A STUDY OF THE INFLUENCE OF GOAL ALIGNMENT ON MULTI- ORGANIZATIONAL PROJECTS: A SYSTEM DYNAMICS APPROACH

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Finally, I want to dedicate this dissertation to the memory of my beloved Father, who always was the best example of hard work and resilience anyone could be. Papa, I am so proud of you.

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CHAPTER 1: INTRODUCTION

1.1 Study Overview

The number of multi-organizational collaborative ventures has been growing during the last several decades in the form of alliances, partnerships, consortia and business networks, etc. (Haagerdoon and Rajneesh, 1996; Doz and Hamel, 1998; Gulati, 1998; O'Sullivan, 2003). New product development, information systems, and large, complex projects where great amounts of resources are required, as well as different technologies and skills not possessed by a single organization, are usually accomplished through multi-organizational collaborative relationships (Singh, 1997; Kane and Esty, 2000; Kanzanjian et al., 2000; O'Sullivan, 2003).

Multi-organizational collaborative relationships have been the focus of extensive research (Kogut, 1988; Pisano, 1990; Williamson, 1991; Folta, 1998, Gulati and Singh, 1998), but this research has mostly related to the rationales for their deployment and to governance issues (Gerwin and Ferris, 2004). The particular case of multi-organizational projects presents specific challenges to management because, to be successful, they require collaboration of diverse organizations with their own objectives regarding the project, and, with probably different strategic goals and priorities (Jones et al. 1998). However, little research has been conducted to define how the level of alignment among the participant organizations toward project goals in a multi-organizational project might affect project performance. Hence, the purpose of this dissertation is to examine the project dynamics induced by the level of alignment toward project goals among organizations participating in multi-organizational projects, and explore how these dynamics affect project performance. The knowledge created through this dissertation could help the management of these organizations to assess the risk involved in that kind of project, and to devise actions to mitigate those risks while increasing the chances of project success.

To accomplish this purpose, previous research in the areas of goal alignment, multi-organizational collaboration, and project management were integrated. This integration materialized in a set of propositions that attempted to explain how the level of goal alignment affects multi-organizational project dynamics and performance. These propositions were assessed through two case studies inquiries, following a replication method (Yin, 2003). The findings of these inquiries are expressed in two system dynamics models, representing the dynamics generated in a multi-organizational project by the level of goal alignment among the participating organizations at the management and project execution levels. These models also aim to contribute to the understanding of how these dynamics affect project performance. The model structures were validated by participants in the studied projects, by a panel of individuals with experience in multiple multi-organizational projects, and by a comparison to findings in previous research in the inter-organizational collaboration and project management areas. Simulations exercises were conducted to assess to what extent the models are able to reproduce plausible multi-organizational project systems' behaviors.

The major finding of this study is that the level of trust and communication between partners was the mechanism through which the level of goal alignment affected project performance in the multi-organizational projects studied. In the first case, the level of goal alignment affected the level of trust and communication, and then the level of information exchange needed to execute interdependent tasks, and the level of coordination required to deploy the effort needed to deliver sub-products on time. In the second case, the level of goal alignment also affected the level of trust and communication, and these levels along with other factors contributed to a low level of efficiency in the project team decision making process. Delays in the decision making process affected the project team's ability to provide feedback to the contractor about project issues, as well as the project team's ability to monitor project progress and to be proactive toward the solution of incoming problems.

Other study findings, theoretical and practical contributions, limitations of the study as well as avenues for further research on the topic are also discussed in the present dissertation report.

1.2 Statement of the Problem

In this section, the reasons to accomplish this dissertation are addressed. Also, the research problem on which this study is focused is defined, as well as the unit of analysis on which the study was performed.

1.2.1 Motivations for the Study

In most projects, the focus is on trying to abide to the basic priorities of time, cost, quality, and scope. Conflicts and trade-offs between priorities (time, cost, quality, scope) are unavoidable due to resource limitations (Roseneau, 1998). Constraints are defined according to the resources available to the project and the attributes required in the outcome, including contracts' specifications (Kerzner, 2003). In many cases, organizations need to accomplish several projects simultaneously (Turner, 1993). In those cases, project resources are limited by the necessity of sharing resources and negotiating priorities with other projects within the same organization (Turner and Speiser, 1992).

In the context of an organization accomplishing several multiple projects simultaneously -having independent existence but still getting resources from a common pool- projects must be integrated into the management control and reporting systems of the resources' pool owner. This might lead to conflicts over resource supply and management control (Payne, 1995).

Engwall and Jerbrant (2003) introduced the so-called "resource allocation syndrome", or the condition in which management is overwhelmed with issues concerning the prioritization of projects, the distribution of personnel from one project to another, and the continuous search for slack resources. Bias in resource allocation is another factor that affects multi-project management. Repenning (2000) studied the allocation of resources in the context of multiple new product development projects and concluded that there is a bias toward allocating resources to projects near to completion at the expense of new ones. This might originate a systematic under-allocation of resources in projects at early development phases. In conclusion, the assignment of priorities and the allocation of scarce resources in organizations accomplishing several projects simultaneously might generate conflicts that should be addressed by management in order to pursue the achievement of the organization's objectives.

Goal and priority conflicts might be even worse in multi-organizational projects, where activities are accomplished and resources are contributed by two or more different and independent organizations. In these projects, the strategic objectives of the participant organizations could be different (Vaaland and Hakenssen, 2003). In the numerous multi-organizational projects functioning to develop and operate the North Sea offshore oil fields (Crabtree et al.,1997; Green and Keogh, 2000), conflicts have been extensively reported as organizations involved in those projects attempt to maintain a range of complex relationships with other organizations that traditionally constituted direct competition, and are still competitors for other projects. Depending upon a particular development, organizations might be simultaneously partners, suppliers, customers or competitors (Crabtree et al, 1997).

The situation found in the North Sea oil fields is common for multi-organizational projects. Researchers have labeled this phenomenon as "Co-opetition" (Eikebrokk and Olsen, 2005). Co-opetition occurs where cooperation and competition between diverse organizations occur simultaneously. In these situations, some units of the involved organizations are cooperating in a specific project, while other units of the same organizations are competing in others. In those cases, goal conflicts might take place anytime. Information and effort might be withheld if the competitive side is more salient than the cooperative side.

Situations like the ones described above can lead to conflict of interest about project goals and priorities (Vaaland and Hakenssen, 2003). Some participant organizations in multi-organizational projects might require the project to be completed sooner than others. Financial capacity might not be equally distributed among the participant organizations to absorb additional costs. Participants might also have diverse quality requirements, leading to differences in quality standards and project scope. Actual or perceived opportunism or "free-riding" might occur as some participants perceive that they are not obtaining project benefits in a proportion commensurate with the effort and resources deployed (Greenlee and Cassiman, 1999).

Participant organizations' business strategies might also change along the project timeline (Norrie and Walker, 2004). This implies that in a certain moment the project goals are aligned to the organization business goals, but in the future, they might not be. Hence, the level of alignment toward project goals among organizations participating in multi-organizational projects might vary during the project life, affecting the priority the project has for each organization involved. To ensure that projects keep their priority level within the organization, managers should ensure that projects' goals are aligned with business goals (Platje et al. 1994).

Today, despite all the potential problems discussed above, many business initiatives make use of multi-organizational projects. These initiatives include new product development alliances (Singh,1997; Doz and Hamel,1998; Gulati,1998; O'Sullivan,2003), inter-organizational information systems serving manufacturing networks (Sherer,1997) and supply chains (Rochie,1993;Sherer,1997), and large infrastructure projects such as off-shore oil exploration and production or airliner design and manufacturing (Green and Keogh,2000; Kane and Esty,2000). These multi-organizational projects are necessary, since no firm alone has the financial and technological capabilities required to accomplish them on their own (Doz and Hamel, 1998; Gulati, 1998; O'Sullivan, 2003).

Although the deployment of multi-organizational projects has grown significantly, little research has been conducted as to the factors affecting multi-organizational project performance (Gerwin and Ferris, 2004). The literature studying multi-organizational relationships has focused mostly on strategic issues, such as rationales for deployment (Doz, 1998), the structures used (Gulati and Singh, 1998; Gerwin and Ferris, 2004), governance issues (Zahar and Venkatraman, 1995), asymmetries between partners (Harrigan, 1988), and general factors that might affect performance (Burgers et al., 1993; Hagerdoorn and Shackenraad, 1994). The tactical aspects concerning the management of multi-organizational relationships have been largely ignored (Gerwin and Ferris, 2004). For example, there are no research studies exploring how lack of goal alignment among participants in multi-organizational projects might influence project dynamics and performance. Hence, the motivation of this dissertation is to fill this gap in the knowledge of multi-organizational projects.

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1.2.2 Research Problem Statement

Multi-organizational projects might present particular problems and challenges due to possible lack of alignment among participants toward project goals concerning quality, cost, schedule and scope. Each organization involved in the project responds to its strategic objectives, which might vary along the project life cycle (Norrie and Walker, 2004). The lack of project goal alignment might impact or create project dynamics that affect project performance beyond what participant organizations' senior managers and project managers would expect. Hence, the problem this dissertation studied can be stated as follows: **to investigate how the level of goal alignment among the**

participant organizations affects multi-organizational project dynamics and performance.

Because the system dynamics approach (Forrester, 1961; Lynneis et al., 2001) was used to study the research problem, the problem was divided into the following sub-problems:

- To build and validate a system dynamics model to represent the multi-organizational project dynamics affected by the level of participants' project goal alignment.
- To perform simulation experiments based on the model to study the effects of the level of project goal alignment on project performance.

1.3 Unit of Analysis

Because the focus of this study was to investigate how the level of goal alignment among the participant organizations affects multi-organizational projects dynamics and performance, the unit of analysis is the multi-organizational project system. A project system is constituted by the following elements (Park and Pena-Mora, 2003):

- Processes (to carry out the work and to control execution)
- Management policies: strategic level (to fit the project's objectives with the organizational objectives), tactical level (project management policies deployed to ensure that the project's strategic objectives are achieved), and operational level (for regulating day to day project activities according to the project management policies).

- Resources: human, technological, infrastructure and materials.
- Scope of the work: definition of what needs to be done.
- Performance constraints: time to completion, quality, and cost.

These elements interact to get the work required done in a specific span of time. In the particular case of multi-organizational project systems, the resources required by the project are contributed by at least two different organizations, and these organizations might have their own goals for the project. In this dissertation, the impact of the level of goal alignment on multi-organizational projects' system dynamics and project performance was assessed.

1.4 Background of the Study

In order to investigate the research problem, this dissertation draws on previous work encompassing several research traditions, namely goal alignment, inter-organizational collaboration, project management, and system dynamics. Because the main purpose of this study was to understand how the level of alignment toward project goals among the organizations participating in a multi-organizational project might affect project performance, it was required to analyze how project goals and priorities are set, and how the concept of alignment has been elaborated in the management literature and extended to the context of multi-organizational projects. Moreover, multi-organizational projects are particular cases of inter-organizational collaboration, so previous research in this area should be useful to elaborate about the dynamics developing within that kind of project and how they could affect project performance.

Finally, a combination of case study inquiry and system dynamics modeling was the strategy selected to accomplish the investigation of the research problem. Hence, the advantages of using the system dynamics approach in the project management domain are discussed, as well as the basic project simulation structures that would work as building blocks of the model simulating multi-organizational project behaviors. In addition, a review of the system dynamics applications to the study of projects dynamics and inter-organizational collaboration is performed.

As follows, an account of the previous research on the aforementioned areas relevant to this study is presented. This literature review formed the base of a set of propositions that guided a case study inquiry. The result of this inquiry was a system dynamics model attempting to explain how the level of alignment among organizations participating in a multi-organizational project might affect project performance (see Fig. 1-1).

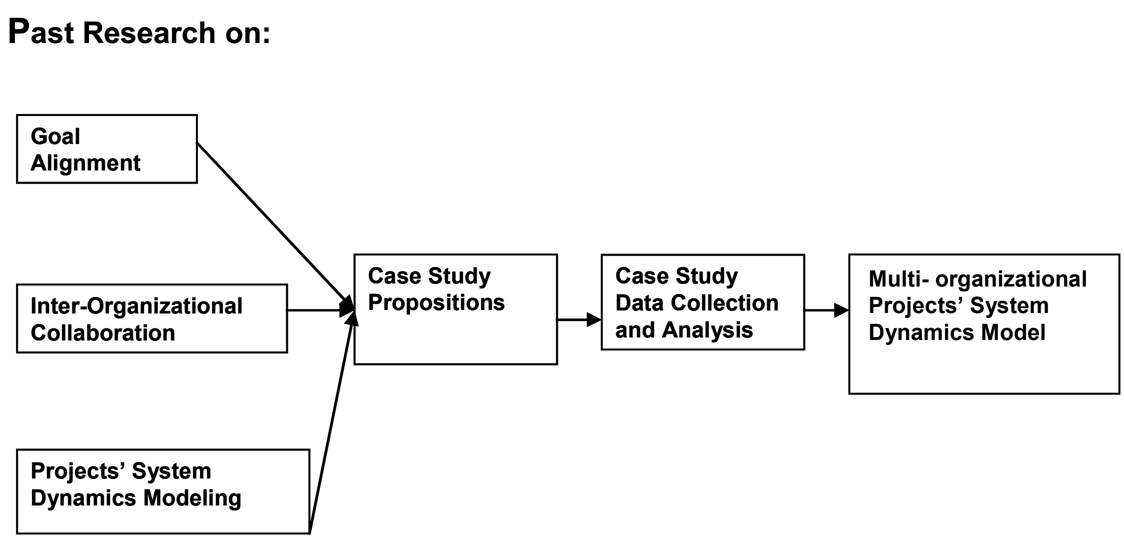

Figure 1-1: Research Strategy

1.5 Summary

In this first chapter the context, background, and relevance of the study were discussed. Multi-organizational projects are expected to be accomplished more and more in the future, because organizations need to integrate their skills and resources in a highly competitive environment. The particular case of multi-organizational projects presents specific challenges to management because they require collaboration of diverse organizations with their own goals for the project. Hence, this study focused on how the level of goal alignment among partners in a multi-organizational project affects projects dynamics and performance. Finally, a combination of case study inquiry and system dynamics modeling was wed to investigate the research question. In the next chapter, the literature review on which the propositions were based that guided the case studies is discussed.

CHAPTER 2: LITERATURE REVIEW AND STUDY PROPOSITIONS

2.1 Chapter Overview

The case study data collection and analysis was guided by the assessment of the case study preliminary propositions. In this study, these propositions were based on previous research in the areas of goal alignment, dynamic theory of inter-organizational collaboration, and on applications of the system dynamics methodology to the project management and inter-organizational collaboration domains. The literature review and the associated study propositions are discussed as follows.

2.2 Alignment in the Organizational and Project Contexts

In this dissertation, the main interest is to find, in the context of multi-organizational projects, how the level of project goal alignment might affect project performance. Because project goal alignment is the independent variables stated in the research problem, it is required to discuss how alignment has been conceptualized in the management literature. Alignment has been conceptualized at different levels, including strategic, organizational, project and team alignment (Miles and Snow, 1984; Itami, 1987; Henderson and Venkatraman, 1993; Griffith, 1997; Skulmaski and Hartman, 1999 Rondinelli et al, 2001). Next, the dynamic nature of alignment as accounted by the literature is presented. Researchers have described alignment as a management process of continuously adjusting to the environment (Sabherwal et al., 2001; Wagner, 2005).

Finally, the alignment concept as applied to multi-organizational projects is discussed, including a road map suggested by the literature review to achieve project team alignment in this kind of projects.

2.2.1 Strategic and Operational Alignment: Fitting Environment, Strategy and Organization's Resources and Structures

Organizational strategy research emphasizes the importance of fitting strategy with the organization's environment (Ansoff, 1965; Miller and Friesen, 1983; Miles and Snow, 1984; Hrebiniak and Joyce, 1985). Strategy is defined as, "the determination of the basic long-term goals of an organization, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals" (Chandler, 1962, p.13). Organizations need to use strategy to adapt themselves to changes in their environment, in order to create competitive advantages in the marketplace and improve its chances for survival and growth (Pfeffer and Salancik, 1978; Venkatraman and Prescott, 1990). Strategic fit involves aligning the organization with its environment and arranging resources to support that alignment (Miles and Snow, 1984). Strategic planning becomes the fitting or alignment mechanism.

Within the organizational strategy paradigm, some researchers have proposed strategic fit models. For example, Itami (1987) proposes a strategic fit model that defines fit as a relationship between external factors -customers, competition, and technology- and internal factors -such as corporate resources and the culture of the organization. This definition leads to five types of strategic fit:

- Customer fit, meeting customer needs, adjusting to changes in customer desires, and capitalizing on customer interactions.
- Competitive fit, deploying competitive weapons, protecting against counterattack, and avoiding direct competition.
- Technological fit, anticipating changes in technology and applying the appropriate level of technology to develop new products or new operational processes in order to satisfy customers and make profits.
- Resource fit, allocating and using existing resources effectively and accumulating resources for the future efficiently.
- Organizational fit. Mobilizing the organization's members, providing focus, matching strategy with its cultural characteristics, then creating momentum and sustaining forward-looking pressures for continuous improvement.

The idea of strategic fit has been explored extensively in the information technology (IT) area (Reich and Benbasat, 2000). In the literature review, I found that the alignment concept has been studied by IT scholars in more depth than by most other business-related lines of inquiry. Information technology researchers have been very active studying the problem of aligning the IT strategy with the business requirements imposed by the environment (Hu and Huang, 2005). In this context, alignment has been defined along two dimensions: (1) fit between business and IT strategy, (2) fit between an organization's infrastructure and processes, and between information systems infrastructure and processes. Both dimensions are thought to reflect the degree to which business and IT executives within an organizational unit understand and are committed to the business and IT common mission, objectives, and plans (Henderson and Venkaraman, 1993; Reich and Benbasat, 2000; Kefi and Kalika, 2005).

Another related idea in the IT area is the concept of co-alignment. Co-alignment is defined as the condition when the several domains of strategic alignment -business strategy and IT strategy, IT strategy and organizational structure- are addressed simultaneously. Lack of co-alignment was found associated with lower levels of business performance (Bergeron et al., 2004).

The operations management area also discusses the concept of alignment (Rondinelly et al., 2001; Papke-Shields and Malhotra, 2001). Rondinelly et al. (2001) define alignment in terms of strategic fit and functional integration. Strategic fit determines the best structure or internal arrangements of the firm to execute the market positioning strategy. Functional integration seeks coordination and cooperation among managerial functions to support the market strategy. Papke-Shields and Malhotra (2001) conceptualize alignment as the degree of understanding and agreement between top management and the manufacturing function on the goals for the organization and the manufacturing function, and on how manufacturing can support the strategic direction of the firm.

In the literature reviewed above, alignment has been conceptualized in two dimensions. The first dimension is strategic, defined as fit between strategy and environment. The second dimension is operational, defined as fit between strategy and the resources needed to accomplish it. Operational alignment entails the development of consensus regarding goals and coordination among the organization's members to accomplish those goals. The coordination effort includes the proper allocation of resources and the congruence of the operations infrastructure/management processes with the operations/infrastructure strategy.

2.2.2 The Dynamic Nature of Alignment

Another aspect discussed in the alignment literature is its dynamic nature. From this viewpoint, alignment is a process of managing constant change and not just a state to be achieved (Wagner et al., 2005). Sabherwal et al. (2001) suggest that alignment evolves in patterns which can continue for a long span of time. However, abrupt and significant changes in the organization environment might interrupt the alignment process, inducing significant changes in the organizations' strategies and management processes.

