The Role of Systemic Effects on Project Performance in Multiproject Environments

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While the focus of the project management literature has been on the management of single projects, the management of multiproject environments is largely neglected. In this research I am focusing on mutiproject environments which exist within a single firm (hereafter called Alpha). Through my investigation in this multiproject environment I explored root causes for project inefficiencies which rather than being possible to attribute to source within each single project boundary, are caused by the effects which I term them systemic effects. System effects are dynamics triggered by the complex linear , nonlinear and time delayed interaction of large number of factors. I develop a model which explains the dynamics through which the systemic effects deteriorate the performance of the projects in this organization. The model is useful in creating awareness among the managers about the lack of holistic approach in decision making and the effects of suboptimum decisions in this environment.

Keywords: multiproject, product development, project management

1. INTRODUCTION

The management of the new product development process is a core capability for manufacturing enterprises operating in competitive markets (Clark and Fujimoto 1991; Karlsson and Ahlstrom 1996). This capability needs to be responsive to demands to compress development lead time, increase team productivity, and ensure the commercial success of project outcomes in the market (Clark and Fujimoto 1991; Meyer and Utterback 1995; Griffin and Hauser 1996; Zirger and Hartley 1996). At any point in time, a manufacturer may be running a large number of product development projects simultaneously (Reinertsen 1997). This makes it challenging for project managers to ensure each project is efficient and effective. Unlike the maturity of existing theory in the development process for single projects , we know little on the dynamics of managing projects unfolding in multi-project environments (Nobeoka and Cusumano 1994; Engwall 2001; Repenning 2001; Soderlund 2004)

In some manufacturing organizations, a large number of projects can take place concurrently to address different needs and objectives. Some projects involve radical development of new products whereas other products involve incremental changes to existing products (e.g., development of a new platform, copying innovations introduced by competitors, improving existing features, changing the supply chain structure or improving production costs.). Managing projects in multi project environments is a complex problem. The complexity stems from various factors including: interdependencies between tasks, competing for shared resources, budget limitations, and the influence of a project output on the development process for another project.

I structure this article as follows: After presenting background literature (§2), I describe my research method, research setting, and data collection procedures (§3). I describe the product development processes in Alpha (§4). Then I analyze the data, and summarize my insights in a system dynamics causal diagram representation (§5). Finally, I discuss the managerial insights and the implications to practice (§6).

2. THEORETICAL BACKGROUND

Acknowledging that the project systems within product development environments in general and specifically in the auto industry are complex systems, decision making in such environments is a very difficult task as there are limits for humans' cognitive and decision making power(Morecroft 1983). The rationality is bounded when it falls short of omniscience. And the failure of omniscience is largely the failure of knowing all alternatives, uncertainty about relevant exogenous events, and inability to calculate consequences(Simon 1979). The principle of bounded rationality suggests that the performance and success of an organization is governed primarily by the psychological limitations of its members(Morecroft 1983). People generally adopt an event-based, open-loop view of causality, ignore feedback processes, fail to appreciate time delays between the action and the response, and nonlinearity in the causal relationships(Sterman 2000 p.27). Over the last few decades one school of thought in the management literature has emphasized the importance of analyzing natural and social phenomena from a more holistic view (Forrester 1971; Checkland 1999). This holistic view is generally referred to as system thinking (Forrester 1992; Sterman 2000). One approach within the system thinking is System Dynamics which is a problem solving method used both qualitatively and qualitatively(Keys 1990; Wolstenholme 1990). System dynamic models implicitly express these limits and both graphically and computationally assist decision making with including the effect of feedback loops, nonlinear relationships, delays and separating the effect of endogenous and exogenous factors in a model.

The understanding of system is central to using System Dynamics. Systems can be classified as "open" or "closed systems". An open system is one characterized by outputs that respond to inputs, but where the outputs are isolated and have no influence on the inputs (Forrester 1971). In contrast closed systems are systems which their performance would change based on their pervious performance. It is very difficult to find systems which are purely closed. Rather, systems tend to be a combination of open and closed systems. Also the classification of a system as a close or open system is not intrinsic to a particular assembly of parts but depends on the observer's viewpoint in defining the purpose of the system (Forrester 1971). System Dynamics is basically about analysing

closed systems. A principal activity in system dynamics modelling is to define the boundary of the system and then translate what lies within the boundary into a closed system model with some rational modelling assumptions.

"Stock and flow" and feedback loops, are two central concepts of system dynamics (Sterman 2000 p.191). Stocks are the accumulations of entities within the system (Forrester 1961 p.68). They characterize the state of the system and generate the information upon which decisions and actions are based (Sterman 2000 p.192). The flows are defined by rates and their connection to the stocks. They determine the rules regarding how the state of the system would change as the time progresses. Feedbacks are structures existing in many systems. Feedbacks show the effect of the behaviours or actions of one component in a system on itself. A feedback is a causal diagram which is usually shown by a loop constructed by arrows indicating the relationships between the elements of a model.

System dynamics has been used in research on the management of large-scale engineering projects (e.g. Cooper 1980; Williams et al. 1995; Lyneis et al. 2001) and new product development projects(e.g. Ford and Sterman 1998; Repenning 2001). Large engineering projects can be characterized by consisting of multiple interdependent components, highly dynamic, involving multiple feedback processes, nonlinear relationships and including both "hard" and "soft" data (Sterman 1992; Shapiro and Lorenz 2000). These features cause these project systems to behave in complex ways which are difficult to understand, predict, and manage.

Applications of system dynamics have contributed useful insights to both the practice and theory in project management in terms of: (1) the effectiveness of different resource allocation policies (Roberts 1964, 1974); (2) the counter-productivity of adding resources in the late project stages as a means to overcome a project delay(Abdel-Hamid and Madnick 1991); (3) the negative effect of "error and rework hiding" in concurrent engineering (Ford and Sterman 2003); and (4) the effect of change and rework in construction projects(Love 2002; Park and Pena-Mora 2003; Love et al. 2004). Other applications of system dynamics exploit its usefulness as a tool to resolve legal disputes in shipbuilding projects (Cooper 1980) and rail wagon manufacturing environments (Williams et al. 1995; Ackermann et al. 1997; Eden et al. 1998). Very few studies, however, use system dynamics to address the problems of managing projects unfolding in a multi-project environment. A notorious exception is Repenning's (2001) analysis of the persistence of the fire fighting phenomena in a passenger car development environment. Through the development and simulation of a system dynamics model about the new product development projects within a car manufacturer, Repenning(2001) demonstrates that if the projects in the organization are not fed with sufficient resources especially in their early stages, they will get trapped in the firefighting mode - the state of focusing on urgent unplanned activities. Further, he indicates that there is a tipping point that, unless enough resources are fed into the projects to pass this point, the firefighting mode will persist in the product development projects.

3. RESEARCH METHOD

This research builds conceptual understanding on the dynamics of multi-project environments from a case study research (Eisenhardt 1989; Yin 1994). The case study method ─ rich in capturing the experiences of the actors and the context (Benbasat et al. 1987; Yin 1994; Strauss and Corbin 1998; Flyvbjerg 2001) ─ suited my research in the face of the infancy of theory on managing projects in multi-project environments. To analyze the empirical observations, I draw from theoretical constructs in product development and system dynamics. I summarize my insights and managerial propositions into graphical models using system dynamics causal loops.

