the system dynamics approach to study the dynamics of the project, when there is change in 'Scope'.

Specifically, the following objectives are formulated to achieve the overall goal of this study:

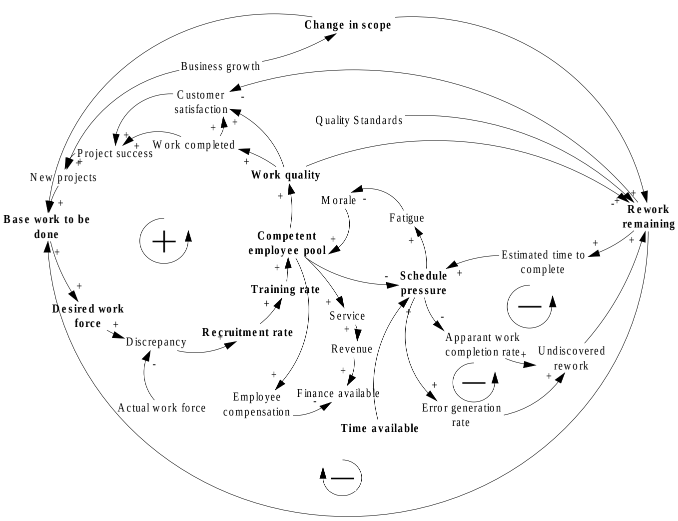
- Identifying and relating variables within the system, using the principles of cybernetics.
- Developing causal loop diagram for the critical factors.
- Constructing the flow diagrams.
- Formulating the governing equations.
- Modeling and simulation of the Project Dynamics.
- Drawing inferences for Project Resource Optimization.

RESEARCH METHODOLOGY
This research encompasses areas such as Project Management; Cybernetics, System Dynamics, and Learning Organization in relation to software development projects. SD is basically built upon the traditional management of Social System, Cybernetics and Computer Simulation (Sushil, 1993). The application of SD to PM covers a wide range of uses, such as, creating team learning and training environments, providing a tool for advanced planning and control of on-going projects, and post mortem analysis to support legal dispute resolution (Rodrigues, Alexandre and Bowers, 1996).

In this research, Cybernetics principles were used in establishing *causalism* (Negoita, 1992) between the dynamic factors, which influence the project success (figure-1). Under ideal situation, the project starts with initial scope of work. The hiring of knowledge workers (KWs) takes place according to the discrepancy in workforce. The KWs are trained to impart competency. On the course of the project, rework occurs due to quality standards, human errors and work obsolescence. These reworks are identified and a fraction of competent KWs are assigned to complete the rework. Customer satisfaction increases when the project is completed on time, on budget and with the expected quality. In reality, change in scope occurs due to changes in business such as change in technology or in markets conditions. Customers often request those changes to be incorporated in the project as and when they occur. This adds more work to existing rework & base work. All these aspects have been considered in the development of the causal loop, using which, the flow diagrams (Mass, 1986) were developed.

The principles of System dynamics (Forrester, 1994; Coyle, 1979, 1996; Law and Kelton, 1991; Mohapatra *et al.*, 1994; Maani and Cavana, 2000; Wolstenholme, 1990) have been adopted for structural

Figure 1. Causal loop Diagram of the a typical IT sector project



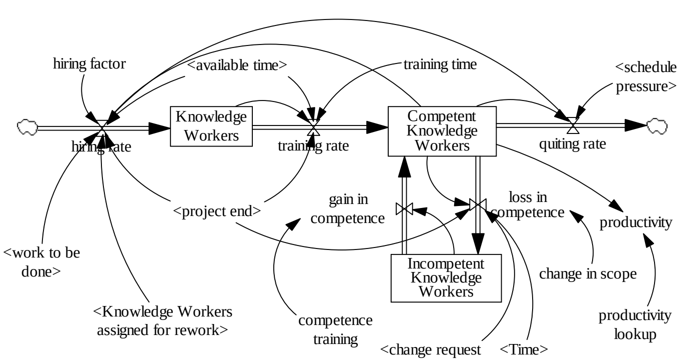
and policy analysis of the developmental projects. The modeling and stimulations are done using Vensim® PLE application software (Ventana, 2005).

MODELING AND SIMULATION

The system dynamics model of a single software development project was constructed to investigate dynamics when there is change in scope. The model consists of three sectors: 1. Competent knowledge workers' sector (Figure: 2), 2. Project workflow sector, and 3. Project knowledge workers' wages-revenue sector. In the competent project staff sector structure, the total manpower required for the completion of work is based on the project completion time, which in turn, decides the hiring rate of the KWs. All the KWs undergo training before they transform themselves into competent KWs. The new work, resulted due to the change in customer expectations has to be accommodated with the existing work. At the same time, some of the previous work done may turn obsolete. When the project reaches the scheduled completion time, schedule pressure increases, which would result in competent KWs turnover and increased rework. Again, a portion of the competent KWs will have to be assigned to complete rework so as to complete the project on time.