In the IT field, researchers have also explored the dynamics of alignment, presenting these dynamics in terms of management processes. For example, Wagner et al. (2005) defined alignment as an organizational capability displayed in specific management processes, acting on a changing environment, adapting organizations internal structures, and processes and skills to the external domain. Alignment as a process depends on smoothly functioning relations between IT and business units to share knowledge and adjust attitudes. Other researchers have found that organizations struggle to fit IT and business strategies, and sometimes go through potentially problematic paths, when the business strategy changes, and one or more of the IT strategy components fails to change appropriately. In those cases, alignment needs to emerge through a process of incremental adaptation and learning (Hirschleim et al., 2001). Finally, the concept of alignment as a management process was also suggested by Peak et al. (2005) and

Sledgianoski and Luftman (2005). This management process is aimed toward the good use of IT resources in meeting the corporation's business objectives. This process comprises corporate planning activities which would produce the divisional strategies and goals that will be used to align IT within the company.

In the literature reviewed above, alignment is not regarded as a static concept but rather as a dynamic one. Alignment is described as the management process of adapting the organization to a continually changing environment. Products of the alignment process are sets of goals on which the organization should focus to accomplish their business strategy.

2.2.3 Project Goal Alignment in the Context of Multi-Organizational Projects

To support the business strategy, the project goals developed by an organization needs to be defined in congruence with the business goals (Norrie and Walker, 2004). The project goals also should be updated as the business goals change as a consequence of changes in the organization's environment (Dooley et. al., 2003; Norrie and Walker, 2004). Therefore, in the case of multi-organizational projects, every participant organization has its own goals for the project derived from their strategic and operational alignment processes.

Skulmaski and Hartman (1999) define project goal alignment as the process of ensuring that key project stakeholders share a common understanding of project goals. This process requires that the key stakeholder expectations and objectives should be considered, documented, and prioritized. In the case of multi-organizational projects, each organization brings its own goals for the project. Hence, the goal alignment process is required to fit these diverse goals into a common set of project goals. Because these goals are the result of each organization's strategic and operational alignment processes aimed to adapt the organizations' strategies to the environment, changes in the organizations environments might require changes in their goals for the project (Dooley, 2003). The project goal alignment process should procure a new fit between the new project goals required by each participant organization. This process might be repeated several times along the project life cycle (Norrie and Walker, 2004). Skulmaski and Hartman (1999) refer to cost, quality, time to completion, and scope as the basic, general project goals. Hence, for this study's purpose, goal alignment is operationalized as the extent to which the level of cost, quality, time to completion, and scope priorities are the same for the organizations participating in the project. Project performance is also assessed based on these priorities.

2.2.4 Project Team Alignment

Skulmaski and Hartman (1999) also suggested that, while providing a set of common project goals supported by the participants, project goal alignment drives participant behavior regarding the effort displayed for the achievement of project goals. Hence, a consequence of the project goal alignment process is project team alignment, defined as "the condition where project participants work within acceptable tolerances to develop and meet a uniformly defined and understood set of project objectives" (Griffith, 1997, p.38). Extending this concept to a multi-organizational project, in this study project team alignment is defined as the degree to which the participants in a multi-organizational project deploy effort to achieve the project goals in the amount and quality expected according to the project plan.

2.2.5 Road Map to Project Team Alignment in Multi-Organizational Projects

The relationships found in the literature between the concepts of strategic, operational, project goal, and project team alignment suggest the framework shown in Fig. 2-1. The figure depicts the simplest form of a multi-organizational project, limited to only two organizations. A brief description of the framework is presented as follows:

- Strategic alignment is the process of fitting the organization to its environment. A product of strategic alignment is the business strategy, which includes a set of strategic goals that the organization needs to pursue.
- Operational alignment is the process of fitting lower level organizational units' goals with the organization's strategic goals. Products of operational alignment are the goals assigned to current and future projects
- In multi-organizational projects, every participant organization brings its own goals for the project, and then a project goal alignment process should take place to fit all these potentially disparate goals into a common set of project goals.
- Finally, the degree to which the efforts of all team members fit in the pursuit of the achievement of the project goals (project team alignment) will depend on the degree to which the project team members perceive that the project goals fit with their organization's goals for the project.

Two considerations will be made regarding this road map. First, because the organization's environment might change, the presented road map is dynamic. Changes in the environment would require adjustment, or re-alignment processes, at all levels - strategic, organizational and project. Second, because this dissertation's purpose was to investigate how performance within a multi-organizational project is affected by the level of project goal alignment and project team alignment, the focus was on the organizations' goals for the project, project goal alignment, and project team alignment concepts - elements in gray in the diagram. The strategic and organizational alignment concepts were discussed to explain how each organization's goals for the project are formed, and that they might vary along the project life cycle.

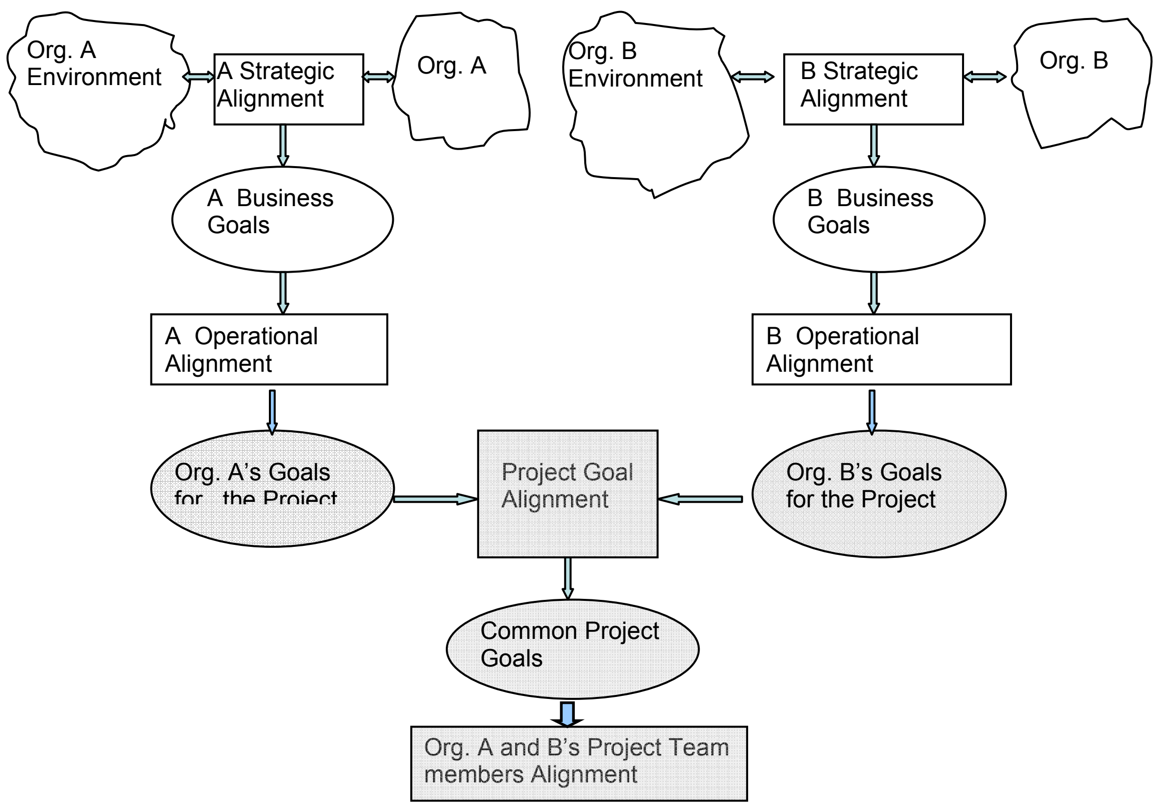

Figure 2-1: Project Team Alignment in a Multi-Organizational Context.

From the literature review associated with the concept of alignment in the context of multi-organizational projects as discussed above, the following study propositions concerning how the level of goal alignment might affect project performance are advanced:

Proposition 1: Participating organizations in a multi-organizational project bring their own goals to the project, according to their strategic and operational alignment.

Proposition 2: Because organizations need to adjust to changes in their strategic environment, participants' goals for the project might change during the project life cycle.

Proposition 3: These changes in project goals might create a situation in which the schedule, quality, scope, and cost goals for the project are not the same for all the participants, regardless of what they had previously negotiated at the beginning of the project. In other words, the level of goal alignment among the participants might vary along the project life cycle.

2.3 Inter-organizational Collaboration

Multi-organizational projects are a particular case of inter-organizational collaboration. Therefore, previous research on the processes associated with inter-organizational collaboration might contribute to explain the dynamics involved in multi-organizational projects.

Wood and Gray (1991,p.146) suggest that inter-organizational collaboration is present when, "a group of autonomous stakeholders of a problem domain engage in an interactive process using shared rules, norms and structures to act or to decide to act on issues related to that domain." In the case of multi-organizational projects, individual organizations engage in interactive processes to accomplish a project, combining resources and expertise not possessed by a single organization, developing a "collaborative advantage", which might help them to achieve organizational objectives that otherwise could not be achieved. According to Gray and Wood (1991), there are three main issues basic for understanding the inter-organizational collaboration phenomena: (1) the conditions that make collaboration possible, (2) the processes through which collaboration takes place, and (3) the outcomes of collaboration. Because the interest here is how the level of goal alignment affects the project dynamics and project performance, the focus of the literature review is on the last two issues.

2.3.1 The Dynamics of Collaboration

In the past, research on the formation of collaborative structures has been more extensive than research on collaborative processes and on the collaborative structures' evolution (Ring and Van de Ven, 1994; Arino and de la Torre, 1998). The transaction cost, agency, and game theory perspectives have been employed by economists to explain why and how organizations decide to participate in inter-organizational arrangements and form transaction governance structures (Armour and Teece, 1978 ; Fama and Jensen, 1983; Kogut, 1988; Williamson, 1991). Organizational scientists have also studied factors that facilitate the formation of an inter-organizational collaborative structure, such as partner interdependence, common values, positive expectations about outcomes, size and structure of the collaboration, and decision making mechanisms (Gray, 1985; Roberts and Bradley, 1991; Wood and Gray, 1991; Chung, Singh and Lee, 2000).

The approaches to the inter-organizational collaboration problem discussed above are rather static; and they do not address the dynamics involved in the collaboration processes. However, some scholars have contributed to development of an evolutionary model of collaborative structures. These structures evolve according to the development of feedback loops, repeatedly checking and rechecking collaboration outcomes with participants' expectations (Ring and Van den Ven, 1994; Doz, 1996; Arino and de la Torre, 1998). Ring and Van de Ven (1994) propose an inter-organizational collaboration model where collaboration evolves following a sequence of negotiation, commitment, and execution stages. Each stage is comprised of a number of interactions, the outcomes of which are assessed by participants, setting new conditions for the next interaction. Doz (1996) suggests a framework for the evolution of collaboration in strategic alliances in which learning processes play a mediation role between collaboration initial conditions and outcomes. Partners learn from their interactions and reassess the collaborative processes by their efficiency and other partners by their fairness and adaptability.

Arino and de la Torre (1998) integrated these two frameworks and introduced a model describing the evolution of inter-organizational relationships. In this model, the collaborative relationships' initial conditions are the product of preliminary negotiation and commitment stages. These initial conditions are accepted by the participant organizations because they satisfy their own objectives for participating in the collaborative effort, generating value superior to other arrangement alternatives. The expected value of the collaborative arrangement depends on the current organization strategy, the expectation about future environment factors, the organizations' expected contributions, and the behavior expected from partners. The expected partners' behaviors will depend on prior experiences and the quality of the relationship between senior management of the involved organizations, including the extent to which they trust each other. If the collaborative arrangement's expected value is greater than the one provided by other alternatives, then the participants will be willing to deploy their contributions and collaborate. But the collaboration initial conditions are subject to change, leading to change in the collaboration's expected value for the participants, and the perceived equity and reciprocity of the relationship. Once changes occur -whether external such as market or technological changes, or internal such as changes in senior management- the affected partners would attempt to reinstate balance in the collaboration. This can be made adjusting the level of contributions or the outcomes distribution scheme.

Arino and de la Torre contrasted their model with the behavior of an international joint venture in the cosmetics and cleaning products industry, in which several internal and external changes occurred. They conclude that both initial conditions and external changes contribute to shape the evolution of an alliance. The quality of the relationship between the participant organizations is both an antecedent and a consequence of the collaborative effort. It is an antecedent as the quality of relationship provides the initial trust and goodwill -the product of previous experiences- required to positively evaluate the collaboration expected outcomes. It is a consequence as the collaboration's outcomes are compared with the outcomes expected. If the actual outcomes are superior to the outcomes expected, the quality of relationships will increase, thereby improving the expectations about future outcomes and reinforcing the parties' willingness to collaborate. On the other hand, if the outcomes are inferior to the outcomes expected, the quality of relationships will decrease, thereby reducing the parties' willingness to collaborate. This is a feedback loop which can contribute in a positive or negative way to build the relational quality in a cumulative way, especially in later stages of the collaborative effort.

2.3.2 The Role of Trust

Core to the construct of relational quality among participants in a collaborative relationship is the concept of trust. A significant part of the sociology, economics, psychology and organizational sciences, literature dealing with inter and intra-organizational collaborations has focused on trust, and trust is regarded as required to sustain and nurture these relationships (Sheppard and Sherman, 1998; Vangen and Huxman, 2003). Trust is associated with the notion of interdependence between partners in collaborative situations (Dasgupta, 1988). Therefore, trust can be understood in terms of partners' ability to form positive expectations concerning the collaboration objectives and the other partner's behaviors regarding these objectives. A basic condition for trust formation is that these expectations can be formed and fulfilled (Gulati, 1995; Rousseau et al. 1998).

The concept of risk is associated with the notion of trust (Ring, 1997; Das and Teng, 1998; Rousseau et al., 1998). In this context, risk is defined as the perceived probability that a partner acts opportunistically (Ring and Van de Ven, 1994). Also associated with trust is the notion of vulnerability (Mishra, 1996), related to the fact that a partner depends on other partners to achieve the desired objectives. Hence, trust could be defined as the willingness of a partner to accept the risk of being vulnerable to other partners' opportunistic behavior.

Rousseau et al. (1998) identify three forms of trust (1) calculative -depending on the ability to assess trustworthiness based on past experiences or other sources of information- (2) identity or knowledge-based -derived from knowledge of partners and emotional attachment developed along repeated interactions- and (3) institutional -based on factors such as organizational culture or legal frameworks. The authors propose that calculative trust plays a more important role during the initial stages of collaborative relationships. Partners assess the trustworthiness of other partners during the early interactions and from past experiences, or from the partner's reputation. After a certain number of interactions, partners start to confirm -or disconfirm- their expectation about other partners' behaviors. Then, knowledge-based trust starts to replace calculative trust.

As a conclusion, the previous discussion suggests that trust building involves a feedback loop, or cyclical process. Every time partners work together to achieve a certain objective, they take a risk from expectations about the anticipated outcomes and the' behaviors. Each time expectations about outcomes and behaviors are met, the trusting attitudes are reinforced, increasing partners' willingness to accept the risks involved in the collaboration and the positive expectations about future interactions.

Based on the previous discussion concerning the dynamics of collaborative efforts, the role of trust, and on the concept of project team alignment as presented in the section 2.2.4, the following propositions are advanced regarding how the level of goal alignment might affect multi-organizational projects performance:

Proposition 4: The effort and resources invested in the project by the participants depend on their expectations of partners' behavior (trust) and project outcomes. These expected project outcomes are the participant's own goals for the project.

Proposition 5: If the expectations are fulfilled, participants will go on investing effort and resources in the project and generating positive expectations about their behavior and project outcomes in their partners, thereby reinforcing trust and the likelihood of obtaining the desired project outcomes.

Proposition 6: If, on the other hand, the expectations regarding partners' behaviors and project outcomes are not fulfilled, participants might reduce their effort and resources invested in the project, not fulfilling their partners' expectations about their behavior and project outcomes, thereby destroying trust and the likelihood of obtaining the desired project outcomes.

Proposition 7: The initial level of trust is based on previous knowledge about partner's behavior and on the perception of the risk involved in the failure of the partner in behaving according to the expected.

2.4 The System Dynamics Approach as a Framework to Study Project Management Issues

Traditional methods for modeling and understanding projects emphasized detailed models of the project components to provide tactical advice about scheduling and controlling project activities. Models became increasingly sophisticated using network-based tools -such as PERT/CPM combined with simulation processes like Monte Carlo. These models are based on the premise that a project can be decomposed into elements that repeated themselves in diverse projects of the same kind, then making possible the generation of reasonable statistical estimates of the duration and cost of each element. All this traditional modeling effort is based on the underlying assumption that getting deeper into the detail level of more accurate models would lead to a better understanding of the project development process (Rodrigues and Bowers, 1996).

However, this sophistication implies a concentration on details that ignores many of the largest and not quantified factors associated with project failure (Davidson and Huot, 1991). These factors involve complex interactions between variables such as perceived progress, staff level, perceived productivity, progress rate, quality, and rework The traditional approaches to project management analyze projects from a static perspective and tend to decompose them into functions or factors, in order to allow project managers to deal with the complexity derived from the interactions and feedback loops. The traditional approach also tends to ignore possible iterations in project processes or incorporate them in activity duration estimates and precedence relationships (Ford and Sterman, 1998). Even more important, the traditional tools consider projects as a unique phenomenon, which hinders efforts to learn from past project experiences, prevents systematic learning, and the dissemination of project management knowledge across project managers' generations (Lyneis et al., 2001). A new approach, based on system dynamics theory, would provide a holistic view of the project and its context, focusing on behavioral trends and their relations with management strategies, generating models to explain project performance.

The system dynamics approach, introduced by Forrester (1961) is a method for analyzing and modeling the behavior of complex social systems, where a holistic view is important and feedback loops are critical to understanding the fundamental interrelationships. For example, in a relatively simple project case, project behavior can be modeled through variables such as progress rate, resource level, schedule slippage, and perceived progress. Higher resource levels lead to a greater progress rate, which increases the perceived progress. To balance the cycle, a perceived schedule slippage is counterbalanced with an increment in the level of resources. This simple model can be easily complicated with the incorporation of external disruptive factors such as budget restrictions, low staff motivation, and changes in the scope of work, etc. (Lyneis et al., 2001).

Once the key feedback loops in the model and the potential disruptive factors are identified, quantitative estimates of the different outcomes can be performed from correlations with past experiences, or from discussions with project team members. There are several software packages in the market to help with this task -for example, Vensim™, PowerSim™, and ITHINK™. Common outputs of these software packages are graphics that feedback dynamics, leading to a greater understanding of the system and supporting experimentation to explore possible consequences of management actions.

Hence, the application of system dynamics to project management has been motivated by the following factors (Rodrigues and Bowers, 1996):

- A concern for the whole project rather than just in the project elements.
- The need to examine the non-linear aspects of the project interrelationships described by the balancing of reinforcing feedback loops.
- The need to capture the mental models derived from project managers -and all project participants- past experiences.

- The need for developing -using the captured experiences and project management theory- a flexible modeling option to support experimentation of diverse management options and predict possible outcomes.

Both system dynamics and the traditional approach to project management examine the same basic issues but from different perspectives. One of the most fundamental differences between the two approaches is the model of project work. The traditional approach views the project work as the sum of a set of work activities, scheduled with precedence relationships and resources requirements. In the system dynamics approach, the project work is represented by a continuous flow of units of work that change from the state of "to be done" to the final state of "done" as resources are allocated to the project. No specific consideration is given to about who does the work and when.

The power of the system dynamics approach is based on its ability to incorporate subjective factors, such as quality, productivity, and motivations, which can have an important influence on the whole projects, and are represented explicitly through causal feedback loops. Therefore, even though a system dynamics model does not provide a breakdown of the project activities' cost or duration, it does explicitly include the indirect causes that are often responsible for overrun and overspend (Rodrigues and Bowers, 1996).