3.1. DATA COLLECTION

The data collection process included face-to-face interviews, analysis of archival documents, and direct observations in a truck manufacturing company . While direct observation and archival documents was useful in relation to understanding of the organization processes and culture, the interviews provided information about each individual's perspective and experiences from their day to day activities. The fieldwork extended over 2 years elapsed time. I started the data collection process with an exploratory stage during which I familiarize myself with the working environment and the organizational culture as well as building relationship for a long term research collaboration. During the exploratory stage (2004), I spent a 5-months student placement in the company participating in some quality improvement projects as a team member. As interviews are regarded as the main source of information collection in System Dynamics(Luna-Reyes 2003), in the second stage (2006) I conducted a total of 62 interviews with members of five divisions of Alpha: product development (34 interviews), manufacturing (5 interviews), purchasing (3 interviews), product planning (9 interviews) and brand management (11 interviews). The respondents had job roles as diverse as project managers (39), functional managers (13), and project liaisons (10).

The interviews were semi-structured, recorded as audio files, and transcribed. The interviews lasted between 40 minutes up to two hours. My key informant in the company provided an initial list of names of senior individuals (e.g., vice-presidents, functional managers) involved in various projects, and an electronic document authorizing the data collection. From this stage onwards, I used a snowball tactic (Rao and Perry 2003): I systematically asked my interviewee for the names of other people who could helpmeprobe more in-depth into the issues emerging during each interview. The interviews were conducted in a time span of 7 months with interviews aiming to identify the potential opportunities and research focus where the interest of the industrial partner and the authors would match. Starting with some unstructured interviews the authors frequently discussed the content of the interviews and gradually narrowed down the focus of the interviews to the issues considered to have value for management research.
The potential interviewees were contacted by email and follow up telephone calls to schedule appointments. The authorization document along with a short description of the research and a sample of questions were sent to each interviewee in advance. Apart from

few instances where two interviewees participated in the interview, the rest of the interviews were one-on-one. In the interviews, the interviewee was first asked to describe his/her role and responsibilities. Thereafter the interviewee was asked to briefly describe the content and context of the projects he/she was involved. This provided the background to ask some standard questions such as: what were some of the key managerial decisions in this project? Or; what were the key interactions with other projects ? However the interview format was kept flexible allowing the interviewer to explore areas that come to light during the course of discussion(McCutcheon and Meredith 1993 p.205; Strauss and Corbin 1998). In the last part of the interviews the discussion was led to the direction where the interviewee were encouraged to express his/her own personal reflections on what problems he/she has observed in the projects and his/her suggestions for improvement.

4. THE PRODUCT DEVELOPMENT PROCESS AT ALPHA

Alpha follows a “strategic bucket” approach in the selection of the projects which means that different envelops of money or buckets are defined as a strategic budget for certain type of projects(Cooper et al. 1997). Projects can be proposed by any individual or team in the organization need to be evaluated by a certain Decision Body based on the scope and relevant bucket (See figure 1). Each Decision Body is a committee comprised of a number of different representatives from different business units of Alpha and is authorized to evaluate and approve projects falling within a certain budget range. The larger is the scope of a project, the higher is the position of the Decision Body in the organization hierarchy. A team of experts who are experienced in project cost estimation initially reviews the proposed projects and only if the benefits of a proposal out weight its cost, they pass the proposal together with their time and cost estimations to the corresponding Decision Body. There are three possible outcomes of the review of the Decision Bodies (See figure 1). First, the project can be rejected because the project may not fit into the current project portfolio or there are not sufficient available resources. Second, the decision body may funds a pre-study to enable the project team to further investigate technical aspects, collect more information, and eliminate some of the uncertainties about the business case. Third, the decision body may decide to fund the project proposal and assign a team responsible onwards for managing the project.

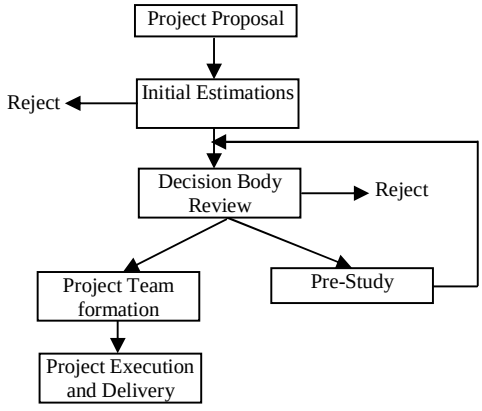

Figure 1. The Project Initiation Process at Alpha

The approved projects are carried out according to a typical stage-gate methodology customized to Alpha. Stage-gate is a model adopted by many product development organizations to enable the efficient and effective movement of new products from idea to launch (Cooper 1990). Stages refer to the activities which should be carried out by the multi-functional teams and the gates are the decision points where senior managers make decisions about the project. The number of stages and gates varies between companies. Some companies may identify as little as four stages whereas other companies may identify eight or more stages; stages themselves, may be comprised of different sequential or parallel activities (Cooper 1990).

Figure 2 illustrates the schematic stage-gate process followed at Alpha. In pre-study, the teams develop in-depth feasibility and profitability studies necessary to make decisions regarding approval/rejection of a project. If the project proposal passes the gate criteria, the team is allowed to move to the concept study stage.

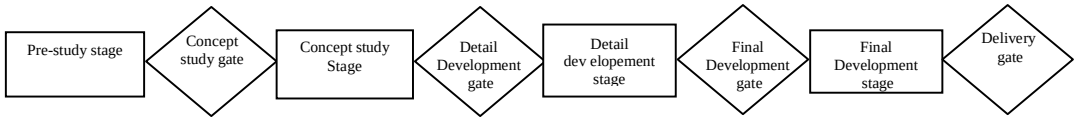

Figure 2. Schematic Representation of the Stage-Gate Process at Alpha. The rectangles represent stages and the diamonds represent the gates

In the concept study stage, the project team needs to develop a technical solution. A multidisciplinary team, involving individuals from marketing, engineering, aftermarket and manufacturing, jointly develops a single or multiple concepts and evaluate the extent each concept satisfies the requested specifications. After a number of iterations and improvements, the team will select a concept and after obtaining approval for the detail development gate, the team proceeds to detail development stage. In the detail development stage, the project team develops detailed technical drawings of the new product, builds prototypes, and tests the prototypes in the field. After getting the approval for the final development gate the project team can proceed to the final development stage. The final development stage is actually the stage where the activities regarding the setup of manufacturing installations take place. While the manufacturing division is typically involved from the early stages of development to communicate their requirements in the designs, the action to setup the manufacturing facilities (which usually require high capital investments) would not be taken before the approval of the design in the final development gate. Completing the final development stage and passing the delivery gate is the start of the serial production.

The project organization in Alpha resembles the light weight team structure(Clark 1992). In this project structure, designers and engineers (who are usually involved in different projects at the same time) reside physically in their functional areas, but each functional department designates a person as liaison who coordinates the project activities of his/her respective department with the project manager and the other liaisons(Clark 1992 ,see figure 3). In this structure the project manager does not have any command authority to any individual designers and engineers but through the respective project liaison.

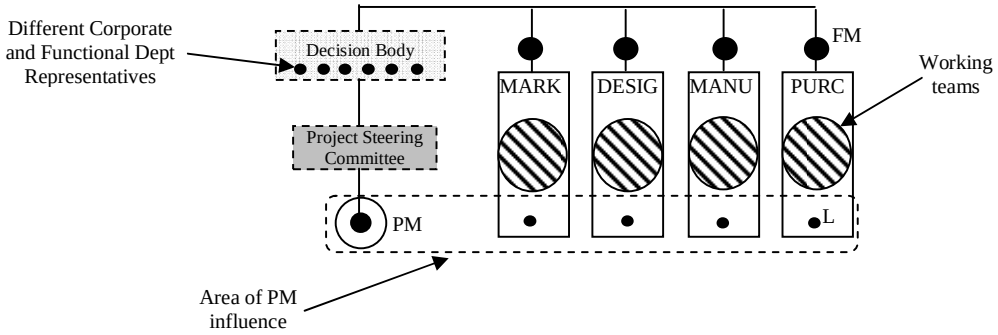

Figure 3. depicts the organization and the area of influence of Project Manager (PM) in relation to Functional Managers (FM).