This research focuses mainly on the explicit modeling of the effects of change in scope of project. As previously mentioned, the change in scope of project may add work to a project beyond the original scope.

Figure 2. Competent knowledge workers' sector



This may result in "Competence Loss". The term 'Competence' in this context includes- knowledge, skill and attitudes of KWs that would enable them to perform the job. 'Competence loss' refers to the failure of the KWs to perform the job because of incompetence. They have to be given proper training to gain competence (i.e. Competence gain) so as to complete the new work.

Simulation Parameters

- Work to be done: 100 man-months (person*month)
- Scheduled completion time: 18 months, change is requested on the 12th month.
- Initially KWs available: 20 (persons)
- Initial competent KWs assigned will be 5 (persons).
- Base case –simulation is for project with no change in scope.
- Case1, 2, 3 are for projects with 25%, 50% & 75% change in scope.
- Interaction effect is provided by way of table look up (Fried, 1995)
- Each change entails in 20% increase in workload.
- Competent KWs requirements are adjusted on monthly basis.
- KWs and incompetent KWs needs training time value 1 month & 0.5 month respectively.
- Competent KWs are taken on the basis of productivity table look up
- Rework identified gets priority over project work to be done.
- All rework identified is assumed to be reworked within one month.
- Competent KWs are allocated to rework first and the remaining are assigned to project work to be done.
- Reduction in available time increases schedule pressure ranging from 1 to 2 and this schedule pressure affects the rejection rate as well as competent KWs turnover.
- Average wage per KW per month is $1,000.
- Available KWs at all times needs to be maintained at 10% of the project staff.
- If-then-else logic is employed in many equations to prevent negative draining of stocks as well as to prevent recurring fractional computations.

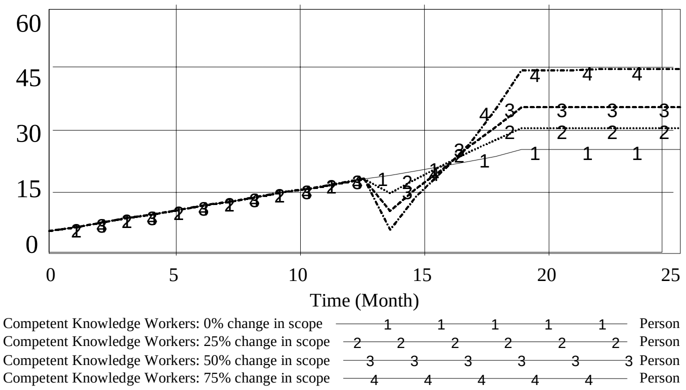
With the above parameters obtained from real-life situations in India, the model is simulated and the following results of base run and three alternative policy runs are obtained.

The Figure 3 depicts the dynamics of competent KWs in a project, when change in scope occurs. The curve-1 indicates an ideal situation where there is no change in scope, and the project ends at scheduled 18 months. This is a highly theoretical scenario, which is often challenged by discontinuities occurring due to changing technologies and market conditions. The curve-2 explains the dynamics of the competent KWs, when there is 25% change in scope. It can be observed that the project still ends on the scheduled time. The curve-3 shows the competent KWs when there is 50% change in scope. Even here, the project ends at the scheduled time. When the change in scope is 75% (curve-4), the project ends on 18th month. Thus, the curve-4 (75% change in scope) may also be considered as a project success. Therefore, proper control of the "competent knowledge workers' pool" would enhance the productivity and would facilitate the project completion on the scheduled time.

CONCLUSION

The model developed in this research gives an in-depth study of the influence of 'change in scope' on Competence loss, Competence development, and Competence absorption of the KWs. It is a known fact that minimal "Competence Gap" would ensure better performance and the project completion on time. So, in this paper it has been shown that even with 75% change in scope the project could be a success through proper deployment of knowledge workers. Hence, the IT strategic managers have to control the competence gain training, in order to optimally utilize the knowledge of the organization to achieve the

Figure 3. Competent Knowledge Workers' Behavior



project success. While no single approach or model can provide a complete understanding of the development projects, this model is developed upon Competence Loss and Gain to have a better understanding of the IT projects.

'Knowledge' is now considered to be a strategic asset as its optimal utilization leads to project success. Hence, minimum 'competence gap' is not only a national concern but also a global concern in this progressive world of globalization, and this paper uses SD approach to achieve this goal.

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