Most systems dynamics project modeling software generates graphic outputs that facilitate simulation and discussion exercises with the participation of the project team members, customers and senior management. This can result in a better understanding of the effects of subjective variables on the project dynamics, and in an improvement in the communication among the project team members, because the system dynamics approach encourages people to make their mental models explicit and then share their understanding of the project (Rodrigues and Bowers, 1996).

In conclusion, system dynamics offers a different view of a project, producing a better understanding of the important underlying influences. Then, system dynamics seems to be complimentary to the traditional project modeling techniques. The integration of both approaches might be obtained through more sophisticated network models including feedback processes and modeling of activities. Moreover, this integration can be done through a more detailed system dynamics model differentiating the major stages of a project as distinct activities, or through the assimilation of main lessons derived from system dynamics analysis in a set of rules to be used in estimating activity duration and cost in conventional networks (Rodrigues and Bowers, 1996).

For the particular purpose of this study, the system dynamics approach permits the visualization of the diverse causal relationships between alignment and other variables interacting in multi-organizational project systems, such as the level of effort displayed, work quality, trust among partners, and project scope. This visualization can contribute to a better understanding of the process dynamics -including feedback loops and non-linear relationships- which develop along a project's life. These dynamics lead to diverse levels of project performance. The system dynamics approach will allow the development of a general model for multi-organizational project performance, not associated with particular activity networks, project phases, businesses or industrial sectors, making the model applicable to a broad range of multi-organizational projects.

2.4.1 Basic Project System Feedback Structures

Ford (1995) extracted from several previously validated project dynamics models the basic project system feedback structures that are presented below. These feedback structures describe the fundamental dynamics within a project and constitute the building blocks of most project system dynamics models.

The Rework Structure

The rework structure depicts how work is accomplished along the project life, incorporating the quality control activity. The “work to be done” stock is transformed through progress (or task performing) into work to be checked by quality control and, depending upon the quality of the work, it becomes either good work (approved) or bad work (rejected). The good work is work completed (work done) and reduces the amount of work to be done; the bad work needs rework and, after this process, it becomes again work to be checked, where it is separated by quality control in good and bad work, repeating the cycle the number of times it is required until all the work is approved and the work to be done stock is completely depleted (project completion). The quality level drives the proportion of good and bad work. The level of work that remains to be done, and the time available until the deadline influence the schedule pressure. A higher level of schedule pressure might induce a reduction in the quality standards, thus lowering the quality level. Lower quality implies more work that needs rework, reducing the amount of work done, increasing the schedule pressure in a reinforcing feedback loop. The rework structure is illustrated below in Fig. 2-2.

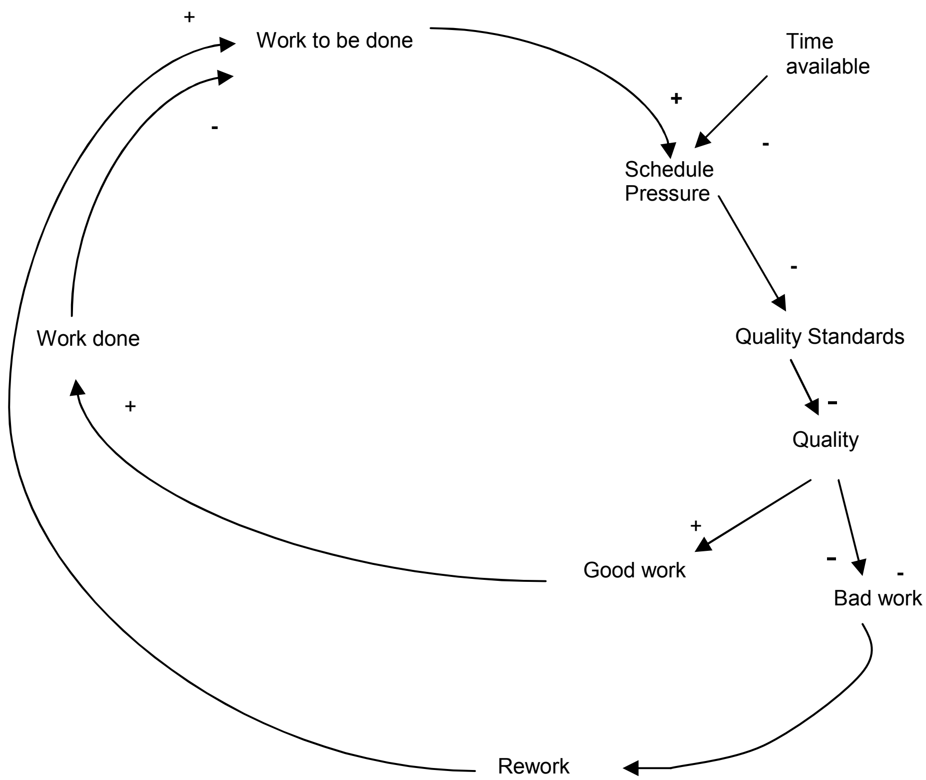

Figure 2-2: The Rework Structure.

The Labor Structure

The effort deployed to generate progress in completing project tasks is a result of the head count and labor intensity, which are driven by the schedule pressure (pressure to complete the project on schedule). The effort deployed to complete the project is translated into progress and then into work done, which reduces the time required to completion. The time required to complete the project is compared with the time available. A negative difference (perceived project slippage) would reinforce a higher schedule pressure, inducing higher labor intensity and head count in a balancing cycle. A graphic depicting the labor feedback structure is presented in Fig. 2-3.

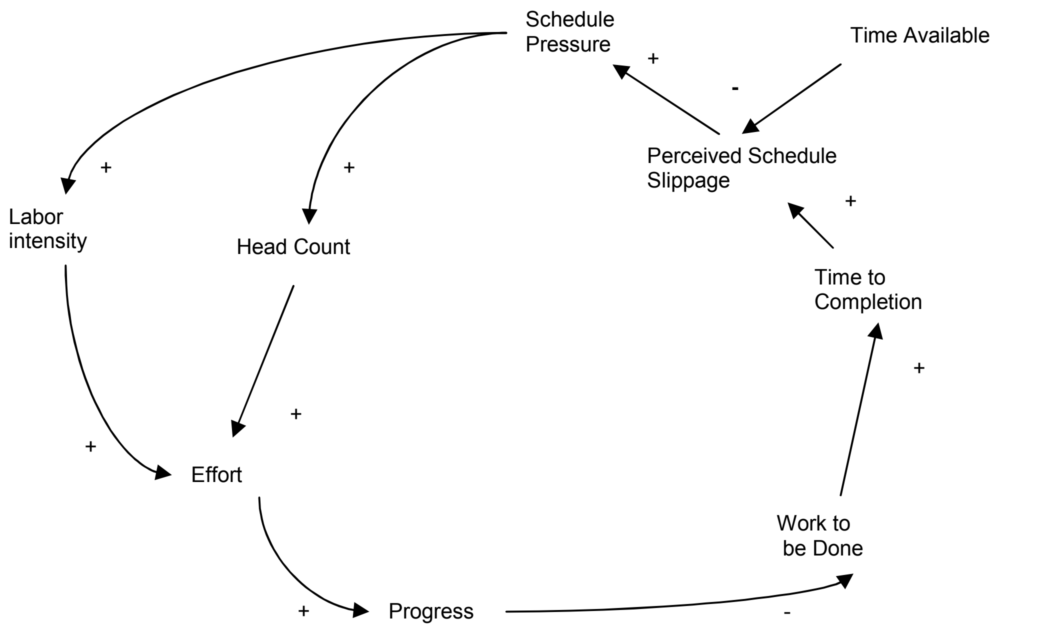

Figure 2-3: The Labor Structure

The Quality Structure

The quality standard (degree to which high quality is pursued in project outcomes) drives quality (degree to which tasks outcomes fulfill project requirements). Quality is the antecedent of the proportion of good work and bad work generated. Bad work generates rework -delaying the work completion- and good work increases the amount of work done. The level of work to be done, compared with the time available until deadline, increases or decreases the perceived schedule slippage. An increasing perceived schedule slippage might lead to a pressure to reduce the quality standard, in order to accelerate the progress and reduce the slippage, but creating a cycle reinforcing quality deterioration of work performed, increasing the level of rework required and then reducing the level of work done.

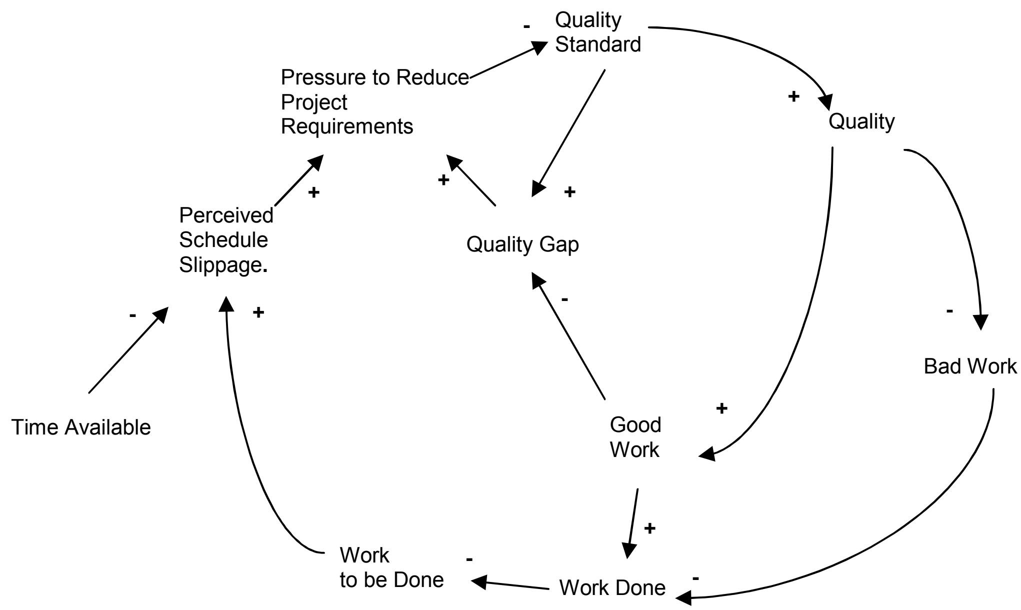

Figure 2-4: The Quality Structure

On the other hand, a decreasing perceived schedule slippage would lead to a decreasing pressure to reduce quality standards, thereby reinforcing quality. The quality structure is presented in Fig. 2-4.

The Scope Structure

The amount of work to be done compared to the amount of time available leads to a perceived schedule slippage and then to a higher pressure to reduce scope in order to catch up with the schedule. This pressure might cause a schedule reduction if it can overcome the resistance to reduce scope associated with project team commitment to project objectives.

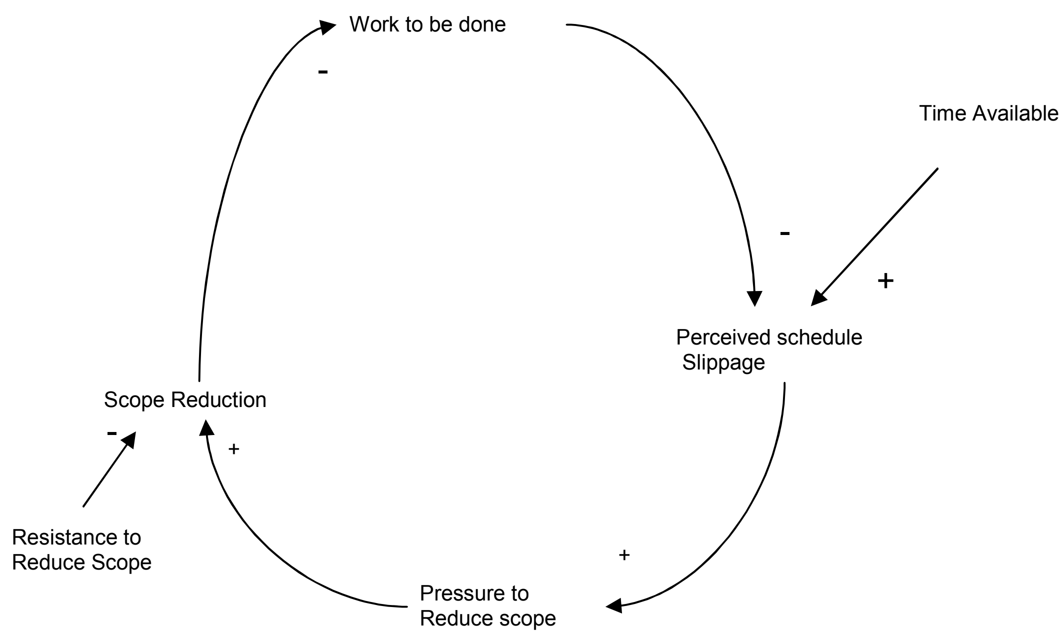

Figure 2-5: The Scope Structure

A reduction of work to be done increases the proportion of work done, thereby reducing, in a balancing feedback cycle, the perceived schedule slippage and the pressure to reduce scope. The graphical representation of this structure is presented in Fig. 2-5.

The Schedule Structure

The time remaining at a given moment to the project deadline is compared to the expected required time to finish the project. If the perception is that there is not enough time to complete the project before the deadline, schedule pressure is generated.

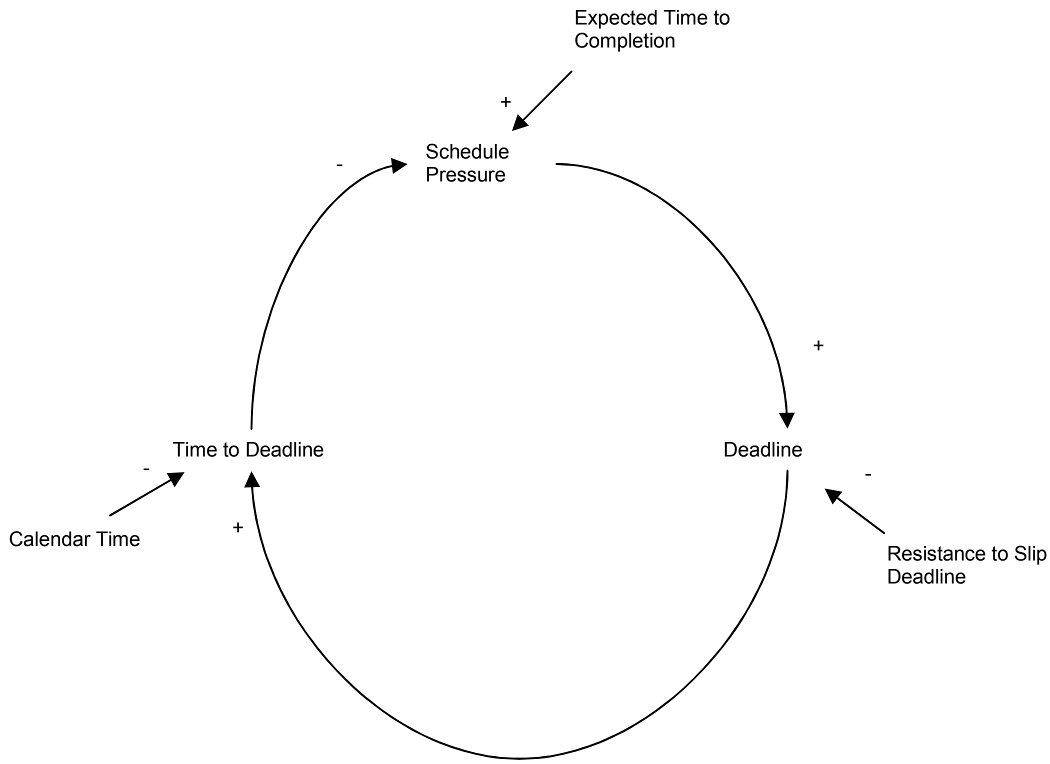

Figure 2-6: The Schedule Structure

The higher the schedule pressure, the higher the drive to postpone the deadline, but resistance to slip the deadline -produced by the relative importance of the schedule goal- should be overcome. If the deadline is postponed, the time to deadline will be increased, reducing the schedule pressure. This balancing feedback loop structure is depicted in Fig. 2-6.

The Basework Structure

Basework is work performed for the first time. An enlargement of the project scope or an increase in the upstream work increases the total basework available to complete, but project constraints might reduce that availability.

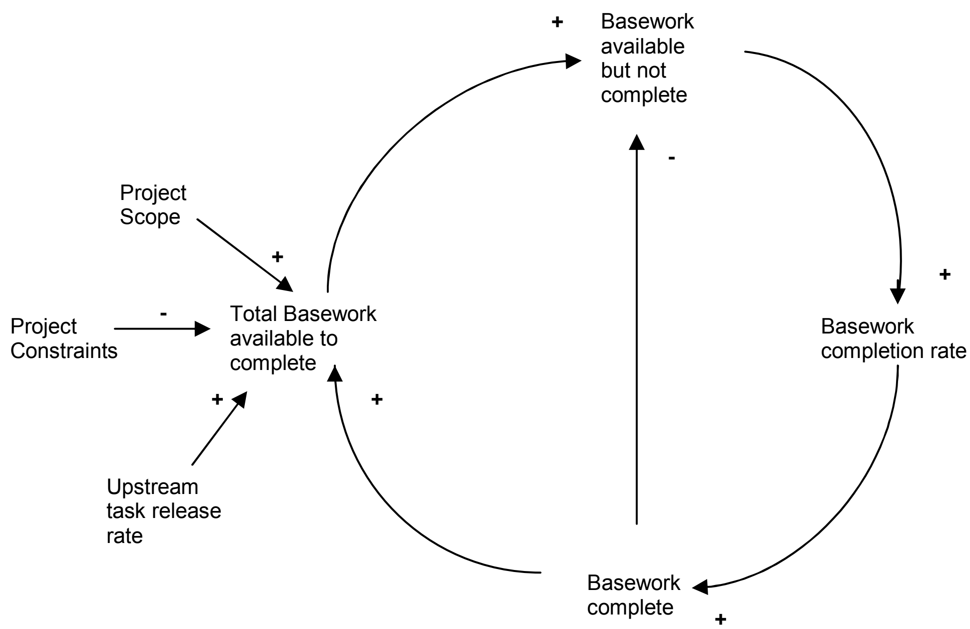

Figure 2-7: The Basework Feedback Structure

The more basework available to complete, the higher the basework completion rate will be and the more basework that will be completed. This basework completed reduces the stock of basework available but not completed, and also might increase the total basework available to complete -that basework completed can be required to perform subsequent tasks. The basework structure is depicted in Fig.2-7.

Because the feedback structures discussed above have been validated in different project contexts and have shown their ability to describe project dynamics (Ford, 1995), an assumption, was made that the basic project feedback, represent properly the basic project dynamics. Therefore, the following proposition is advanced:

Proposition 8: Variations of the level of goal alignment will affect project dynamics, as described by Ford (1995), through variation in the level of effort and resources invested in the project by the participant organizations.

2.4.2 Brief Review of Past System Dynamics Applications to Project Management and Inter-organizational Collaboration

The first system dynamics project management application was developed by Roberts (1964) to study the dynamics within R&D projects, but the first groundbreaking application was developed by Pugh-Roberts/PA Consulting during the 1970's for Ingalls Shipbuilding. The application was designed to resolve a cost/overrun dispute with the US Navy. Until the year 2001, Pugh- Roberts/PA Consulting has applied system dynamics in more than 30 contract disputes, with a value beyond $4 billion (Lyneis et al., 2001). Moreover, Pugh-Roberts/PA Consulting alone has applied system dynamics modeling in a proactive way to more than 75 different projects in diverse areas, with reported savings for the customers of $5 billion (Lyneis et al., 2001).