Since in the light weight project structure, the project manager authority is limited, a steering committee comprised of different experienced managers and representatives of departments frequently reviews and directs the project managers in major decision making points. The steering committee is only entitled to make project management decisions. However in case of any decision affecting the project scope and required resources it is only the Decision Body which have the decision making authority.

5. MODEL DEVELOPMENT

The multiproject product development environment within Alpha can be considered as a complex system(Sterman 1992; Williams 2002). From the outset of my framework I hypothesized that a large part of the managerial difficulties existing in product development within Alpha are originated from systemic effects (Rodrigues and Williams 1998; Williams 2005). Systemic effects are the effects appearing in the projects because of the feedback structure, non-linear interaction of the variables or the delay between action and the results. System Dynamics, strong in capturing systemic effects was selected as a suitable theoretical lens to assist me in collecting data and analysing the problems in product development projects at Alpha.

As the factors involved in the any real world situation is numerous and their interactions, I need to define which factors I am analysing in my research and which factors I consider their impact negligible. In addition, as a fundamental principle of System Dynamics modelling I also need to define what factors are endogenous and what factors are exogenous to my model. Endogenous factors are the factors arising from within the system whereas exogenous factors are the factors arising from outside the system. In System Dynamics the goal is to develop and endogenous an explanation for the problematic dynamics(Sterman 2000 p.95).

Regarding the exogenous factors, firstly I do not measure or evaluate project success or failure based on the competence of the individuals in the teams. Rather, this study assumes that everyone in every project is competent in their field at the normal level. Secondly my analysis does not look at the projects which Alpha outsources to other

parties. I totally exclude all the issues regarding external uncertainties to the project. I acknowledge their existence but are not going to analyse their form or their origins. Thirdly all issues regarding the serial production after completion of a project are also excluded in this research. Fourthly, I also consider available resources as an exogenous factor meaning that the internal dynamic which I will depict in my model do not have any connection to recruitment or laying off of resource.

I construct a comprehensive model compassing all the factors I consider in this research. To further simplify the construction and explanation of my complex model I divide my data analysis and model building into five sections:

(1) Project approval and early phases decision making
(2) Maximizing resource utilization
(3) Accelerating project progress and its effect
(4) Multitasking and project team exhaustion
(5) Closing the loop: why the problem persists

I construct this model which I believe is very helpful in understanding the product development in similar environments to Alpha, however I do not follow the quantification direction in System dynamics as I do not have enough quantitative data and even with making assumptions I believe the results from the quantitative analysis of this model could be misleading and fragile(Coyle 2000)

I elaborate on each of these five sections presenting evidence from my data and developing my model using causal diagrams. Just as a reminder one should know that in the causal diagrams, arrows indicate the direction of the causality. Signs (‘+’ or ‘-’) imply the polarity of relationships: a ‘+’ denotes that an increase in the independent variable causes the dependent variable to increase. A “-“denotes that an increase in the independent variable causes the dependent variable to decrease. An arrow crossed with two parallel lines represents presence of time delay. From this point the italic phrases in quotation are refereeing to the parameters in my System Dynamics model.

5.1. PROJECT APPROVAL AND EARLY PHASES DECISION MAKING

Before a project team can acquire necessary resources to start, the project needs to be approved by the relevant Decision Body according to the process depicted in figure 1. I have identified some dynamics for the project which go through this stage and I try to graphically model them with the causal diagrams. Figure 4 depicts the early stages of the stage-gate process in Alpha. The proposed projects enter the first stock (“*Projects in DB Review*”) through a flow and get reviewed by the respective Decision Body. The Decision Body review would have three possible outcomes: (1) the project would get approved and required resources would be allocated to it, (2) the project is rejected or delayed based on the available information or (3) authorized to form a pre-study team to further investigate the opportunities and costs associated with running the project. In the model the projects requiring pre-study enter the stock of “*Projects in Pre-study*” and after the completion of pre-study, the projects return to the stock of “*Projects in DB Review”* (DB refers to Decision Body). The approved projects will pass the concept study gate (“*C S gate”*) and

move to the next stage of their development. The projects in the pre-study will be reviewed by the Decision Body again after the pre-study completion.

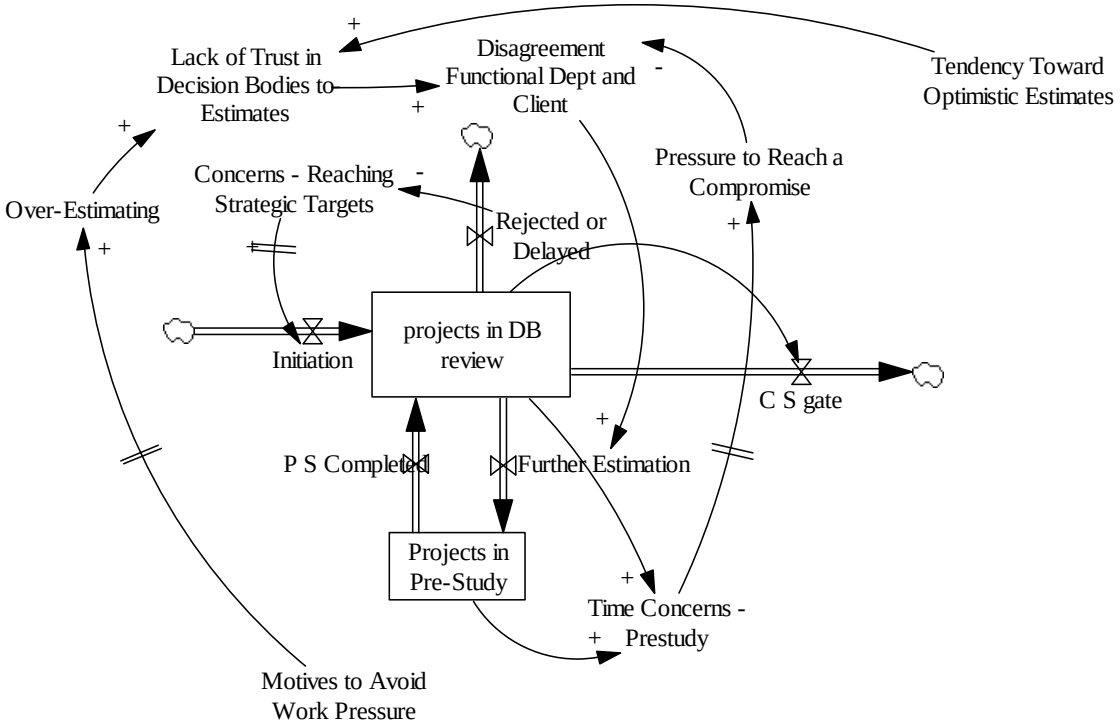

Figure 4.Project Approval Phase for a new projects

One important point, is that the projects which are passed to Decision Body review definitely are advantageous for the company, because the proposing team (with the assistance of some internal consultancy teams) has carefully analysed them and only the proposals which their benefits outweigh their cost are passed to the Decision Bodies. Therefore the Decision Body may reject a project only if the project does not fit with the current project portfolio of the organisation or there are not sufficient resources for such a project at the time. Considering that there has been a reason (or a concern in relation to strategic objective of the organization) for proposing a project, rejecting a project for portfolio or resource reasons means that the organization is loosing some opportunities for improving its market position or revenue. Regarding the long term strategic objectives of the company such projects would probably be initiated later in the organisation in its original form or with modifications. This fact is shown in figure 4 by the arrow connecting the "*Rejected or Delayed*" flow to the "*Concerns Reaching Strategic Targets*". This indicates that the more projects get rejected or delayed, the more concerns regarding the achievement of strategic targets emerge. Consequently this concern later leads to introduction of new projects to address the strategic targets which are not achieved in the current project.

The presence of many different uncertainties in the product development projects and especially at the early phases, referred to as fuzzy front end in the literature, is a major

source of difficulty in management of product development projects(Verganti 1997; Kim and Wilemon 2002). Through my empirical investigation it was identified that more than the technical and market uncertainties, it is the management uncertainty(Kahn et al. 2003) in the early stages of projects which endangers the success of the projects in Alpha. One of the most important management uncertainties I researched in my empirical investigation is caused by the disagreement between the Decision Bodies (which are strongly governed by business units funding the projects) and the functional departments (which own the resources for the projects). Usually disagreements cause the projects at their early stages to go through several iteration of pre-study and Decision Body Review. The disagreements arise usually in the cases where the Decision Bodies considers a project should not be rejected, but disagrees with the cost estimates provided by the functional departments. Or in another word, Decision Bodies consider the project costs to be overestimated. Therefore the Decision Body may ask the functional departments to reduce the estimates. In contrast, the functional department are reluctant to accept reductions in the cost estimates (which means delivering the project with the same scope but less cost) insisting that the estimates are realistic, and reliable. This situation was described by one of the project leaders as:

> *"I should say that it is like a theatre that I am selling something to the management and they push to get the best deal and I am trying to scream and ask for the resources I want, they continue to ask me more for less price and only would stop when I am almost dead of screaming" Project* Leader

Through my interviews I realized that disagreement is actually derived from the "*Lack of Trust in Decision Bodies to Estimates*". This lack of trust originates jointly from "*Over-Estimating*" practices in the functional departments and the persisting "*Tendency Toward Optimistic Estimates*" in the Decision Bodies." *Over-Estimating*" itself is caused by the "*Motives to Reduce Work Pressure*". These relationships are indicated in figure 6. The source of "*Motives to Reduce Work Pressure*" and the "*Tendency Toward Optimistic Estimates*" is from some other causal relationships which I postpone their explanation till section 5.5.

Since the projects circulation in the pr-study and Decision Body review means more and more delays in a project, when a project goes through several cycles, the project managers realize the risk of time delays and failure in the next stages and therefore she/he pressurizes the Decision Body and the functional departments to reach a compromise. The compromise is usually involving the start of the project with some initial resources while still the total required resources of the project are to be agreed. Although, this type of compromises would permit the start of the project, still projects do not have sufficient resources to progress satisfactorily. One of the project liaisons describe this dynamics as:

> *"In fact, it is* "the time*" which makes most of our decisions. We get trapped in endless discussions until we find that there is not much time left for the project. So hastily agree on starting the project while still there is disagreement with the Decision Bodies and the project suffers from sufficient committed resources."* Project manager

I indicated this dynamic by the two arrows starting from "*Projects in DB Review*" and "*Projects in Pre-Study*" pointing to the "*Time Concerns –Pre-Study*" which basically indicates that; the increase of the number of projects in the decision body review and projects in pre-study boosts the concern of the project managers about their project being delayed. The arrow connecting "*Time Concerns Pre-Study*" to "*Pressure to Reach a Compromise*" indicates that the increase in the project managers' time concerns, leads them to put pressure on the two sides to reach a compromise. And as indicated in the model, this pressure will cause the disagreement to decrease and consequently the "*Further Estimation*" rate will be reduced. The reduction of "*Further Estimation"* rate means that the projects would go through fewer cycles of Decision Body review and pre-study.

I finish this section while leaving explanation for the following two factors for section 5.5: How "*motives to reduce the work pressure*" regarding project cost overrun and working under pressure is created? Why "*tendency toward optimistic estimates*" in the Decision Bodies persists?

5.2. MAXIMIZING RESOURCE UTILIZATION

The second part of the model is related to some of the short term decisions within the functional departments which affect the performance of the projects. The functional departments within organizations such as Alpha are very specialized groups of people which the organization through strategic human resource planning has assembled throughout many years and the organization is very keen in maintaining and improving its technically competent members. Therefore, steps to make changes in the human resources are taken with great deal of caution. This means that human resource capacities in the functional departments are very stable. On the other side, there is fluctuation in utilized resources, since different projects need different amount of each certain type of resources at each phase of their life cycle. However, the gap between capacity and utilized resources may further increase because of many different reasons including delay in the upstream phases of the projects, cancellation of a project, or temporary low demand of certain specialty because of project portfolio combination. Therefore, temporary idleness is a probable state in any department because of different reasons some of them mentioned above.

In general, idleness is regarded as a vulnerable situation for both individuals and departments concerning job security and face. In addition, low work load and excess capacity increases the risk of reduction in the departmental resource budget for the next financial period. Therefore, in the periods of time where the functional managers observe unused resources in the departments, they encourage the initiation of some new projects which would utilize the existing excess resources. However because of organizational complexities and the management uncertainties regarding which projects will be approved in the next periods, the functional departments engage resources which could after a while become bottlenecks(Goldratt 1997; Kania 2002) in the pipeline of projects. My observations in Alpha indicated that the functional managers tend to seek solutions to engage unutilized resource as soon as possible rather than tolerating idleness and smother

project pipeline. This is in contrast to recommendations in the literature that propose considering some buffers in project schedules(Goldratt 1997).

I represent these dynamics as following: Three arrows with negative polarity connect the stock of projects in the last three stages of development to the variable "*Perceived Available Resources*". This means the fewer projects are accumulated in those stocks, the more resources are perceived to be available in the functional departments (see figure 5). An arrow in the model connects "*Perceived Available Resources*" to "*Rejected or Delayed*" basically indicates that when the "*Perceived Available Resources*" increases then the functional departments' relationships with Decision Bodies is more in favor of accepting projects or in another word avoiding rejection of the projects in review. In addition, another arrow pointing from "*Perceived Available Resources*" to the rate "*Initiation*" indicates that by more available resources the functional departments encourage submission of more project proposals.

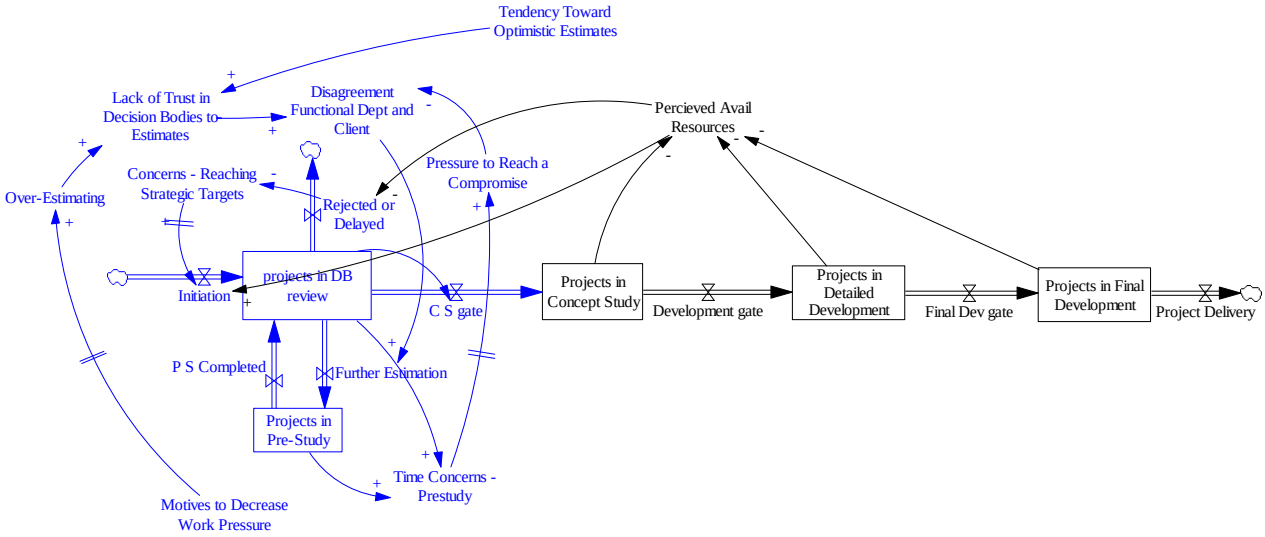

Figure 5.Causal relationship regarding maximizing resource utilization. The parts of the model not in focus I this section are colored blue.