In the academic field, system dynamics modeling of projects has focused on explicitly displaying and integrating the influences of processes, resources, scope, and targets on performance (Ford and Sterman, 1998). The works of Richardson and Pugh (1981), Cooper (1980) and Homer et al. (1993) have applied system dynamics to model project resources and study the effects of resource management on project performance. Models for particular project management applications or cases have also been developed For instance; Abdel-Hamid (1984) built a system dynamics model of software development in which task progress is driven by the level of work force deployment and work force productivity. The Abdel-Hamid model, like the one developed by Richardson and Pugh, incorporates the influence of schedule targets on performance, and also the distinction between initial completion and rework.

Rodrigues and Williams (1998) approach the problem of assessing the impact of client behavior in project performance using system dynamics, including modeling the effects of schedule restrictions, high demand on progress reports, and delays in approving documents and changes. Lyneis et al. (2001) developed a comprehensive, strategic project management model incorporating much of the knowledge and experiences derived from the previous models discussed above, to assist project planning -including the initial schedule and budget, organization structure, and processes design- determining measurement and reward systems, assessing risks, and learning from past projects. This model was successfully applied to the case of the Peace Shield Air Defense project, helping to support the bidding process, and identifying potential risks and the potential benefits and shortcomings of management policies to be implemented.

Ford and Sterman (1998a) elaborated a model that describes the dynamics involved in a product development project, which explicitly integrates four performance drivers -processes, structure, resources, targets and scope- in a multi-phase project network. The model aims to study the role of dynamic concurrence and inter-phase coordination on project performance. The model was built on the basis of previous model structures, adapted to their particular objective, and then calibrated against a real-life, multi-phase new product development project, to determine the quantitative parameters required to predict project behavior. The behavior "predicted" by the model was found to be similar to a large extent to the real project.

Concerning applications to the inter-organizational collaboration problem, Black et al. (2003) studied the dynamics of multi-organizational collaboration in the context of information systems development, with an emphasis on factors such as trust, knowledge sharing and collaboration. The model attempted to simulate the dynamics associated with the collaborative work accomplished by New York State and homeless services provider agencies, who were engaged in the process of developing specifications for an inter-organizational information system. The model consists of three main components: (1) a basic project model -similar to those previously developed in the project management area- to represent the dynamics of doing work, (2) the participants' stock of knowledge about their work and the partner's work -and the resulting trust and engagement required to continue with the collaborative effort- and (3) the influence of facilitation efforts. In this model, the participants' engagement or willingness to collaborate is a function of their sense of project progress -which depends on the perception of work done correctly and the sense of how hard the participants have worked to achieve project goals- and on the level of trust in the other participants.

A model related to the Black et al. model is the one developed by Luna et al. (2004) as a part of the same New York State University research program. The model attempted to simulate the dynamics associated with the development of trust among participants in inter-organizational collaborations. The model represents a dyadic situation in which participants in an inter-organizational collaboration observe the partner's behavior and develop a certain level of trust through their interactions. The model is based on the trust generation mechanisms suggested by Rousseau et al. (1998) discussed above: calculative, knowledge-based, and identification-based. Based also on the Rousseau (1998) work and on field data, the model assumes that the calculative mechanism explains more of the trust development during the early stages of the collaborative relationship, evolving later to a knowledge-based trust development. Trust is learned and reinforced (or reduced) as a product of the knowledge of partners' past behaviors.

Supported by these three assumptions, the model defines trust as the weighted average of two perceived probabilities: calculative -based on the relationship between the perceived desirability of the collaboration to the risk involved and the participant attitude to risk- and the perception of partner's trustworthiness -based on previous information and information obtained during the interactions. The weighting factor applied is the level of knowledge about the partner behavior and intentions. The higher the level of knowledge, the more the relative weight of the probability assigned to the partner's trustworthiness. The most important contribution derived from this model is that trust formation in collaborative contexts appears to be path dependent. Trust development patterns tend to remain on the same trend along the duration of the collaborative effort with certain fluctuations. Hence, the initial stages of the trust development seem to be crucial for the level of trust achieved during the collaboration.

Black et al. (2003) suggest the exploration of the diversity of dynamics possible when the collaborative effort produces a range of asymmetric benefits and costs for each participant in the collaborative effort as an avenue for further research. In this dissertation, that research avenue will be pursued from the perspective of multi-organizational projects, where possible lack of goal alignment might create perceptions that the project outcomes are not producing the benefit expected by some or all participants involved.

2.5 Summary

Because a multi-organizational project is a particular case of collaborative effort, past research on goal alignment and inter-organizational collaboration was reviewed to identify theoretical propositions that could help to understand how the level of goal alignment affects multi-organizational projects performance. In that review, trust among partners emerged as potentially significant factor affecting inter-organizational collaboration performance. These propositions guided the case study research and then the conceptualization of the multi-organizational project system dynamics model, and constituted a preliminary description of the dynamic behavior of the multi-organizational project systems, or system's "reference mode" (Pfahl and Lebsanft, 2000; Sterman, 2000). The assessment of these propositions was the focus of the case study as discussed in the next section concerning the dissertation's research methodology.

Literature concerning project system dynamics models was also reviewed, because system dynamics was the approach selected for modeling the effect of goal alignment on multi-organizational project performance.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Chapter Overview

A combination of case study inquiry and system dynamics methodology was selected to investigate the research question on which this dissertation is focused. Therefore, a significant part of the methodology discussed below entails the case study inquiry and the process of building a multi-organizational project system model. This methodology also includes experimentation with the model, to study how the project dynamics induced by the level of goal alignment among the participants in a multi-organizational project affects project performance.

This chapter starts with a brief account of how system dynamics proponents have conceptualized the model building process in previous research. Because the proposed methodology is mostly based on qualitative data, this account includes a discussion about the importance, collection and use of qualitative data for model building. Last, the specific methodology that was used to investigate the dissertation's research problem is discussed.

3.2 The System Dynamics Model Building Process

Since Jay Forrester introduced the system dynamics approach in the early 1960s; its proponents have developed procedures for the model building process (Richardson and Pugh, 1981; Roberts et al., 1983; Wolstenholme 1990; Sterman, 2000). These and other proponents have also suggested diverse arrangements of the activities involved in the model building process. While in those arrangements vary in the number and denomination of the process stages, the activities included in those stages are mostly the same (Luna and Andersen, 2003). In order to describe the model building process, the modeling stages proposed by Randers (1980), namely conceptualization, formulation, validation and implementation are used (see Fig. 3-1).

The conceptualization stage includes: problem definition and system conceptualization (Randers, 1980). Problem definition is the verbal description and delimitation of the system to be studied, including a characterization of the variables involved. System conceptualization is the verbal description of the system's feedback loops that are assumed to cause the system's variables behaviors. Usually, these verbal descriptions are translated into influence diagrams showing the relationships between the system variables. These descriptions are located primarily in the system participants' mental models and also in the system documentation or written database. Hence, it is required at the conceptualization stage to devise methods to get access to the system participants' mental models (Richardson and Pugh, 1981; Forrester, 1994; Sterman, 2000).

The formulation stage entails the definition of a detailed model structure, system parameters, and of the mathematical relationships between the variables. Therefore, this stage is basically focused on collecting and analyzing a system's quantitative data, such as numerical records of diverse system parameters, which would help to estimate the shape of the relationships between the system variables (Randers, 1980). Nonetheless, qualitative concepts also might be formulated, especially in systems where "soft" variables such as customer satisfaction, trust, engagement, etc. are present (Luna and Andersen, 2003). Richardson and Pugh (1981) propose that modelers working with qualitative concepts should define them explicitly, create units and measurement scales, and handle them consistently across the model.

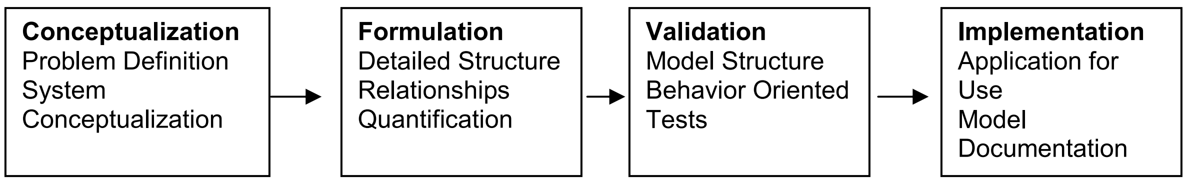

Figure 3-1: The System Dynamics Modeling Process Stages

Randers (1980) describes the validation stage as the process of reviewing whether the mechanisms included in the model actually generate the model variables behavior (reference mode), and if the assumptions made about relationships between the variables included in the model are reasonable. However, validation of system dynamics models has been the subject of critics due to its reliance on subjective, informal and qualitative procedures (Barlas, 1996; Zellner, 1980). Part of the criticism originated in the fact that system dynamics models are causal-descriptive, constituted by a set of propositions about how the real systems actually operate. In these cases, conventional statistical tests applied to determine the accuracy of the system's outputs behaviors are not sufficient to determine the model validity. What is really important is the validity of the structure of the model (Barlas, 1996).

A system dynamics model is a theory about system functioning, and should not only predict its behavior, but also explain how this behavior is developed. In other words, system dynamics models are not built for mere forecasting purposes, but also for explanatory purposes. From statistical point of view, the testing of these models is extremely complicated, if not impossible, because each proposed causal link is a hypothesis and all these hypotheses are interrelated, generating problems of autocorrelation and multi-collinearity (Barlas, 1996).

However, there are several tests that can be used to assess the validity of a model. Structure-oriented tests assess the validity of the model structure. Once the model structure has been validated, behavior oriented tests can be applied to assess the degree to which the model reproduces the model behavior. These two categories are briefly described below.

Structure-Oriented Tests

Tests included in this category are of two types: (1) direct structure tests and (2) structure-oriented behavior tests (Barlas, 1996). Direct structure tests assess the validity of the model structure by comparing each element of the model with existing knowledge of the real system. These tests can be theoretical or empirical. The theoretical tests compare model structure with the knowledge existing in the literature. Empirical tests compare model structure with information obtained from the real system. Forrester and Senge (1980) describe the following direct-structure empirical tests:

- Structure confirmation test: comparing the equations of the model with the relationships existing in the real system.

- Parameter confirmation test: compares the parameters of the model with knowledge of the real system.
- Direct extreme-condition tests: assessing the validity of model equations under extreme conditions by comparing the model behavior with that expected from the real system behavior under these conditions.
- Dimensional consistency test: checking both sides of each model equations for dimensional consistency.

The structure-oriented behavioral tests assess the validity of the model structure indirectly, applying behavior tests on the model-generated behaviors' patterns (Barlas, 1996). These tests are:

- Indirect extreme conditions test: assigning extreme values to certain parameters and comparing the results of the simulation with the behavior of the real system under the same circumstances.
- Behavior sensitivity test: determining the parameters to which the model is sensitive, running a simulation, and analyzing if the real system would behave in the same way
- Turing test: a shuffled collection of real and simulated system behaviors are presented to experts and to see if the can distinguish between the real and simulated behavior. If these behaviors are statistically undistinguishable, the model passes the test.

Behavior-Oriented Test

Once confidence in the validity of the structure of the model has been built, some tests can be applied to assess how accurately the model can reproduce the real system behavior patterns. The focus is on pattern prediction, not on variables' values at certain points (Barlas, 1996). A technique to validate system dynamics models used in project management applications is to "calibrate" the model parameters against the data of a past project and then simulate the project behavior. The simulation outputs are then compared with the past project actual patterns behavior, to assess to what extent the model is able to reproduce them (Ford and Sterman, 1998).

The last stage in the modeling process is the implementation stage, which Randers (1980) conceptualizes as the transfer of the study insights to the model's users and the application of the model to system analysis and policy formulation. In the case of academic research, I consider that the implementation stage should include two basic activities. The first activity is to perform experiments with the model in order to find how certain variables of interest affect the system's dynamics and variables' behavior. The second activity is the elaboration of a proper model documentation, which will help future researchers to build on the results of the study to conduct future research or to attempt to replicate the study in other contexts.

3.3 Collecting and Using Qualitative Data for System Dynamics Model Building

System dynamics models are mathematical representations of the dynamic relationships between the components of a system. However, it is widely accepted that most of the information available for the model building process, as described in the previous section, is qualitative in nature (Forrester, 1994; Luna and Andersen, 2003). Forrester suggests that these qualitative data are located in two databases: in a written database (system documentation) and in a mental database (the system actors' minds). Moreover, Forrester states that the most important information source for the modeler is the system actors' mental database. This assessment by Forrester is shared by most system dynamics scholars (Richardson and Pugh, 1981; Roberts et al. 1983; Wolstenholme, 1990; Sterman, 2000).

However, there is not a similar agreement on how to collect the data residing in the mental databases or on how to use this data (Vennix, 1996; Luna and Andersen, 2003). The problems derived from the quantification of qualitative variables have led some researchers to adopt an only qualitative approach to system dynamics (Wolstenholme, 1990). Others consider that the results of simulations based on models that include quantified qualitative variables might be misleading, and these researchers discard the inclusion of all soft variables in the models (Coyle, 2000). On the other hand, it is generally accepted that, as discussed above, qualitative data play a main role in the conceptualization stage, while quantitative data play a more significant role in the formulation stage (Coyle, 2000; Sterman, 2000).

Amid the debate about the appropriateness of the use of qualitative data in system dynamics modeling, Sterman (2002) proposes that not considering qualitative variables in a model because no numerical data is available to measure them is probably worse than using judgment to estimate their value. "Omitting concepts because we have no numerical data is a sure route to narrow model boundaries, biased results, and policy resistance. Of course, we must evaluate the sensitivity of our results to uncertainty in assumptions … modelers who follow these principles owe no apology to those who would judge model validity by historical fit and statistical test alone" (Sterman, 2002, p.523).

However, Sterman (2002) also argues for the use of statistical methods to estimate model parameters and evaluate the ability of the model to replicate historical data, whenever numerical data is available. In conclusion, Sterman argues that quantitative data should be used when available to measure rigorously defined variables, but variables relevant to explain the system dynamics should not be discarded simply because numerical data is not available to measure them.

More recently, Luna and Andersen (2003) made an extensive account of methods used to collect and analyze qualitative data for model building, including the estimation of system parameters when no numerical data is available. For collecting the qualitative data residing in systems actors' mental models, the most used methods, as cited by Luna and Andersen, are interviews, focus groups, Delphi groups, observation, and participant observation. Interviews are among the most important tools for data collection in social sciences, allowing direct interaction between the researcher and the respondents. The role of the researcher in an interview is to guide the dialogue toward the study line of inquiry, but allowing the interviewee to tell stories, provide examples, or clarify points. Focus groups are group interviews in which group members interact among themselves, exchanging opinions about the subject studied. Delphi groups are similar to focus groups, but with repeated iterations of the intervention while providing feedback to the group, in order to obtain group consensus. Observation entails capturing information about the social structure, processes, and culture, etc. of a certain group, without direct participation of the researcher in the environment dynamics. Finally, in the participant observation method, the researcher interacts with the studied situation to collect the required data.

Regarding the methods to analyze qualitative data, Luna and Andersen discussed several methods, including hermeneutics/discourse analysis, grounded theory, ethnographic decision models, and content analysis. Hermeneutics/discourse analysis consists in finding meaning in a textual database, and connecting this meaning to the cultural context. Grounded theory is a set of techniques to identify themes or concepts in texts, linking them to generate meaningful theories about the system observed. An ethnographic decision model entails building decision trees describing decision alternatives and the processes to make the decisions. Finally, content analysis consists in defining codes to classify contents and then applying them systematically to a group of texts. These methods can be used alone or combined to analyze the data collected from the system actors' mental models and from other system documentation.

As mentioned above, in some cases there is not numerical data available to estimate system parameters or the shape of the relationships among system variables (Richardson and Pugh, 1981). Qualitative methods have been used to approach this problem. The Delphi method can be successful in eliciting parameters from a group of system experts (Luna and Andersen, 2003). The modeler can ask the experts about their estimation for a certain parameter. After collecting the individual judgments, the modeler provides a summary feedback to the experts, who should rethink their initial judgment based on the received feedback. The process is repeated until consensus is reached concerning an estimate for the parameter.

Ford and Sterman (1998b) propose a method for defining the probable shape of unknown relationships between system variables. This approach consists in asking experts to create graphic depictions of the relationships in two stages. First, they are asked to think of certain “anchoring points” or distinctive points like maximums or minimums. Then, the experts should think how these points are connected. Ford and Sterman argue that this two-step method contributes to improved knowledge elicitation by reducing the cognitive processing required in each stage, and that the two stage method slows the elicitation process, giving more time for thinking and revision.

In the following section, the research methodology that was used to investigate the research problem is presented. This methodology includes some of the techniques discussed in this section to collect and analyze the qualitative data required to build the multi-organizational project system dynamics model.

3.4 Study Research Methodology

The research methodology employed in this study combined the case study empirical inquiry with the system dynamics approach (see Fig.3-2). The strategy consisted in analyzing multi-organizational projects’ cases in which variations of the level of goal alignment had taken place, in order to formulate a theory expressed in the form of a system dynamics model that describes how the level of goal alignment affect project performance. The case data collection and analysis was guided by the assessment of the case study preliminary propositions as formulated in the previous chapter. An assessment of the validity of the theory developed was performed by participants in the studied projects and by individuals with experience in other multi-organizational projects, to evaluate the extent to which the theory developed is generalizable. Simulation experiments were performed to assess to what extent the model elaborated reproduced plausible multi-organizational projects behaviors according to the cases data, and to explore the effect of possible moderating factors.

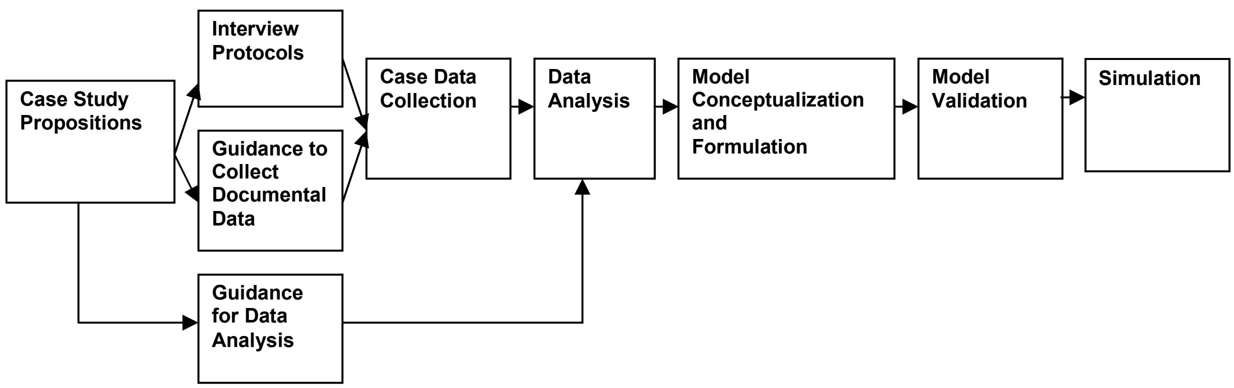

Figure 3-2: The Proposed Research Methodology

3.4.1 Rationale for the Approach

The case study and system dynamics modeling approach was suitable for this research because:

- "A case study is an empirical research approach that investigates a contemporary phenomenon within a real life context when the boundaries between the context and the phenomenon are not clearly evident" (Yin, 2003, p.13). Multi-organizational projects are contemporary phenomena -many of them are currently being executed, and many have been executed in the recent past. Therefore, it is likely that there are still individuals involved in that kind of project and available for interviewing, as well as project documentation available. Multi-organizational projects are phenomena that develop within the context of the participant organizations and their own strategic and operational circumstances, and it can be difficult to define the borders between the project and its context due to the mutual relationships that affect one and the other.