5.3. ACCELERATING PROJECT PROGRESS AND ITS EFFECTS

In previous sections I explained how the intensive cycles before a project getting approval, results in the projects being delayed. In addition because of many reasons, some projects in their early stages may suffer from insufficient resources (as discussed earlier) and therefore they experience slow progress. In addition, because of unexpected events in projects some reworking may be required which cause further delays in the projects. Therefore, the result is that commonly project managers face circumstances where the risk of project time over-run is very high, unless she/he prepares solutions in

each stage of the project to accelerate the project delivery. I especially found that project managers mainly follow three strategies to speed up the project delivery in Alpha:

(1) Project descoping
(2) Cutting the corners
(3) Deploying faster alternative methods

Project descoping is the practice of reducing the content of a project usually after the project proposal is approved. Apart from the cases that the project team realizes that a part of the project is not technically/economically feasible, the project manager may support a change request where descoping is necessary to reduce the content of the project to rescue the rest of the project from being late. While descoping a project needs approval from the project steering committee and the respective Decision Bodies, it might be the only way a project can be delivered on time. As an example, in the "Green Engine" project the delivery of the some truck variants initially included in the project were excluded from the project as the pressure to on time delivery of some of the variants were very high.

Project descoping to reduce the content of a project to overcome time and budget difficulties is a common practice in Alpha. This practice works tactically because projects get descoped but their resources (often) are not reduced proportionally or even sometimes does not change at all.

I found that project descoping is primarily occurring in Concept Study stage and Detailed Development stage. In contrast, I found that project descoping in the Final Development stage is minor since the projects in the Final Development are highly mature in terms of design and tests and the activities in this stage are mainly manufacturing setup related activities. Therefore Steering Committees and Decision Bodies are reluctant to accept descoping while the product development is nearly completed. In my model I have depicted the descoping practice only for Concept Study stage and Detailed Development stage.

In the model (figure 6) the increase in the stock of the projects in the Concept Study causes the "*Time Concerns for Projects C S*" to increase. With an arrow pointing from this variable to "*Descoping C S*" I have indicated how the "time concerns for the projects in the Concept Study" encourages project managers to practice descoping in this stage. Practicing the descoping in the Concept Study helps projects to progress faster and therefore the flow of "*Development Gate*" increases. On the other side, by an arrow connecting the "*descoping C S*" to the "*Concerns –Reaching the Strategic Targets*" I have shown by descoping the projects some strategic targets- which determine priority of the product development deliveries- are not satisfied. Therefore some new projects should be initiated in the future for the delivery of parts missed in the earlier projects.
A similar structure is depicted for Detailed Development in Figure 6.

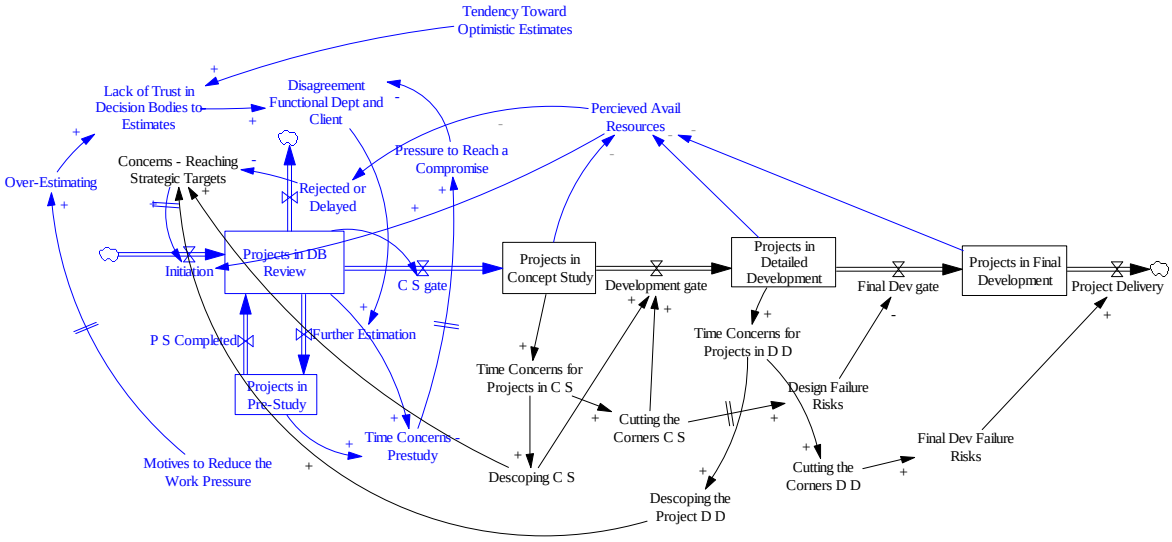

Figure 6. Effects of project accelerating strategies. C S and D D refer consequently to Concept Study and Detailed Development

Cutting the corners is the practice of skipping some necessary steps of the projects to reduce the project duration (Repenning and Sterman 2001). When projects are under time pressure, project teams may leave out some key activities in the interest of saving time (Cooper et al. 2000). One respondent observed how some necessary gate criteria were relaxed to speed up the project:

> *"We were really behind the schedule. The Winter tests take a lot of time and we usually do it six times for reliability matters. To speed up the project we decided to do only 1 winter test while taking the risk of low reliability and posing the company to high warranty costs"* Project Liaison

Although cutting the corners would help higher project progress rate, this practice, increases the chance of technical failures and quality related problems in the later stages of the projects(Cooper et al. 2000; Sethi 2000). As put by one of the respondents:

> *"The late start caused that in the later stages of the project there was not time to complete all the tests. Either we skipped some test or continued to the next stage when the reliability test was still running and we were not sure about the results. In some instances the test vehicle was difficult to build because the parts were not available. The pressure was to pass the gate without really satisfying the requirements.* Project Liaison

> *"In the project we had to build the prototype vehicle two times* [which we usually do it only one time] *since the first time which we were asked to*

do we did not have the design of all the components we require. However because of the project time pressure we built the prototype using some of the parts from the previous designs. Later we found lots of problems with the prototype and we had to build it again from the beginning. This caused a lot of cost and further increased the project time pressure …. We had to spend a lot more and work harder to meet the deadline to compress the project time." Project Liaison

I represent this practice in my model (see figure 6) as follows: An arrow starting from the "*Time Concerns for Projects in C S*" points to "*Cutting the Corners C S*". This arrow indicates that by the increase in the time concerns, the "cutting the corners" practice increases. Another arrow connecting "*Cutting the Corners C S*" to "*Development gate*" indicates the effect of cutting the corners in increasing the rate which the projects pass the development gate. The negative effect of cutting the corners, which usually happens after a time delay, is indicated by the arrow connecting "*cutting the corners C S*" to "*Design Failure Risk*". Consequently, the increase in the "D*esign Failure Risks*" leads to the decrease in the "*Final development gate*" rate. A similar structure for Detailed Development gate is depicted in Figure 6. However cutting the corner strategy is not possible to practice in the Final Development since the project team is supposed to deliver the project as a complete fault free whole; there is not chances of skipping any requirements. In fact this is the stage where the parts skipped in the previous stages and their associated issues needs to be resolved. Therefore I have not included "cutting the corner" as a project accelerating technique in the Final Development gate.