- The research question on which this study focused was a “how” question. In other words, the purpose of the research was to develop an explanation about how the level of alignment affects multi-organizational projects performance. Case studies are suitable for that kind of explanatory questions because they permit a researcher to deal with cause-effect links that should be traced along a certain span of time, rather than the simple frequency or incidence of certain variables (Yin, 2003).
- The case study approach is preferred when relevant behaviors cannot be manipulated, in other words, when the research question is not suitable of being investigated through experiments or quasi-experiments (Yin, 2003). As mentioned above, multi-organizational projects are complex phenomena subject to the influence of variables related to the participant organizations’ contexts. These influences are varied and disparate in nature, and very difficult to control or to simulate outside of the real-life context.
- Case study research usually provides context-rich stories relevant to the practitioner (Luna, 2004). Because case studies collect data from real-life

settings, their findings and lessons learned might be very useful to practitioners dealing with similar situations.

However, when compared with more established research strategies, case studies have been criticized for the following motives:

- Case studies can be more susceptible to problems associated with bias, lack of systematic procedures, inclusion of non-sustainable evidence, and researcher's sloppiness in general, mostly because case studies lack a rigorous and reliable methodology (Yin, 2003).
- Because the case study strategy collects data from a single case or only a few cases, it gives little support for the generalization of their findings to other contexts (Yin, 2003).
- Case study outcomes are, in many cases, long and unreadable documents (Yin, 2003). When presented in a traditional report way, many case studies lose value for practitioners and even for researchers.
- It is difficult to replicate a case study, arriving at similar findings or conclusions in subsequent research (Luna, 2004)
- Because in most cases control of variables is not possible while conducting case studies, it is difficult to make controlled deductions (Luna, 2004). In many cases is not possible to assess the contribution of specific variables to the system studied outcomes.

To overcome the case study limitations as described above, some researchers have combined the case study strategy with simulation modeling in their research designs. For example, Black (2002) and Luna (2004) employed a combination of case study and system dynamics modeling to study the dynamics of collaboration in the healthcare/new product development and multi-organizational information systems settings. The combination of the system dynamics and case study approaches can contribute to overcome some of the case study limitations:

- Simulation models can preserve the richness of knowledge contained in the case study findings (Luna, 2004), providing a structured way to describe the complex interrelationships among the case study's variables.
- Case study research strategies supersede the static view of quantitative research on social phenomena, concentrating on analyzing the dynamics present in single settings (Eisenhardt, 2002). These dynamics could be properly depicted through a system dynamics model.
- The data collected through case study research can be in many cases mostly verbal, with some ambiguity embedded. However, the mathematical nature of the system dynamics method forces the researcher to be specific and precise in defining the causal dynamic mechanisms that translate a verbal theory and empirical data collected into a model. (Hanneman and Patrick, 1997)
- Like experiments, case studies are generalizable to theoretical propositions and not to populations. A case study does not represent a sample, and in doing a case study the goal is to expand and generalize theories and not to enumerate frequencies (Yin, 2003). The system dynamics model derived from a case study can be applied to similar phenomena in other contexts to assess the generalizability of the theory developed about the system's behavior (Luna, 2004).

- Simulation models can be useful to extend what is learned from case studies (McCaffrey et al., 1985). System dynamics can help to perform simulation experiments to analyze the impact of changes in relevant variables and provides explicit cause-effect relationships drawn from the analysis of qualitative data (Luna, 2004). Hence, the use of system dynamics may help to control and manipulate system's variables that in real life cannot be controlled, and might help to assess their individual impact on the system's outcomes. This feature might contribute to some extent address the case study limitation concerning the lack of control of variables in real-life settings.
- A holistic perspective of a studied system is an advantage of case studies (Gummenson, 2000), as well as of the system dynamics approach. Both approaches attempt to understand the analyzed system as a whole, with all the variables interacting among them, in order to develop a comprehensive theory, rather than a segmented one, of how the system operates.

3.4.2 Research Methodology Description

The research methodology entailed the completion of the following activities:

- Preparation of the case study protocol
- Cases selection
- Data collection
- Data analysis and modeling process.
- Model validation.
- Simulation experiments.

- Model documentation.

Preparation of the Case Study Protocol

In order to guide the research effort and increase the study reliability, a case study protocol was prepared, so future researchers can follow the procedure to replicate the study (Yin, 2003). The protocol contained the following parts:

- Introduction: case study question, theoretical framework and propositions
- Criteria for the selection of the case.
- Data collection procedures, including interviews protocols and criteria to use documentation related to the case.
- Data analysis strategy and techniques.
- Description of the case database, including how the data was collected, classified and stored for better accessibility.

Case Selection

Case selection was based on two criteria. The first criterion is accessibility, or the degree to which individuals involved in the case, as well as the project documentation were available for interviewing and examination, respectively. The second criterion is akin to the concept of theoretical sampling suggested by Eisenhardt (2002), establishing that the case selected should be the one with more potential to provide data related to the research question. In this case, this criterion was defined as follows:

- Significant variations of the project goal alignment level have been reported.

- The project lasted long enough (more than a year), so that to make the dynamics induced by variations in the level of goal alignment were apparent. Shorter project durations might not have allowed these dynamics to fully develop.
- Cases in which the relationship between the organizations participating in the project is a collaborative relationship were preferred. In other words, cases were favored for selection when the organizations involved were partners, not clients and contractors. Because a client–contractor relationship is a hierarchical one governed by contracts, the possible impact of lack of alignment toward project goals might be significantly reduced.

To find the potential cases, I relied on four basic sources:

- Businesses and organizations connected with the Industrial Engineering and Management Department at Oklahoma State University.
- Part-time students of the Master of Science in Engineering and Technology Management program at Oklahoma State University.
- Personal contacts.
- Professional organizations.

A brief description of the project was requested from the authorized organization's officials to assess to what extent potential multi-organizational projects cases met the criteria established above. Due to particular circumstances associated with the research subject, it was not easy to find multi-organizational projects cases to analyze. More than 40 individuals with experience in multi-organizational projects were contacted through the Oklahoma State University Master of Science in Engineering and Technology Management program and through personal contacts within several industries and project management consulting firms. Only two were willing to contribute with specific cases. Most individuals wanted to discuss their experiences with multi-organizational projects in a "generic" way, but not their specific experiences in particular projects. It seemed that even though complete confidentiality was assured, they did not want to take the risk that their opinions about certain organizations or individuals might become public. In most cases, those organizations or individuals are, or could be, potential partners or customers in new businesses, and the interviewees did not want to hurt their relationship with them.

Data Collection

To collect the data required to answer the research question, I had intended to use two sources of evidence: interviews with individuals involved in the project and project documentation review. The data collection process was guided by the study line of inquiry (Yin, 2003). Hence, the data collection process was oriented to assess the validity of the study propositions.

In the dissertation proposal, I anticipated that four to eight individuals directly involved in the multi-organizational project studied were going to be interviewed. These individuals should be from at least two different organizations, preferably with different roles in the project -project sponsors, project managers, project engineers- to introduce different perspectives that might enrich the data collected. Moreover, the interviewees should have worked on the project for at least 50% of its duration. However, within the cases I was able to use for the study, I faced limitations for the data collection effort. First, for reasons stated above, individuals coming from the different organizations were very concern about the confidentiality of the data, and I had a hard time to convince them to participate. In one case, two of the organizations involved prohibited their employees from participating in the study. Then, I was only able to interview three individuals from the other organization involved, and one from a project contractor. In the other case, I was able to interview individuals from all partners involved -three from one partner, and one for each of the other two.

To make sure that all the interviews were conducted in a way that addressed the pursued line of inquiry and that the data collected through them is comparable, an interview protocol was prepared. The interviews were conducted as a fluid conversation rather than as a structured survey (Yin, 2003). Questions were designed to elicit the interviewees' recollections and opinions that might support or question the study propositions, and were open-ended to allow the interviewees to extend on points they consider relevant to the issues discussed. During the conversation, questions were asked in a non-leading way to minimize possible bias (Yin, 2003). For example, "how" questions were preferred over "why" questions, in order to avoid provoking defensive responses. Moreover, the "how" questions were formulated in a neutral way, not leading to confirmation or rejection of the study proposition. The interview protocols are shown in the appendix A. Finally, during the interview, questions were asked about other people who might have potentially relevant information for the case, or about documents that might support the points made during the interview. The interviews lasted between one and two hours. They were recorded with the permission of the interviewees, and a guarantee of confidentiality was provided. Transcripts of the interviews were elaborated and compared to the original recordings to ensure their accuracy. In some cases, the interviewees were contacted later again during the data analysis phase for clarification of certain points or when contradictory data was found.

In case studies, it is always recommended to use different sources of evidence for triangulation (Yin, 2003). In this study, besides conducting the interviews, documentation related to the project studied was required to conduct the triangulation strategy. This documentation entailed project reports, meetings minutes, communications, memoranda, etc. However, that documentation was not accessible for confidentiality reasons. Hence, performing a triangulation strategy with interviews and the analysis of written documentation was not possible. In order to get more data and different sources of evidence to elaborate the model, I applied a replication strategy using two cases for study instead of the one I stated I was going to use in the dissertation proposal, (Yin, 2003)

Data Analysis and Modeling Process

Yin (2003) suggests that potential difficulties in the data analysis process which might rise while conducting case studies can be reduced if a general strategy for analyzing the data -such as the assessment of theoretical propositions, definition of rival explanations or elaboration of descriptive frameworks-is used. The application of a certain strategy for data analysis leads to the selection of a particular analytic technique - like pattern matching, explanation building, time-series analysis, logic models, and cross-cases' synthesis. For example, if the assessment of theoretical propositions is the data analysis strategy selected, and these propositions constitute a predicted pattern of case outcomes, pattern matching should be the analytic technique to be selected. If the pattern based on the data collected matches the pattern found in the study propositions, then the potential validity of the case study propositions is enhanced.

It is important to select the strategy for data analysis and the analytic technique before the data collection process. Data collection should be guided by the data analysis strategy, defining what data should be collected and how it should be organized. Otherwise, the data analysis process will be very difficult to accomplish (Yin, 2003).

In this study, preliminary propositions were elaborated based on previous research on goal alignment, collaboration theory, and system dynamics applications to project management. The case propositions reflected a hypothesized basic pattern of behavior of a multi-organizational project system under the influence of the level of project goal alignment among the participant organizations. Hence, the general strategy selected to analyze the data was the assessment of these case propositions.

Because the study propositions defined a pattern of system behavior or reference mode, the pattern matching analytic technique was used. Therefore, the analysis of the case empirical data was oriented to support or challenge the multi-organizational projects' system behavior affected by the level of goal alignment, as defined by the study propositions. Content analysis was performed to classify the data collected according to their link to the study propositions. Then, the cause-effect links that constituted the pattern described by the study propositions were confirmed, modified, extended or eliminated according to the evidence obtained through the data collection and analysis processes. Moreover, new cause–effect links were added to the reference mode. The cause-effect links defined as a result of the case data analysis, along with the basic project feedback structures as described in Chapter 2, constitute the multi-organizational project system dynamics model that depicts the explanations developed while conducting the case study.

Because replication strategy was adopted, a cross-case analysis was performed based on the degree to which the data collected for each case supported or challenged the study propositions. The cross-case analysis allowed identifying patterns across the cases' data (Yin, 2003). When data collected for both cases supported or challenged a certain proposition, it provided more confidence on the derived conclusions.

Model Validation

During the analysis of the case data, the preliminary dynamic structure as described in the study propositions was contrasted with the empirical data collected from the projects studied. In other words, the model's structures that resulted from the case data analysis were to some degree validated for these particular cases. However, once the new model was completed, a questionnaire was sent to the same individuals in order to assess the model. The questionnaire contained verbalized statements and graphics describing the basic model feedback structures (Appendix B). The questionnaire asked subjects to assess the extent to which the model structure reflected their experiences in the project. If the data collected uncovered significant discrepancies between the model structure and the interviewee's experiences, follow-up contacts were performed to clarify the points. Minor discrepancies were also reported and their possible impacts on the model were analyzed.

Direct extreme-condition tests were carried out as described in Chapter 6 to increase the confidence in the model structure. The results of these tests were analyzed and reported.

In the dissertation proposal, I suggested the use of a second case to evaluate the validity of the model developed in other multi-organizational project. However, as I mentioned above, I contacted a group of individuals with experience in multi-organizational projects in diverse sectors who were willing to cooperate with the study, but not willing to discuss a particular case. I used their experiences to assess the possible applicability of the theory developed in other multi-organizational projects. The second case was used as a replication to provide additional data to elaborate the preliminary model, and was used for comparison in order to enhance the confidence on the findings.

The model's assessment by the panel of experts was conducted using the same questionnaire protocol employed for the assessment of the model by the participants in the cases, but including the two models developed (see Appendix B). Before sending the questionnaires, I requested the experts to send me evidence of their experience with multi-organizational projects. I included in the panel only individuals who had participated in more than two multi-organizational projects. The panel was asked to compare their experiences within multi-organizational projects to the verbalized model structures. The data collected were analyzed to show significant matches and discrepancies between the model structure and the experts' experiences. Several discrepancies were reported and their probable causes and impact on the model's structure and behavior were analyzed. These discrepancies might constitute alternative explanations about how the level of goal alignment affects project performance in multi-organizational projects, and would constitute the subject of further research.

Finally, the model's structure was assessed from the perspective of previous related research findings -for example, findings in multi-organizational collaboration, alliances' behavior, and system dynamics applications concerning project dynamics and collaboration. Coincidences and discrepancies were analyzed to assess the degree to which past research findings supported or challenged the proposed model's structure.

Simulation Experiments

To understand how the level of goal alignment affected multi-organizational projects dynamics and performance, simulation experiments with the system dynamics model were conducted to analyze the impact of variations in certain variables. The system dynamics modeling software allowed conducting controlled experiments or sensitivity analysis that permitted certain model variables to vary while keeping others constant. The logic of these experiments was to select sets of variables to be manipulated - for example, setting those variables in high-low modes, in a combinatory way-, and then assessing the impact of these manipulations on the model outputs. After all variables of theoretical interest were manipulated, an assessment was made of the model behavior and the degree to which it resembled plausible project system behaviors based on the cases

The rationale for the experiments' design, including the criteria for selection and combination of the variables to be manipulated, is discussed in Chapter 6 of this dissertation. An analysis of the experiments' outcomes from a perspective concerning to the impact of goal alignment in multi-organizational project dynamics and performance is also incorporated.

Model Documentation

Model documentation entails making available for future researchers the case study protocol as previously described, the model's mathematical formulation, and the evidence of support for every cause-effect link in the model. Hence, the data collected during the case study was organized and displayed to show the link between every model feedback structure and the data. Chapter 5 is dedicated to model's description

3.4.3 Research Methodology Limitations

Limitations of the proposed research methodology are discussed below:

- The case study research strategy has been criticized for the limited generalizability of the study's' findings. However, a significant part of this criticism is based on the application of the "sampling" logic to case studies, while what is applicable to case studies is the "replication" logic (Yin, 2003). The sampling logic applied in survey studies is based on the definition of a population from which, through a statistical procedure, a sample is selected. From the data collected in this sample, statistical inferences about the population characteristics can be made. In case studies, this logic is not applicable. For example, in this particular case, it is impossible to define a "population of multi-organizational projects" to be sampled. Conversely, "replication" logic views every case study like an "experiment," which can be replicated to assess the validity of the findings in similar or contrasting contexts. In a case study, a theory is developed about the observed phenomena. The generalizability of this theory is tested through replications of the study. This is called analytic generalization, in contrast to the statistical generalization associated with surveys studies (Yin, 2003). In this research, an explanation about how the level of goal alignment affected project performance was developed -through a first case study- and expressed in a system dynamics model. If, the theory developed is still useful to explain how the level of goal alignment affected multi-organizational projects performance in a second case, then there is an indication that the theory has a potential for generalizability. Moreover, this potential can be increased with the accomplishment of more case studies on different multi-organizational projects. On each case new lessons can be learned and the system dynamics model can be improved, again increasing its potential generalizability.

- Difficulties were faced while finding cases that met the case selection criteria, and in gaining accessibility to individuals and data within the cases. The accomplishment of the study required having access to eight different organizations. Lack of time for interviews and confidentiality issues hindered the data collection effort. To encourage participation, the research effort was presented as a learning opportunity for the organizations and individuals involved. In addition, copies of the dissertation final report, a presentation of the findings, and a discussion of the implication of the findings for each organization was offered to the participating organizations. Another problem observed during the data analysis was the divergence between the data collected from the individuals with different roles in the project. Project managers had the tendency to report higher levels of team processes and a more positive view of project outcomes than other project team members. This problem has been reported in other studies (McComb et al., 1999; Larson and LaFasto, 1989). This problem might have introduced some bias in the analysis.

- The use of theoretical propositions to guide the data collection and analysis might limit the possibilities of finding alternative explanations to the studied phenomena (Luna, 2004). The use of theory to guide a case study might cause the researcher to see only evidence that confirms that theory (Walsham, 1995). The researcher should be aware of this and question why some data are used and other data are not. The researcher should always look for alternative explanations to the studied phenomena.

3.5 Summary

A combination of case study inquiry with system dynamics modeling was the methodology selected to investigate the study research question. The case study inquiry is best suited to answer "how" research questions, as the one on which this research was focused. System dynamics modeling provides a tool to present the research findings in a way that allows performing experiments to analyze the factors involved and their possible interactions. Hence, the principles of case studies research and system dynamics modeling were described in this chapter. Limitations of the methodology adopted and problems encountered during the data collection and analysis were also discussed, as well as the strategies used to overcome them.

CHAPTER 4: CASES DESCRIPTIONS AND ANALYSIS

4.1 Chapter Overview

In this chapter, a description of the cases based on the data collected is presented. These descriptions encompass a brief discussion of the contexts in which the cases were embedded and the project dynamics induced by the level of goal alignment between partners. Because some of the information presented in the descriptions are considered sensitive by the parties involved, and in order to preserve the required level of confidentiality, no organization or individual are mentioned by its real name, and no observations or opinions advanced by the subjects are literally transcribed.

In addition, this chapter includes an analysis of the cases' data. That analysis was performed as described in the research methodology section. The cases' data were contrasted to the study propositions, in order to check if the data collected supported or challenged them. Data analysis also included the discussion of how the level of goal alignment affected the typical project dynamics as described by Ford (1995) and presented in the literature review chapter. The results of the cases' data analysis provided the base for the development of the system dynamics model that represented the multi-organizational project system dynamics.

4.2 Case 1 Description

The first case studied (case 1) is a project accomplished by major aerospace company (Partner 1) that the Department of Defense contracted with to develop an aviation control system, including hardware and software elements. Partner 1 hired an advanced research organization (Partner 2) to incorporate state-of-the-art technology into the system. In addition, because of a customer requirement, Partner 1 also hired a military organization that is also an end user of the system developed (Partner 3).

Therefore, under the contract, Partner 3 is also an end user of the product to be developed. Moreover, Partner 3 was starting to perform some of the Partner 2's specialty jobs and Partner 2 has started to perceive Partner 3 as a potential competitor. These particular roles, structures, and relationships between partners impacted the level of goal alignment, with consequences to the execution of the project (see Fig.4-1)

There was no misalignment among partners concerning the overall cost and schedule goals. Partner 1, as the leader of the project, set the cost and schedule goals according to the contract signed. All parties understood that the project should be completed within a specified period of time and agreed with that deadline. However, a lack of common understanding -like the number and nature of the task and subtasks required for the completion of the scope- generated disagreements on project costs and required funding. Sometimes, partners did not understand the scope and therefore underestimated the resources required, thereby not having the resources required to perform certain tasks at the time required. Not enough time and effort was put into requirements definition, and then only overall, not specific, goals were defined.