As I have observed, there are limits for practicing the first two project accelerating strategies. There is always reluctance from Decision Bodies to approve descoping request and there are always cases where the risk of cutting the corners is large and evident. A third strategy which is *deploying faster alternative methods* is used in Alpha to improve the speed of the projects. Basically this strategy is about using some methods (e.g. recruiting temporary external designers, using prototyping manufacturing methods for mass production of some delayed components, etc) which usually cost more but can help the project to deliver faster. Extensive reliance of this strategy leads the product development organization to be trapped in firefighting mode. As researched by Repenning (2001), neglecting the earlier stages of product development and focusing on fixing problems after their occurrence leads to high cost and inefficiency in the projects(Repenning and Sterman 2001).

In Alpha "deploying faster alternative methods" is usually practiced at the very late stages of the projects where there is no other option. As previously mentioned the Decision Bodies are very much cost concerned and therefore usually only in the late sages where the project is really in danger, the Decision Body would authorize using faster alternative methods. Therefore I did not include this practice in the Concept Study stage. In the detailed development stage and final development stage I depicted this strategy by the arrow connecting the "time concerns for projects in D D" to deploying "faster alternative methods D D"(see figure 7). Two other arrows indicate that this practice increases both the "Final development gate" rate and the "project costs". Similar relationships are indicated for Final Development stage.

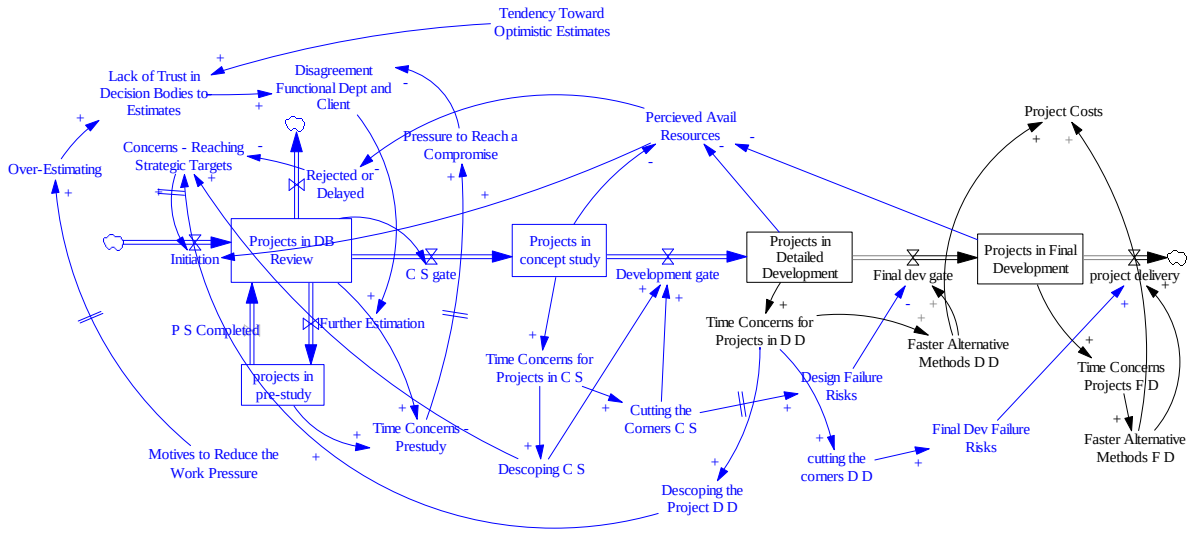

Figure 7: Deploying Faster Alternative methods to speed up the development of the projects

Historically project teams in Alpha were enjoying the rather relaxed project deadlines as the Decision Bodies used to suspend project deadline so the project team would catch up. However the tougher competition in the Truck industry needs the manufacturers to deliver their product to fixed deadlines such as Truck exhibitions or emission regulation enforcement deadlines. Consequently the firefighting mode has emerged as a dominant working mode in many of projects in Alpha as project in their early stage suffer from deficiencies caused by systemic effects mentioned earlier.

5.4. MULTITASKING AND PROJECT TEAM EXHAUSTION

So far I explained how the projects inflow to the product development organization of Alpha and how project managers would attempt different strategies to accelerate the project progress. Because of the inflexible capacity of the organization and the fluctuating rates of the demanded resources at each point in time, the resource utilization percentage in this organization is subject to large scale variations. I explained how the functional departments react to the situation when the capacity is more than the commitments of the department. However the reverse situation where the work load to the functional departments is more than their capacity is more frequent than the idleness situation. These situations usually happen when several high priority projects need the same expertise at the same time (see figure 8). To a great extend this is because the management start new projects without considering the status of the existing projects in the organization. This is a common management in product development described by Wheelwright and Clark(1992 p.90) as “canary cage approach” in which new canaries(projects) are thrown into the cage without any analysis of the effects of the other canaries already in the cage.

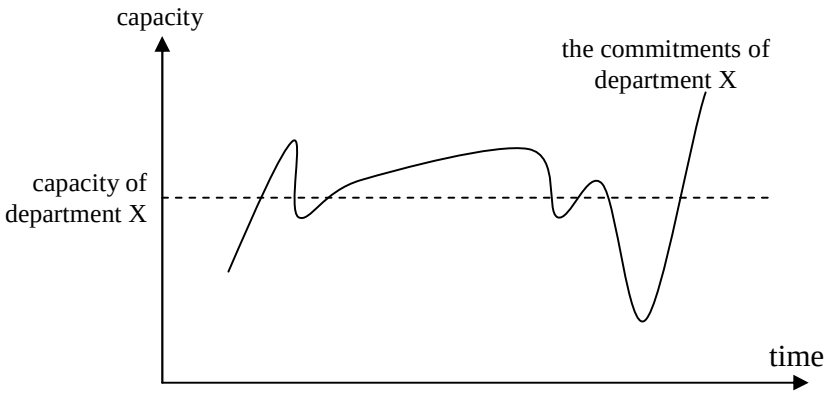

Figure8. A schematic graph indicating a possible pattern of fluctuation in utilized resources

In such circumstances usually the management in Alpha persuades the project teams to work harder and/or assign several different tasks to each individual. As two of the interviewees describe their situation as:

> *"When the reliability test failed for the second time, we decided to develop a completely different concept and a new material … the other project which needed our output had to stop; waiting for us* [delivering to them the component we were designing]. *So we were under very high pressure from them to deliver as soon as possible. Consequently we had to put pressure on the people working with us. Even one of our principal designer cancelled his vacation and work on the design during the holidays"* project manager

> *"There is always too much to do, I am involved in too many projects. I can not totally focus on one project as there is always some interruptions to my work;, other project members have queries, attending different meetings…"* Designer

Although working overtime and working harder can increase the progress of the projects in short term, but they cause reduced motivation and productivity in the project teams(Li et al. 2000). In addition, a resource which is multitasked and switches from activity to activity and from project to project face increased set up and coordination costs. While managers aim to provide equal treatment for all projects, multitasking and thinly spread of the team members across projects increase stress and inefficiency in the individuals(Karau and Kelly 1992; Cooper et al. 2000; Lechler et al. 2005). Clark and Wheelwright(1993) suggest that the optimum number of projects assigned to an engineer is two, still the situation could get worse when even more than this number is assigned to engineers in Alpha.