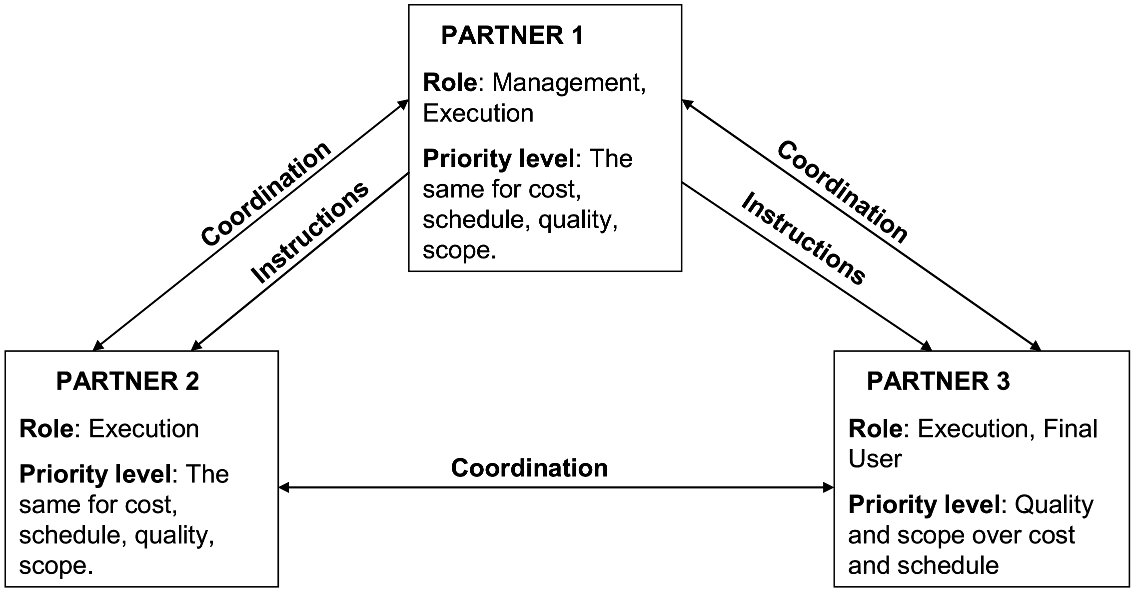

Figure 4-1: Partners' Roles, Relationships and Priorities' Levels in Case 1

Moreover, in some cases, partners did not agree as to the time required to complete a task. In some cases, decision had to be made whether the project should be delayed or extra effort deployed to accommodate certain tasks. Partners also sometimes disagreed on who was responsible for doing certain tasks or subtasks. In many cases responsibility was not clearly specified in the contract or in each participant's scope of work.

Because project scope was driven by hardware requirements, the scope needed to change along with changes in hardware requirements. But once the minimum scope was established, there was no more variation allowed in scope because the customer required that certain scope to be delivered in accordance with the contract. When required, more time was put into the project to deliver the scope. In the trade-off between scope and schedule, schedule was sacrificed for scope. Nonetheless, sometimes Partner 3, as an end user, wanted to go beyond the specified scope to satisfy to the largest extent possible its requirements for the project. This scope pressure was a consequence of defining requirements at a high level, leading to a certain degree of ambiguity and lack of a clear or shared interpretation of the project requirements.

On the other hand, there was a perception among Partner 3's project team members that some features were taken out of the final product in order to avoid addressing some quality issues and to prevent further delays. These features would be added in future versions of the product. Also, it was hard to understand for some project team members that the introduction of some certain features in the final product would require an amount of time and resources that was beyond the project's budget. This situation led to unfulfilled expectations and some degree of frustration among some Partner 3's project team members, who would have liked to see all the features included in the product as soon as possible. On the other hand, Partner 2 was pressing to include scope not directly related to end user needs, but favored the development of certain technologies that Partner 2 had an interest in . This also contributed to Partner 3 level of frustration.

There was a significant misalignment concerning the project quality goals. Partner 3's project team members wanted to maximize quality for the end user, with less regard for the cost or schedule goals. On the other hand, Partner 1 was interested in delivering a product with the quality specified by the customer, but also considering cost and schedule. Partner 1 wanted to maximize profits and to continue doing business with the project owner. Partner 2 was interested in delivering a quality product according to the customer's defined requirements.

Hence, there was neither a common understanding of quality, nor any common criteria for the quality-cost-schedule trade-off. Because Partner 3 was going to be a final user of the product, for that organization quality was more important than project cost or schedule. For Partners 1 and 2, cost and schedule goals had the same level of priority as quality. Moreover, there was not a set of common quality standards defined. For example, there were not common standards about how many comments should be included in software line, how to include them, or about the revision procedures to follow. Quality actions had different meanings for the participant organizations. Therefore, clear definitions of these quality actions and documented standards were required. But the rush to start the project activities prevented the project team from preparing those quality definitions and standards. Partner 2, therefore, pursued only the quality objectives as specified in the contract; and because there was a lack of clear requirements at a workable level of detail, those quality objectives were subject to some degree of interpretation. Conversely, Partner 3 wanted to exert all the effort required to pursue maximum quality according to the end user needs, despite of what was specified in the contract.

The lack of goal alignment between Partners 2 and 3 regarding the quality goals generated low morale among their project team members. The perception of unfulfilled expectations regarding quality and scope by Partner 3 increased the level of animosity between Partners 2 and 3's project team members, thereby reducing the level of trust and communication. Comments from a partner about quality issues in the work performed for another partner, caused the affected partner to comment on work performed by the other, creating a dynamic of mutual criticism that generated bitterness and reduced mutual trust. Also, a perceived low capacity to perform certain tasks affected the level of trust between partners.

An additional problem related to trust and communication that was present during project execution was lack of respect. Partner 3's project team members perceived Partner 2 as not completely trustworthy. Partner 2 was perceived as not having the same commitment to quality, and not providing the required quality checks. On the other hand, Partner 2 sometimes perceived Partner 3 to be somewhat less technically skilled in certain areas. These perceptions sometimes influenced the way partners were treated –for example, tone of voice and emails. Hence, perceived lack of respect led to low levels of trust. Lack of trust reduced the level of communication.

The level of trust affected both the frequency and content of communication between Partners 2 and 3. When trust was low there was not much communication, and when communications occurred, it did not have much useful content. Team members started to think about the possible reactions of partners to the communications and hesitated about what to say. In addition, Partner 2 seemed to restrain the flow of information, because Partner 2 saw Partner 3 as a possible future competitor. Partner 2 thought that if Partner 3 gained certain know-how, Partner 2's services might not be needed in the future. Partner 2 hesitated in several occasions to supply required information to Partner 3. This led to a perceived lack of transparency in communications between Partners 2 and 3, although Partner 3 had been warned by Partner 1 about the limitations in the information to be provided by Partner 2. The perceived lack of transparency in communications affected the level of trust. Despite those limitations, Partner 1 tried to keep the level of trust and communications high by involving every party in all communications, in order to reduce the perceived secrecy or lack of transparency. Hence, the level of communications between Partner 1 and Partner 2 and between Partner 1 and Partner 3 was good along the project execution.

Other factors were mentioned as affecting the level of trust and communications. In a positive way, the fact that Partners 2 and 3's project team members knew each other well from past projects contributed to increase somewhat the level of trust and communication. In contrast, sometimes preconceived notions about a partner hindered communications. Lack of co-location was also mentioned as a factor affecting communications between the project team members belonging to the different participating organizations. In some cases, people misunderstood messages -due to different speech or email taken in a way that the sender did not intend. Non-verbal signals were also important. Lack of personal contact influenced the level of trust. The fact that the parties were not co-located to some extent prevented the project team members from different organizations to develop a working relationship. Lack of co-location also affected the frequency of communications. Project team members did not communicate on daily basis. Communications took place in average every three days. This caused some project team members to not have been properly informed about what other team members were doing.

There were some cultural issues. Partner 2 is a R&D organization, and Partner 1 was a production oriented organization. Partner 2 was therefore driven by technical accuracy, and the Partner 1 was driven by reducing time to completion. Partner 1 was also driven by accuracy, but time to completion was their main priority.

Communication issues introduced schedule slippage, because documentation that partners had to deliver to other partners did not arrive on time. This caused the recipient partners to delay the execution of the associated tasks. Sometimes the delays in receiving input from other partners led to working with preliminary information, which was changed later, thereby introducing rework, and producing schedule slippage, schedule pressure and more quality problems. Communication problems also affected the accuracy of the content of the information exchanged and product quality. Finally, the low level of communication impacted the understanding of inter-organizational working processes, affecting the deployment of resources on a timely basis. Partners often did not exactly know when sub-products were required by other partners.

. The participating organizations conducted mutual project reviews. The level of animosity generated by the lack of perceived quality and scope goal alignment sometimes led to conflicts in the reviews and, in many cases, the pointing out of non-significant issues. When a partner called attention to some defects, the affected partner would answer focusing on non-significant problems in the other partner's work. Pride and jealousy were significant factors in these dynamics. In some cases these conflicts went out of proportion, causing delays. Review conflicts also took effort and time from productive work, negatively impacting the progress in project tasks. The project is still work in progress. The product has been hold back for about a year.

Summarizing, the factors discussed during the interviews that affected goal alignment and project performance were: (1) the lack of clearly defined and documented project requirements, (2) and the lack of effective conflict resolution mechanisms. The pressure to start the project prevented management from defining project objectives at a detailed level, reducing the ambiguity and misinterpretation of the requirements. Lack of clear requirements affected the level of alignment, because it was not apparent what objectives toward which the participant organizations should be aligned. This, in turn, allowed Partner 3 to push for more scope and higher quality. Lack of clear goals also affected the definition of resources required to accomplish the goals. An example of that was the development of inspection procedures, which were being performed without clearly defined requirements. An agreement on inspection procedures could not be reached, so Partner 1 had to define what areas had to be inspected, and to what extent. Additionally, there was not a master schedule that showed to all the participating organizations a complete view of the project and how their efforts were interrelated.

On the other hand, Partner 1 defined a mechanism that allowed a partner to bring their own ideas, and if these ideas are accepted by all the participant organizations and the customer, then their implementation was approved. The rejection of ideas seemed to have had little effect on day to day operations. However, issues emerged because there were problems with the interpretation of the requirements as defined in the contract.

4.3 Case 2 Description

The second case analyzed involved the design and construction of an offshore oil production facility project. In this project two medium-sized oil production companies were associated with a large gas transportation and distribution organization. The production organizations were responsible for the oil production, and the gas transportation organization was responsible for sending the oil production onshore. An engineering, procurement, and construction (EPC) contractor -which was not a member of the association- was hired to design, purchase the materials and build the facility, under the supervision of a project team constituted by members assigned by the partners (see Fig. 4-2). However, all communication between the project team and the EPC contractor were conducted through one of the production partners.

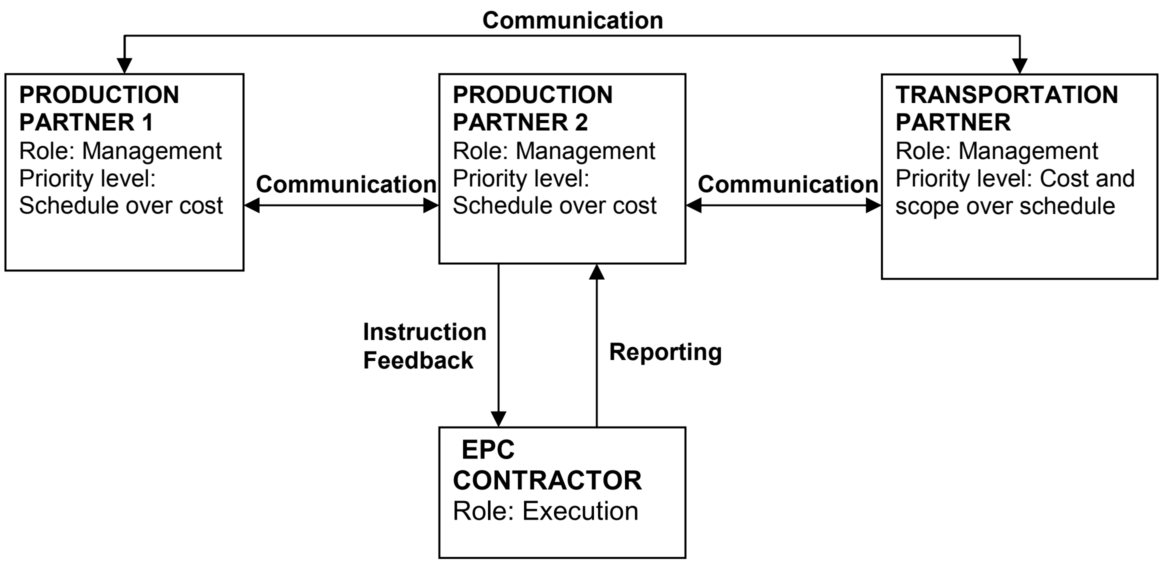

Figure4-2: Partners' Roles, Relationships and Priorities' levels in Case 2

The project entailed the development of a series of oil fields and oil transportation facilities. In the contract agreement, the transportation organization revenues were constituted by a fixed fee for the first field and by a percentage of the oil-produced revenues in future fields. The production organizations obtained their revenue from the sale of oil produced.

In an environment of rising oil prices, these contractual agreements induced misalignment among partners regarding the project cost and schedule goals. The production organizations were interested in completing the project as soon as possible to take advantage of the high prices, and they were willing to pay an extra price to get the facility producing as soon as possible. On the other hand, the transportation organization did not have an oil prices incentive. Hence the transportation organization was not as willing as the production organizations were to assume more costs in order to get the facility producing earlier. Indeed, the transportation organization was more willing to accelerate the development of the future fields than the first field, because it did not have any price incentive in the first field

The contract agreement dictated penalties for not meeting the project deadline, so initially the participant organizations were aligned toward schedule goals. However, conflicts appeared when the producing partners tried to accelerate the project to capture high oil prices at the expense of assuming higher costs.

One example of the participant organizations' misalignment regarding the cost and schedule goals was the decision to purchase and additional mooring line. The mooring line connects the floating production system to the seafloor. Mooring line installations can be difficult and the oil producing organizations recommended purchasing additional lines in the event that problems were encountered. This was essentially an insurance strategy against a negative impact on the production schedule if a mooring problem occurred. A statistical analysis was performed based on several scenarios involving possible mooring problems. The analysis concluded that the additional mooring line should be purchased. However, from the transportation organization's point of view, it made more sense to defer the additional mooring line purchase and accept the risk of a potential production delay.

The transportation organization's focus on minimizing costs affected its behavior in the project, and the perception that project team members had about its intentions in the project. Sometimes the transportation company's employees felt that caring mainly for costs-doing only the minimum required by contract or to avoid penalties-interfered with otherwise sound project decisions. Moreover, the production organizations' project team members perceived that the transportation organization would not cooperate with problem solving strategies if higher costs were involved.

Regarding the project quality goals, there was an agreement about the use of industry standards for design and construction. Hence, there was alignment among the participant organizations concerning quality goals.

In general, there was alignment concerning the project scope among the participant organizations. Nonetheless, disagreement was observed concerning the technical features that could support a swift start of oil production-as favored by the production organizations-and the pursuing of other features that would support the long-term operability of the facilities-as favored by the transportation organization which would own the installations. These disagreements led to some change requests during the design and construction phases that had to be discussed by the project team, causing delays to the project schedule.

An additional issue involved the way in which the contract agreement was negotiated. The production organizations had a decision to make as to whether they would take full responsibility for the project or bring in a transportation partner. The transportation organization was not the production organizations' first choice for the project, but the first choice failed and then the transportation organization was asked to participate and entered into the project without much preparation. The final negotiation period only lasted two weeks, and not enough time was spent in developing a mutual understanding the project, and the schedule and tasks. The project management team was not involved in the negotiation of the contract terms, and only participated in solving particular issues.

Goal conflict problems were detected early in the way the contract was framed. The transportation company had no incentives in the short run, only penalties. Despite these contractual conditions, the transportation organization's senior management decided that a project of this magnitude was needed at that moment. The fee structure did not provide any incentive for the transportation organization to speed up the project. The rush to get into the project and start producing oil caused the participating organizations to dedicate less time than what was required to plan; they then underestimated the risk and the consequences of failure.

Another aspect of the contract agreement was that the transportation organization would pay for the project costs upfront, and the production organizations would then use oil production revenues to pay the transportation organization. Furthermore, even though the transportation organization was paying for the facilities construction, one of the production organizations was the one who was in direct contact with the EPC contractor. This led to a perception of the transportation organization's project team members that, although the transportation organization was investing significant resources in the project, it was considered by the production organizations as a vendor or financing entity rather than as a partner.

The low level of alignment concerning cost and schedule goals affected working relationships between the participant organizations. The goal conflicts that emerged made the production organizations wonder about the transportation organization intentions for the project and vice versa, thereby affecting the level of trust. Trust deteriorated to a very low level during the project execution. Trust affected the level of communication. Communication between the production organizations and the transportation organization became very guarded and cautious, reducing transparency. The perceived low transparency in communication influenced negatively the level of trust, creating a reinforcing cycle of diminishing trust and limited communications.

Other external factors affected the level of trust among partners. There were some concerns about the financial capabilities of one of the participant organizations. There were also questions about that organization's ability to continue with the project. Also, the project in question was the first time the participating organizations had worked together. Hence, the only time they had for developing a working relationship was during the contract negotiation process, which lasted a relatively short period of time, and had very limited project team member participation.

The trust and communication issues often led to little or no timely communication, affecting the process of finding workable solutions for critical issues that needed to be solved. As a consequence, the project team analysis, problem solving and decision making capabilities were limited and the frequency of required changes increased. There was no aggressive decision making done by either party. The lack of goal alignment helped to create an atmosphere of the "other group is responsible" because no participant organization had both project management and funding responsibility. Therefore, neither group took full accountability or responsibility.

The project team faced several problems during the project execution-including supply chain disruptions, and vendors failing to deliver equipments or materials. Moreover, there were some very significant delays due to offshore construction issues, welding problems at foreign yards, and other construction-related issues. Adjustments had to be done to bring the project back on track. In making adjustments a significant level of communication and coordination was required, and because that level was not there, the impact on the project was amplified.

When a problem was identified, including changes requests, it created a lot of finger pointing and haggling over contract terms, because of the lack of cost and schedule goal alignment. There were not common criteria for making the trade offs required to solve the problems. Problem solving, therefore, required the involvement of higher levels of management and distracted the project team from actively managing the work and instead focused their attention on recreating events that led to issues. This prevented the deployment of resources allocation strategies that might have avoided schedule problems. A cycle was created in which less time was spent monitoring the work and actively managing the schedule, leading to the accumulation of more issues to be resolved and to significant delays in decision making, and in communication with contractors.

Therefore, the alignment and trust issues did not directly cause the project delays or quality problems, but, rather, these problems combined with those issues and resulted in very difficult and lengthy decisions that required the involvement of many levels of management. The result was less effective decision making and problem solving that consumed a significant amount of time that could have been used to prevent the problems instead of dealing with them after they occurred.

Moreover, the organizations did not assign to the project team the people with the experience required for this kind of project. The participant organizations did not have experience in this kind of project, so they did not know the amount and quality of human resources required. That fact, combined with the high amount time and resources invested in decision making and problem solving diverted resources away from the supervision of contractors. The quality of certain works, therefore, was not sufficiently supervised by the project management team and some rework was required to meet project requirements.