In my model (see figure 9) I have indicated this phenomenon by two arrows connecting the "*Projects in Detailed Development*" and "*Projects in Final Development*" to the variable "*Multitasking and Work Pressure*". This means that the increase in these two stocks is an indicator of the work overload for the functional departments. This overload basically means that the members of the projects are working more and more or in another word they are more multitasked and are under work pressure. I did not draw a similar relationship for "*Projects in Concept Study*" since usually the concept study is not very resource intensive. There is also evidence from the literature that multitasking brings distraction and exhaustion to the project teams which consequently reduces productivity(Rosenau 1988; Lee and Miller 2004). Therefore I included an arrow connecting "*Multitasking and Work Pressure*" to "*Productivity*" which means the increase in the multitasking and work pressure leads to reduced productivity. Consequently the low productivity causes the "*Final Development gate*" rate and "*Project Delivery*" rate to decrease.

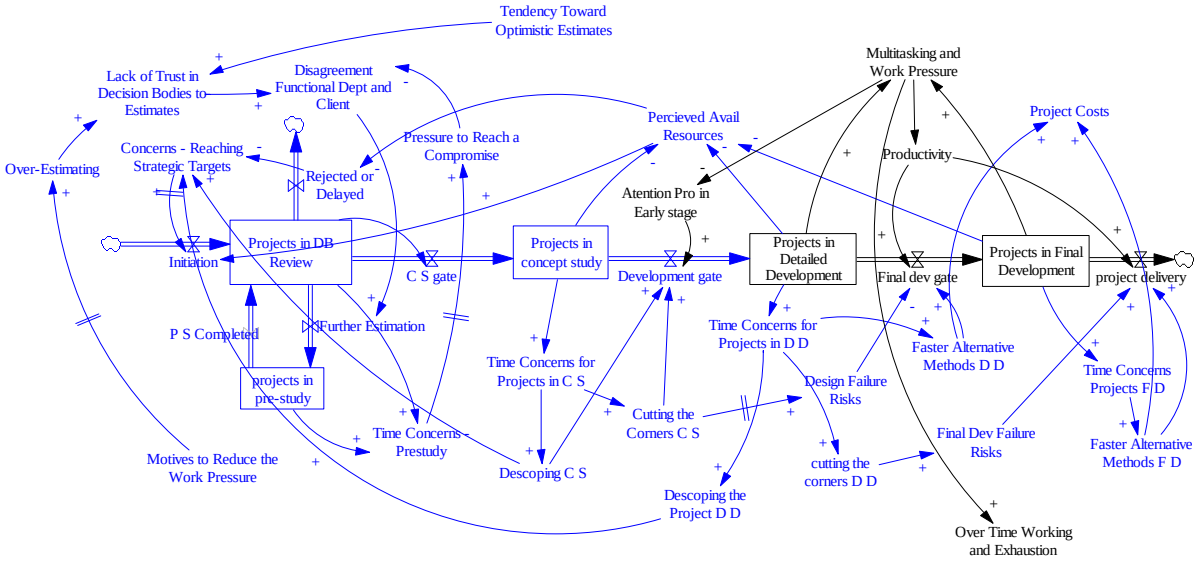

Figure 9. The practice of "Multi Tasking and Work Pressure" and its effects on the performance of the projects in the organization

On the other side the "*Multitasking and Work Pressure*" cause that the attention of the teams to be only concentrated to the most urgent problems which may not necessarily be the most important problems. It is common in the product development teams that urgent problems precedence over important things(Cooper et al. 2000). This is the same phenomena observed by Repenning(2001) as firefighting and this is a major obstacle in frontloading - shifting the problem solving workload to the early stages of the project(Verganti 1997; Thomke and Fujimoto 2000). In the model this phenomenon is indicated by an arrow connecting "*Multitasking and Work Pressure*" to "*Attention to Projects in Early Stage*". Low "*Attention to Projects in Early Stages*" consequently leads to the reduction in the rate of "*Development gate*" as indicated in the model.

An arrow connecting "*Multitasking and Work Pressure*" to "*Overtime Working and Exhaustion*" means that the because of doing several tasks at the same time and working under time pressure, the staff are necessarily working longer hours and they experience an exhaustion mode.

5.5. CLOSING THE LOOP: WHY THE PROBLEM PERSISTS

In the previous section I indicated how the projects are undertaken in Alpha and some systemic effects which affect the performance of the projects. However one question is: why the organization is not able to identify and remedy these issues and improve the whole product development performance? Looking into the model that I have built so far, it does not seem a very complicated matter which the managers within Alpha have not thought about it. As one of the project manager stated:

> *"Every time we finish one of these troublesome projects we decide in the next project to put most of the work load to the beginning of the project, but we do not succeed. It is a complex situation where every time we can not give enough effort to the projects in the early stages because of resource scarcity and late decisions and …"* project manager

So what are the reasons why the teams can not improve their projects although they have had some learning? I believe that while learning occur at the individual level this learning do not transform to organizational learning. Organizational learning is the process through which organizations develop new knowledge and change heir behavior to reflect the better understanding of their domain(Slater and Narver 1995). Organizational learning is not simply the sum of the individuals' learning (Kim 1998).I have identified learning obstacles which I analyze them in two categories:

(1) Human Resource mobility and organizational complexity
(2) Organizational politics

5.5.1. Human Resource mobility and organizational complexity

The organizational structure of Alpha is very complex. People are members of different departments and different projects at the same time. The line of command is not clear and there is confusion regarding the performance reporting. Also part of the complexity is because, the truck is a complex product and organically different functional departments have evolved with responsibility of certain parts of the truck. However the architectural dependency of the different parts of the truck prevents them from work independently and interference and interaction is a natural matter in departments of Alpha. This complexity makes it difficult for the project managers and team members to analyze the project problems independent of organizational problems. Below are some statements from our interviewees regarding the organizational complexity:

> *"… Our project is giving very important information to the green engine project, however green engine which is in a different business unit than us change project manager almost in the detailed development gate. Almost all the relationships we developed with the previous project manager was wasted then … the new project manager had different perspectives on the matters..."* project manager

> *" … the general problem in Alpha is that if you consider my role in a middle phase of the process of a project, I am completely unaware of what the people are doing in the phases before me and what the people are doing after my work …"* project team member

> *"The matters were becoming almost personal between my representative and the representatives of the green engine project because we did not know who the boss is. The governance of the projects is complex here in Alpha! The green project was not trusting in how we are going to deliver our project output. They wanted to directly talk to our suppliers. Obviously we did not want them to interfere in our job …"* project manager

Also the temporary nature of the projects and the combination of diverse type of knowledge tend to forget quickly when the teams are dismantled(Grabher 2004). In addition, the diverse experience of the people in different types of the projects makes it difficult to reach a harmony when team member disjoin old teams and join new different teams. Therefore, while the learning from the past projects happens at individual level when the individuals form a new team, the collective learning does not happen(Easterby-Smith et al. 2000). In addition, the fact that the individuals are involved in several projects means that at every point in time the individual is under pressure with some urgent issue in one of the project and there is not time to reflect about the process and improve the process. Learning is difficult to take place when employees are harried or rushed(Garvin 1993).

5.5.2. Organizational Politics

Organizational politics specially when it comes to the individual political skills can serve as a catalyst to enhance communication and effectively orchestrate the collective interpersonal interactions necessary for team and organization performance(Ferris et al. 2000). However the politics in the organization may not be in favor of the project performance. Flyvbjerg(2005) introduces the notion of "the survival of the unfittest" meaning it is not the best project that get implemented, but the project which is supported by more powerful people. As an example during my empirical investigation, I asked an

interviewee about why a particular project is not abandoned despite the clear evidence that it is not profitable. The honest answer I received from the interviewee was:

> *"There are many answers for this question but this project has been running for a long time and many people are specifically employed for this project, as the project is technically very special the project team can hardly find any other place in the organization where there is relevant need for their skills. Therefore …" Project Liaison*

In my model(see Figure 10) I have indicated the issues about learning obstacles by an arrow connecting "project cost" to " motives to learn from the past" which indicates that by more and more cost overruns there is more motives to avoid similar problems in the future. However one would argue that motive for learning is not only in the projects which are cost overrun but also in the projects where they run perfectly. Although I acknowledge the existence of the learning in the later type of situations where the projects run perfectly well, I believe the learning motive is insignificant in these cases as usually steps are not taken to improve something unless a problem occur. Repenning and Sterman (2001) support this statement as they have identified that in many product development environments " No one gets credit for fixing the problems that never occurred".