The lack of goal alignment concerning the cost and schedule goals induced a strict interpretation of the contract terms, reducing the room for compromise in decision making. In addition, senior management was required to participate when the problem was significant and its solution involved compromising some of the organizations' goals for the project. However, senior management, in particular the transportation organization senior management, was not very involved in the project. Senior management, therefore, was not completely aware of the magnitude of the risk and the complexity of the project -it was a new business and geographical area. These facts, added to the issue that there were not designated project sponsors, led to additional delays in decision making. Preventive actions required from sponsors-such as communications with other executives to discuss resources allocations, changing priorities, and getting more support from the organization-were not taken on timely basis. Senior management intervened numerous times to solve the issues created by misalignment, but with limited effectiveness.

Other factors that affected project performance mentioned during the interviews were:

- The placement of the project team members in different geographical locations, which, despite the telecommunication facilities, affected the level of communications. Sometimes the project team members waited until the periodic face-to-face meetings to discuss some issues, introducing delays in the communication and coordination processes.
- The incorporation of personnel without the required level of experience. In an attempt to catch up with the schedule, several individuals were added to the project team in order to increase work progress. However, those individuals had to be trained and supervised, consuming additional effort from the project team members. The productivity level dropped after the incorporation of the new personnel.
- The schedule imposed to the EPC contractor was not realistic. The push to meet the schedule requirements led to several quality problems, especially with subcontractors, that required rework and induced more delays.

The project finished a year late, which translated into liquidation damages being paid by the participating organizations. On the other hand, the facilities are operating as expected.

4.4 Cases Data Analysis

As discussed in the research methodology chapter, cases' data analysis was guided by the assessment of the study propositions. Hence, cases' data were analyzed contrasting it with the study propositions, and looking for patterns across the cases' data. The results of that analysis are presented in the following table:

Proposition	Case 1	Case 2
1) Each participant organization in a multi-organizational project will bring their own goals to the project	Partners project goals: Partner 1: maximize profits, deliver the required quality on schedule, obtain future business Partner 2: maximize profits, obtain future business, deliver the required quality on schedule, minimize the sharing of proprietary technology, develop new technologies Partner 3: maximize quality for the end user	Partners project goals: Production organizations: in an environment of rising oil prices, contractual agreements induced a misalignment among partners regarding project cost and schedule goals. The production organizations were interested in completing the project as soon as possible to take advantage of the high prices, and they were willing to pay an extra price to get the facility producing as soon as possible. Transportation organization: the transportation organization did not have that oil prices' incentive. Hence, the transportation organization was not as willing as the production organizations to assume more cost in order to get the facility producing earlier.
2) Since organizations need to adjust to changes in their strategic environment, participants' goals for the project might change along the project life time	Partner 2 tried to develop new technologies during the project using project funds. Partner 3 wanted to improve the quality standards during the project according to their knowledge of the user needs.	Production organizations: rising oil prices made the production organizations to give schedule goals a higher priority, Transportation organization: it did not have any incentive to assign a higher priority to schedule goal over cost goal.

Table 4-1: Cross-Cases' Analysis Table

Proposition	Case 1	Case 2
3) These changes in project goals might create a situation in which the goals for the project regarding time, quality, scope, and cost are not the same for all the participants, regardless of what they had previously negotiated at the beginning of the project. In other words, the level of goal alignment among the participants might vary along the project life cycle	There is no common understanding of quality. For Partner 3, quality is more important than cost or schedule, because Partner 3 is also the final user, potentially affected by quality issues. These issues changed as Partner 3 compared the final product with the final user requirements. For Partners 1 and 2, schedule and cost were as important as quality. Only overall goals were defined, which led to some scope misinterpretation. Partner 2 tried to work on things not related to the end user needs, but rather with their own research interests (scope misalignment)	Conflicts appeared when the production organizations tried to accelerate the project to capture the high oil prices, at expense of assuming higher costs. In general, there was alignment concerning the project scope among the participant organizations. Nonetheless, certain disagreement was observed concerning the pursuing of technical features that could support the oil production start swiftly (as favored by the production organizations), and the pursuing of other features that would support the long-term operability of the facilities (as favored by the transportation organization, which will own the installations).
4) The effort and resources invested in the project by the participants will depend on their expectations of Partners' behavior (trust) and project outcomes (these expected project outcomes are the participant's own goals for the project).	Partner 3's did not perceive its quality and scope expectations as fulfilled. However, effort and resources were not restrained if expectations were not perceived as fulfilled. All partners wanted to go on doing business with the other partners.	Transportation organization cost expectations was not perceived as fulfilled. However, effort and resources were not restrained if expectations were not fulfilled.
5) If the expectations are fulfilled, participants will go on investing effort and resources in the project and generating positive expectations about their behavior and project outcomes in their Partners, in a feedback loop reinforcing trust and the likelihood of obtaining the desired project outcomes	Trust is generated through open communication. Partner 3 was informed that Partner 2 would only provide the information strictly required by Partner 3 to perform project tasks, because Partner 2 would not reveal their proprietary technology.	The goal conflicts that emerged made the production organizations wonder about the transportation organization intentions for the project and vice versa, thereby affecting the level of trust. Trust deteriorated to a very low level during the project execution.

Table 4-1: Cross-Cases' Analysis Table (Continued)

Proposition	Case 1	Case 2
6) If, on the other hand, the expectations regarding Partners' behaviors and project outcomes are not fulfilled, participants might reduce their effort and resources invested in the project, not fulfilling their Partners' expectations about their behavior and project outcomes, in a reinforcing loop destroying trust and the likelihood of obtaining the desired project outcomes	Because Partner 3 did not perceive Partner 2 as having the same level of commitment to quality, the level of respect and then trust was low .Quality misalignment has led to discussions and mutual criticism, sometimes not focusing on the important issues, then increasing animosity, and reducing the perceived level of transparency in communication and level of trust. The fact that Partners did not work with the same quality standards affected the level of trust concerning the reliability of the work generated by the partner. Partner 2 was more willing to reduce scope to fix schedule slippage. This affected the level of trust, because Partner 3 felt that Partner 2 was not standing by what they promised. At times in the project, some partners' expectations were not fulfilled. Partners did not understand the level of resources required to implement certain product features. Not fulfilled expectations affected the level of communication.	The low level of alignment concerning cost and schedule goals affected working relationships between the participant organizations. The goal conflict made the production organizations to question the transportation organization intentions for the project and vice versa, thereby affecting the level of trust. Trust deteriorated to a very low level during the project execution and affected the level of communication. Communication between the production organizations and the transportation organization became very guarded and cautious, reducing transparency. The perceived low transparency in communication influenced negatively the level of trust, creating a reinforcing cycle of diminishing trust and limited communication.
7) The initial level of trust is based on the previous knowledge about Partner's behavior and on the perception of the risk involved in the failure of the Partner in behaving according to the expected.	Sometimes, pre-conceived notions about partners coming from previous projects, affected the level of communication. Sometimes knowledge of a person facilitated the communication, and other times that knowledge hindered it. Partners' organizations knew each other very well, influencing positively the level of trust.	External factors affected the level of trust among partners. There were some concerns about the financial capabilities of one of the participants. The project in question was the first opportunity for the participating organizations to work together. The only time the project team had for developing a working relationship was during the contract negotiation process, but the participation of project team members was very limited.

Table 4-1: Cross-Cases' Analysis Table (Continued)

Proposition	Case 1	Case 2
8) Variations of the level of goal alignment will affect project dynamics and performance through the variation of the level of effort and resources invested in the project by the participant organizations	The lack of alignment regarding quality goals led to disagreement in the level of inspection, and then to mistakes that required rework. Low trust reduced the level of communication, increasing the delays in reviews, leading to schedule slippage. The low level of communication impacted the understating of schedule requirements. What other partners meant by "quick" was not clear, creating ambiguity about when sub-products were required. When the meaning of quick was finally understood, it created schedule pressure, overtime and rework. Sometimes the lack of communication and lack of understanding of processes interdependence between partners affected the timeliness of resources deployment. The low level of communication affected partners when working in parallel on the same sub-products, and problems of incongruence were discovered later, or when partners were working on tasks different from what was expected.	The trust and communication issues often led to little or no timely communication, affecting the process of finding workable solutions for critical issues that needed to be resolved. As a consequence, the project team analysis, problem solving and decision making capabilities were limited. When a problem was identified it created a lot of finger pointing and haggling over contract terms, because, due to the lack of cost and schedule goal alignment, there were not common criteria for making the trade offs required to solve the problems. This required the involvement of higher levels of management and distracted the project team from actively managing the work. Hence, a cycle was created where less time was spent monitoring the work and actively managing the schedule, leading to the accumulation of more issues to be resolved and significant delays in decision making and in the communication with contractors.

Table 4-1: Cross-Cases' Analysis Table (Continued)

Concerning propositions 1 and 2, the data suggest that in both cases partners brought different goals to the project, despite the fact that project goals were defined in the project or alliance contract. In case 1, partners seemed to have different interpretations of project goals. For example, Partner 3 interpreted that quality and scope goals can be stretched to fulfill changing user requirements. On the other hand, Partners 1 and 2 interpreted the quality and scope goals in a strict way, according to what is written in the contract, and then balanced those goals with the cost objectives in order to preserve project profitability.

In case 2, partners negotiated a contract in a certain business environment in which goal alignment was possible, but once the environment changed the premises on which that goal alignment was sustained fell apart. High variations in crude oil prices led oil production partners to press for a shorter completion time, while the transportation partner did not want to incur in higher costs to stretch the project schedule. This situation matches with proposition 2, which states that partners' goals might change as they own strategic environments change. As a conclusion, cases data support propositions 1 and 2.

Proposition 3 states that changes in partners' goals for the project might create a situation in which the level of goal alignment among partners vary, because goals might vary in a different direction or intensity for each partner. If conflicting goals cannot be renegotiated in a way that satisfies partners' goals for the project, the level of goal alignment would be reduced. Situations described in cases 1 and 2 relates to this statement. In case 1, the changes in Partner 1's quality and scope goals dictated by its position as final user of the product could not be aligned with Partners 1 and 2 cost and schedule goals. On the other hand, Partner 2's management introduced a goal concerning the use of project time to improve Partner 2's proprietary technologies. That goal was not shared by Partners 1 and 3, who wanted to focus resources on achieving project's scope, quality and schedule goals.

In case 2, the change in oil prices led to a change in the production organizations' goals for the project. The negotiated schedule goal defined a date for operations start up, but production partners wanted to put that date forward, in order to take advantage of the higher oil prices, even though they will have to invest more resources to do so. Conversely, the transportation organization would not benefit from an early start of oil production, and due to its financial situation it was not in a good position for allocating more resources to the project. Hence, the rise in oil prices induced a reduction in the level of goal alignment among project partners, since the level of priority assigned to schedule and cost goals varied in a different way for the parties involved in the project. This analysis of the data collected in cases 1 and 2 suggests that proposition 3 is also supported.

Proposition 4 states that the level of effort deployed by an organization participating in a multi-organizational project would depend on its expectations concerning other partners' behaviors-level of trust-and about project outcomes, as compared to the organization own goals for the project. Neither case 1 nor case 2 data collected support for this proposition. Partners involved in the studied multi-organizational projects did not vary the amount of resources allocated to the project according to their expectations of partners' behaviors or project outcomes. In the studied cases, partners were obliged by contractual terms to allocate certain amount of resources to the project effort. Moreover, they perceived that if they fail to fulfill their contractual obligations, future business with their partners would be compromised. A possible explanation to the discrepancy between what was stated in the proposition and what was observed in the cases data lies on the fact that the relationships between partners were regulated by contracts which partners should abide to. In the collaborative relationships described in the literature review chapter the deployment of resources was more "voluntary", because the governance structure of the alliances o joint ventures studied was more market than hierarchy oriented (Williamson, 1991). Hence, in those cases partners would contribute to the collaborative effort only if they perceive that the outcomes would be aligned to their own objectives.

Another reason that could explain why partners in the cases studied did not vary their effort deployed according to the expected project outcomes was the fact that all partners operate in the same markets-defense for case 1 and energy for case 2-and they did not want to compromise their reputation, which would probably affected future business.

Propositions 5 and 6 suggest the development of a feedback loop in which, while partners' expectations are fulfilled concerning partners' behaviors and project outcomes, they would be willing to allocate more resources to the project, then satisfying other partners' expectations concerning their behaviors, and increasing the probability of obtaining better project outcomes. This would lead to a reinforcement of the positive expectations about partners' behavior - higher level of trust- and about project outcomes.

This feedback loop could also operate in the opposite direction. The perception that other partners are not contributing to the collaborative effort as expected, or that the project outcomes diverge from partners' goals for the project, might lead partners to allocate fewer resources in the project, sending them to projects perceived as more profitable. That could lead to a reinforcement of negative expectations about partners' behaviors, as well as about project outcomes.

As discussed above, no evidence was found in the cases' data supporting the reduction of effort deployed as a result of low level of trust on partners or of not fulfilled expectations concerning project outcomes. On the other hand, evidence was found in both cases that perceptions that partners were not supporting the same project goals -

quality and scope goals in case 1 and cost and schedule goals in case- led to conflicts, mutual animosity and to poor communication. Lower levels of communication prevented partners to know and understand other partners' motivations and constraints for the project, which reduced the level of trust and partners' willingness to share information, lowering even more the level of communication, in a reinforcing cycle of deteriorating trust and communication.

Proposition 7 says that the initial level of trust between partners is determined to a large extent by previous knowledge and perceptions about partners' behaviors and the risk involved in partners' potential failure to behave as expected. Cases' data support the fact that past experiences (case 1) and second- hand information -like in case 2, where information was circulating among energy market players about the dire financial situation of one of the partners-contributed to the formation of the initial trust on partners' willingness and capabilities to work for the achievement of project goals. Moreover, case 2 participants attributed the low level of initial trust and communication to the fact that the studied project was the first time they were going to work together, they did not have enough participation in the project negotiations phase to form an idea of partners' intentions and capabilities. However, case 1's data point out that having experience working together might contribute to the formation of preconceptions that hinder instead of helping communication. Partners might expect negative reactions to certain communication and then decide not to share the information or to make it more "palatable" for the other partner.

Finally, proposition 8 states that variations of the level of goal alignment will affect project dynamics and performance through the variation of the level of effort and resources invested in the project by the participant organizations. Again, no evidence was found in the cases data that support the statement. However, both cases' data support the fact that the level of goal alignment affects project dynamics and performance through variations in the level of trust and communication between partners. Despite the fact that in the cases studied trust and communication mechanisms operated in a different way -that is because the projects were also structured in different ways, in case 1 the project tasks were executed by the project team, while in case 2 the project team only managed the project, which was executed by an EPC contractor- these mechanisms affected project dynamics and performance in both cases. Because advancing in understanding how the level of goal alignment affects project dynamics and performance in multi-organizational projects is the main objective of this research effort, a detailed analysis of how the level of goal alignment affects projects' system dynamics and project performance as observed in cases 1 and 2's data is presented below.

4.4.1 Analysis of the Effect of Goal Alignment on Case 1 Project Dynamics and Performance

In Fig.4-3 an influence diagram is presented to illustrate in a holistic way the dynamics observed in the case 1's data collected. For simplicity and clarity, only the causal relationships observed explaining how the level of goal alignment affects project performance are shown. In this diagram, the level of goal alignment between partners is translated into the degree of agreement on design and problems solving criteria. In this particular case, the diverse degrees of priority given to quality and scope goals induced different reactions in partners to the levels of quality and scope reduction in the project, including the perceptions of the degree to which their quality and scope goals were considered when the project team performed required goals trade-offs. If partners perceived that their goals had not been accomplished -as is the case of Partner 3 in case 1- mutual animosity and conflicts start to stifle the relationships between partners, reducing the level of communication and trust. Low level of communication affected the knowledge that partners had about other partners' objectives for the project, their requirements and constraints, and then affected the level of trust. In addition, the level of trust affected the degree to which partners were willing to share their objectives, requirements and constraints with other partners, creating a reinforcing cycle between communication and trust.

Low levels of communication and increasing conflicts among partners affected the exchange of information. Delays in information exchange induced partners to work with preliminary or wrongful information, leading to quality problems and rework. Moreover, a low level of communication affected the understanding of partners' requirements -not knowing exactly when sub- products are required to be processed by partners- leading to a deficient activities and resources' planning -resources were not allocated to activities with higher priority, then reducing the level of effort applied to these activities. The level of effort applied to high priority activities was also affected by the level of effort allocated to review partners' work. The level of trust in partners determined in part the amount of effort deployed to review the work performed by these partners.

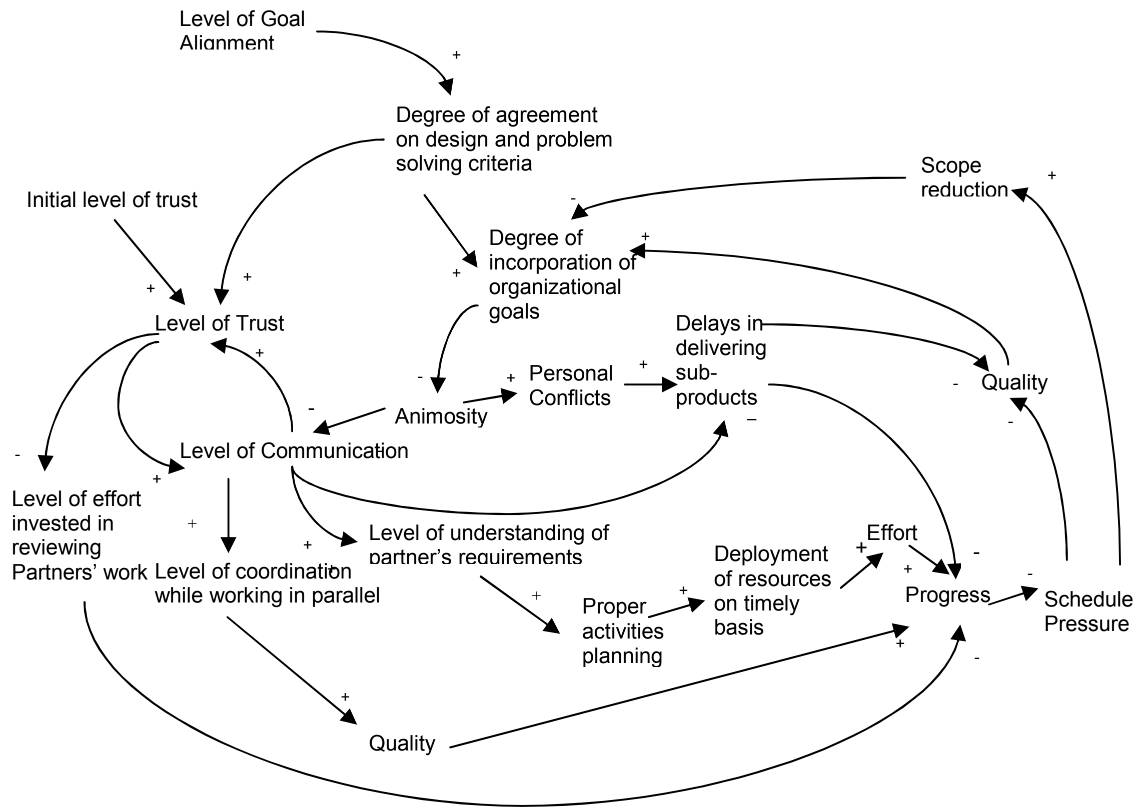

Figure 4-3: General View of Case 1 Dynamics Generated by the Level of Goal Alignment

Both the level of quality and effort deployed affected progress. When progress was below what was expected, schedule pressure developed, leading to more quality problems -work is rushed and less time is assigned to quality assurance activities- or to scope reduction to cope with schedule slippage. Reductions in quality or scope expected induced more conflicts between partners –due to the low alignment concerning the affected goals- leading to lower levels of communication, in a reinforcing feedback cycle leading to lower levels of trust, quality and scope. These dynamics are described with more detail below.