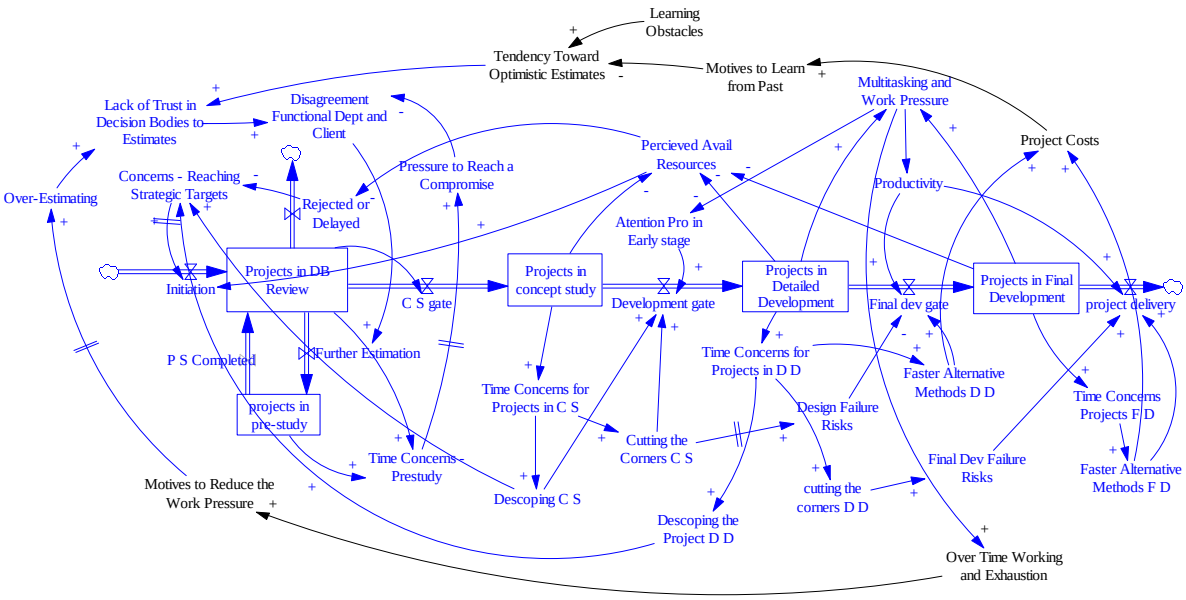

Figure 10.Closing the loop: Explanation of the relationships of the experience of the troubled projects to the projects in Decision Body review

In the model I group all the factors I mentioned as the learning obstacles in "Learning Obstacles" and in the model indicate how the low learning effectiveness cancel out the effect of "Motives to Learn from the Past" and therefore resulting to persistence of

"Tendency Toward Optimistic Estimates" in the organization. This is in fact the answer to question I raised at the end of section 5.1. Here actually I am closing the loop of my explanation about the systemic effects in Alpha and indicating the relation of the systemic effects happening in the late stages of the projects and the systemic effects happening for the projects which are at their early stages.

The other question I raised in section 5.1 was about why there are "*Motives to Reduce the Work Pressure*" and its consequences (the practice of over estimating).

My investigation revealed for me that most engineers and project managers within Alpha are aware of the learning obstacles (maybe not explicitly) and generally do not expect any improvements to remedy the system effects analyzed earlier. Therefore they take action by themselves and find the best way to avoid troublesome projects by better playing the negotiation game. And they do it by submitting inflated estimates for the future projects. As one of my interviewee stated:

> *"….so for the designers to get the resources they want they start to overestimate, so after the budget discussion and budget reduction they will reach the budget which they want. "* Project Liaison

In the model I have indicated this relationship by connecting "O*vertime Working and Exhaustion*" to "*Motives to Reduce the Work Pressure*" through an arrow with positive polarity. Thereafter, "*Motives to Reduce the Work Pressure*" is connected to "*Over-Estimating"* by an arrow having positive polarity. This is the other leg of explaining the connection of system effects of the projects in the late stages to the projects in the early stages.

6. CONCLUSION

While most of the project management environments in today businesses could be considered as multiproject, the research in project management about such environments has been limited. This paper is based on explorative study of product development division of a manufacturing firm operating in the automotive industry. The research basically aims at investigating the root causes for project performance deficiencies. While this research question is not new, previous research has only focused into this problem within the single project boundaries. My core argument in this research is that while managing resources and activities within each project is important in the success of each project, the influence of the projects on each other and the dynamics within the permanent organization has a significant influence. Using System Dynamics methodology and by analyzing the data I collected from the firm which is my case study, I developed a system dynamics model depicting the dynamics existing in this firm and their systemic effects on the project performance.

Development of the aforementioned model assisted in mapping and bringing together the facts which are widely known in the organization but are tacitly kept by members of the organization in scattered and fragmented bits and parts. Some of these facts are:

- The process regarding the review and selection of the projects is usually subject to delays
- The high work load and working under time pressure reduces the performance of the teams as well as the quality of the output
- There is competition for resources and projects would affect each other negatively in regard to acquiring their resources
- The organization needs to learn from the previous experience and take corrective action

Through assembling the facts collected from this firm into a comprehensive model, rather than investigating linear relationship between the causes and effects, it became possible to identify dynamics and complex interrelationships of the factors which could explain the causes for bad performance of the projects in this firm.

Through analyzing my model I have got some managerial insights which can be helpful for practitioners in the similar multiporject environments. The main insights and implications of this research are:

Firstly, in the presence of large number of uncetainties which exist in every project, over emphasis on decision making merely based on early cost estimates are misleading. As the reliability of most estimates about a project cost is very low in the start of projects, rather than over reliance on merely financial information, more factors determining project success should be considered in evaluation of the projects.

Secondly, improvement of the performance of the projects can be increased by good planning and good control of each project, however the significance of the factors influencing project performance from outside project is comparatively high in multiproject environments. Therefore along with emphasis on optimizing what and how a project delivers, a more holistic management system should plan and handle inter-project issues in a higher aggregated level. This system should especially monitor the synchronization issues existing in multiproject environments. Therefore, suboptimal decision which would endanger the performance of the whole system would be avoided
.
Thirdly, while the temporariness of the team structure for project based working would make learning difficult and sometimes irrelevant to projects, single firm multiproject environments have high potentials for learning and maintaining lessons learnt. The advantage of single firm multiproject environment is the supporting permanent organization which encompasses the projects. While the projects are temporary, this organization can store and retrieve lessons learnt in the projects. In addition, the existence of simultaneous projects in these environments creates the opportunity to transfer the learnings on a real-time basis between the projects; shortcutting the conventional project review processes. Therefore the managers in charge of product development should be aware of these opportunities and use them toward further improvement of projects performance.

There are also limitations for this research which can be future improved by future research. The findings of this research are based on the case study of a single firm

(Alpha). Therefore, the generic criticism of case study research regarding the genralizability of the findings still holds to this research. Future research can expand the generalizability of the findings by doing similar case studies in other firms or using other research methods like surveys.

Future research can also be done in the direction aiming to quantify and simulate the model I have developed in this research. I did not have access to quantitative data in this firm, so I could not quantify my model. Therefore, I have been for focused in elaboration around the model development and validation of the model. Quantified simulation outputs can bring more insightful information and better support the findings of this research.

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