The Fig. 4-4 shows how the level of goal alignment between partners affected the quality structure in case 1. The solid lines depict the relationships between the system variables as present in the quality feedback structure. The dotted lines show the effect of the level of goal alignment on the dynamics described by that structure. The level of quality goal alignment determined the level of agreement on quality standards between partners, which defined the level of mutual trust between them -Partners 2 and 3 in case 1 disagreed in the quality standards, leading to a low level of trust on other partners' intentions for the project. The level of trust determined in part the level of communication. A lower level of communication led to quality problems while working in a concurrent way, since changes might not be timely communicated, and partners worked with wrong, non-updated information. Moreover, low levels of communication led to delays in information release, and partners worked with preliminary information that in some cases changed later, generating incongruence in product design.

Quality problems led to less work completed and thereby to perceived schedule slippage and schedule pressure. Schedule pressure led to reduced quality standards, producing a negative reaction in Partner 3, which perceived that its quality goals were not being considered by the other partners, deteriorating even more the relationship and the level of communication, in a reinforcing cycle of reducing communication, trust, quality, and scope.

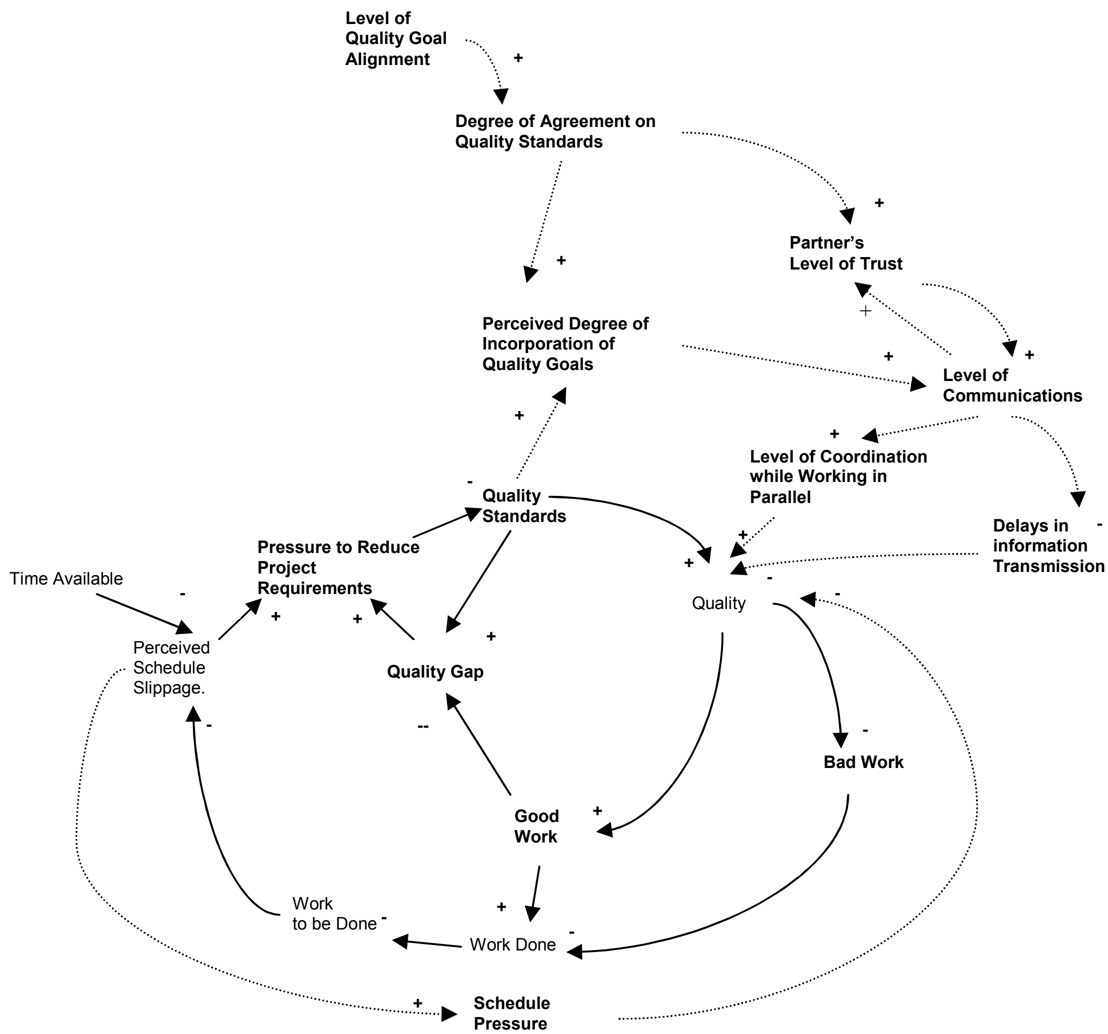

Figure4-4: Effect of the Level of Goal Alignment on the Case 1 Quality Structure

The cycle described had a significant impact on project performance in case 1, particularly on schedule performance.

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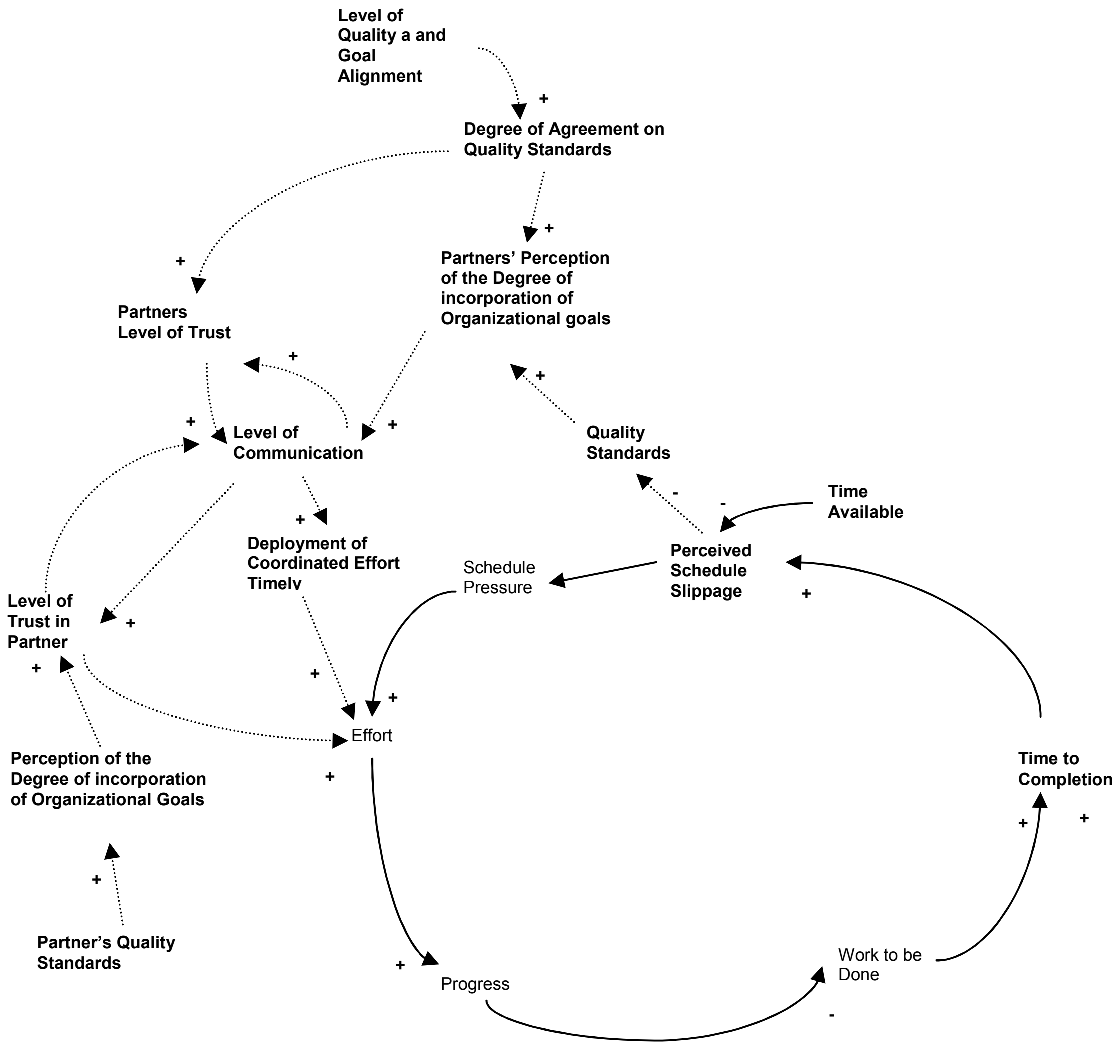


Figure 4-5: Effect of the Level of Goal Alignment on the Case 1 Effort Structure

The effect of the level of goal alignment on the case 1 effort feedback structure is shown in Fig 4-5. The project dynamics observed in case 1 that affected the effort structure are represented by the dotted lines. Again, the level of goal alignment affected the degree of agreement on quality standards among Partners 2 and 3, affecting the level of trust and communication. The level of communication between Partners 2 and 3 affected the timely deployment of effort that required coordination-effort allocated to tasks which outputs affected the execution of tasks executed by other partners. The level of trust also affected the amount of effort allocated to the review of other partners' work. The lower the level of trust, the higher the effort allocated to that review, taking it from the effort available for basework.

The resulting level of effort available for basework affected the level of progress. Lower than expected work completed led to a perceived schedule slippage, schedule pressure and then to the deployment of more effort.

Moreover, when resources were not available to deploy more effort, higher schedule pressure led sometimes to relax the quality standards in order to accomplish the schedule objectives. In these cases, Partner 3 perceived that its quality and scope goals were not being considered, leading to less trust and communication, thereby reducing the level of coordination required for effort deployment, and increasing the level of effort allocated to review partners' work. As a consequence, the level of effort dedicated to basework was reduced, affecting progress, in a reinforcing feedback cycle.

The effect of the level of goal alignment on the scope feedback structure is similar to the effect on the quality structure (see Fig. 4-6). The level of scope goal alignment led to a level of agreement on scope trade-offs -the degree to which partners are willing to reduce scope to favor the accomplishment of other project goals. That level of agreement influenced the level of trust -partners considered that they could trust each other because they perceived that they shared the same objectives- and the level of trust contributed to the achievement of a certain level of communication between partners. As described in the analysis of the effect of goal alignment on the quality structure, the level of communication affected the level of quality, thereby the level of rework and the level of work completed. The level of communication also determined the level of coordinated effort deployed. In addition, the level of trust affected the level of effort deployed by partners to review other partners' work, which reduced the effort dedicated to execute basework. The resulting effort also contributed to determine the amount of work completed.

When the work completed was less than the expected according to the project plan, schedule pressure developed. Partners who assigned low priority to the scope goal attempted to reduce scope to cope with the schedule pressure, leading to conflicts with partners that assigned a higher level of priority to the scope goal. In case 1, Partner 3 perceived that Partner 2 wanted to reduce scope in order to avoid delaying the project due to quality problems. That created a conflict between Partners 2 and 3, because scope was more important than schedule for Partner 3. The conflict reduced the level of communication and trust, which led to more problems concerning quality and effort allocation, reducing the work completed and generating additional schedule pressure. The described dynamic contributed to the fact that the project was behind schedule.

The schedule, rework, and basework structures were also affected by the level of alignment, but that impact was mediated by the effects on the quality, effort, and scope structure. The effects described in this section are the base of the structure of the system dynamics model that attempts to represent the multi-organizational project dynamics as observed in case 1. In the next section, the effect of the level of goal alignment on case 2 project dynamics is discussed.

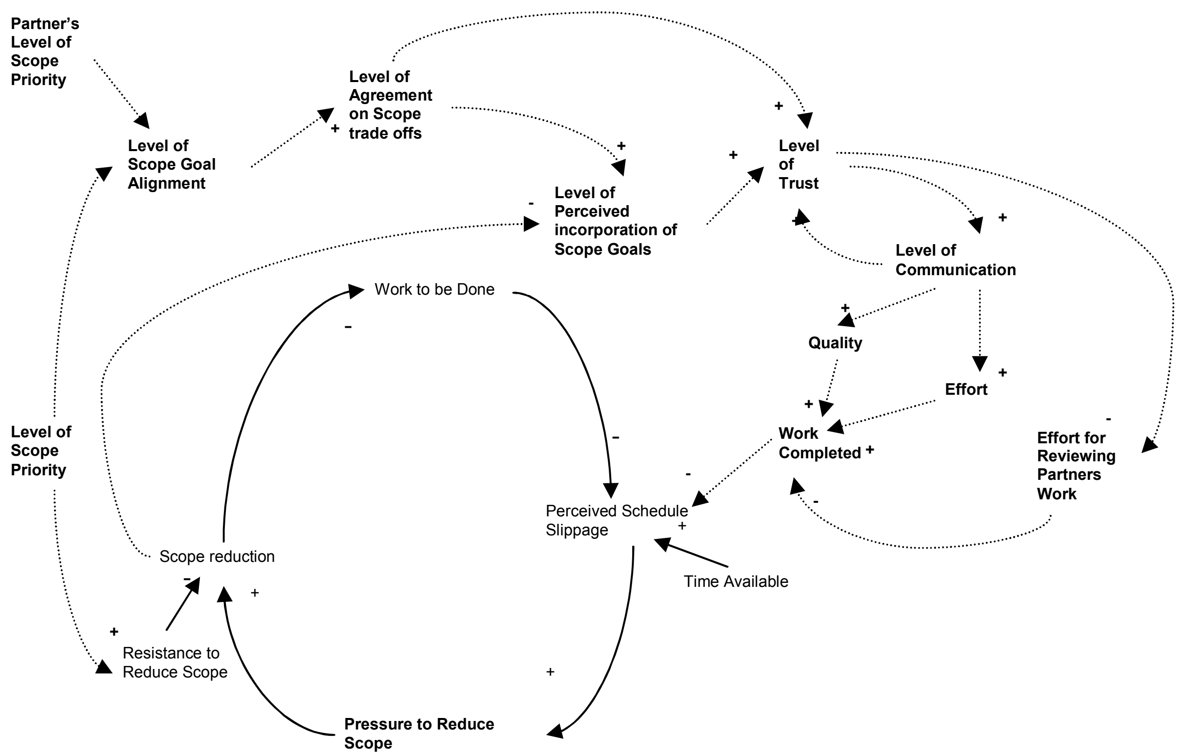


Figure 4-6: The Effect of the Level of Goal Alignment on the Case 1 Scope Structure

4.4.2 Analysis of the Effect of Goal Alignment on Case 2 Project Dynamics and Performance

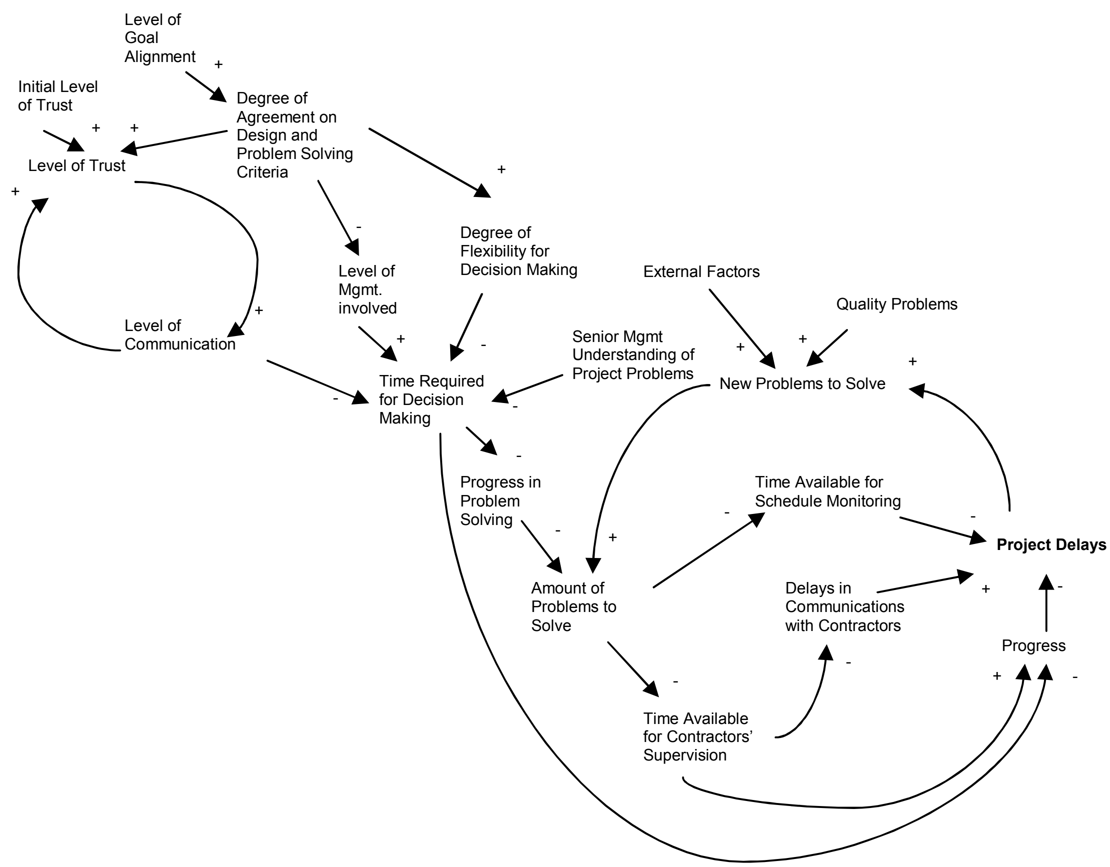


Figure 4-7: General View of Case 2 Dynamics Generated by the Level of Goal Alignment

Fig. 4-7 depicts an overview of the dynamics generated by the level of goal alignment among partners in case 2. The level of priority assigned to the cost, schedule, and to some extent scope goals by partners lead to disagreements in the design and problems solving criteria -in particular, to the criteria employed to decide cost, schedule and scope trade offs. These conflicts affected the level of trust and communication among partners, because they are not sure about other partners' intentions concerning the project. Partners did not want to give information that they perceive could be used against their interest. Low levels of communication, added to the need to involve higher levels of management -who have to decide about trade offs, due to the conflicting goals- to the low level of knowledge about the project that the involved senior managers had, and to a low level of flexibility in contract interpretation -the low level of alignment made more difficult to find satisfactory compromises and solutions outside the contracts- delayed the project team decision making process.

Delays in project team decision making led to delays in the delivery of instructions to the contractor, reducing the progress rate. Moreover, delays in decision making reduced the rate at which project problems were solved, thereby generating the accumulation of problems to be solved. The accumulation of problems to be solved diverted time and attention from the project team effort to monitor project progress, reducing project team ability to anticipate problems and to procure the deployment of effort in order to correct deviations form the original project plan. The deviations from the project plan, or schedule slippage, created new problems to solve that accumulated, generating a reinforcing cycle that created more delays. A more detailed description of these dynamics are presented below, where the way in which the level of goal alignment affected the typical project feedback structures will be discussed.

The Fig. 4-8 shows how the level of goal alignment between partners affected the rework-progress structure in case 2. The dotted lines show that effect. The level of goal alignment determined the level of agreement on design and problem solving criteria among partners, which defined the level of mutual trust and communication between them. In case 2, the level of alignment concerning cost and schedule was low, because the

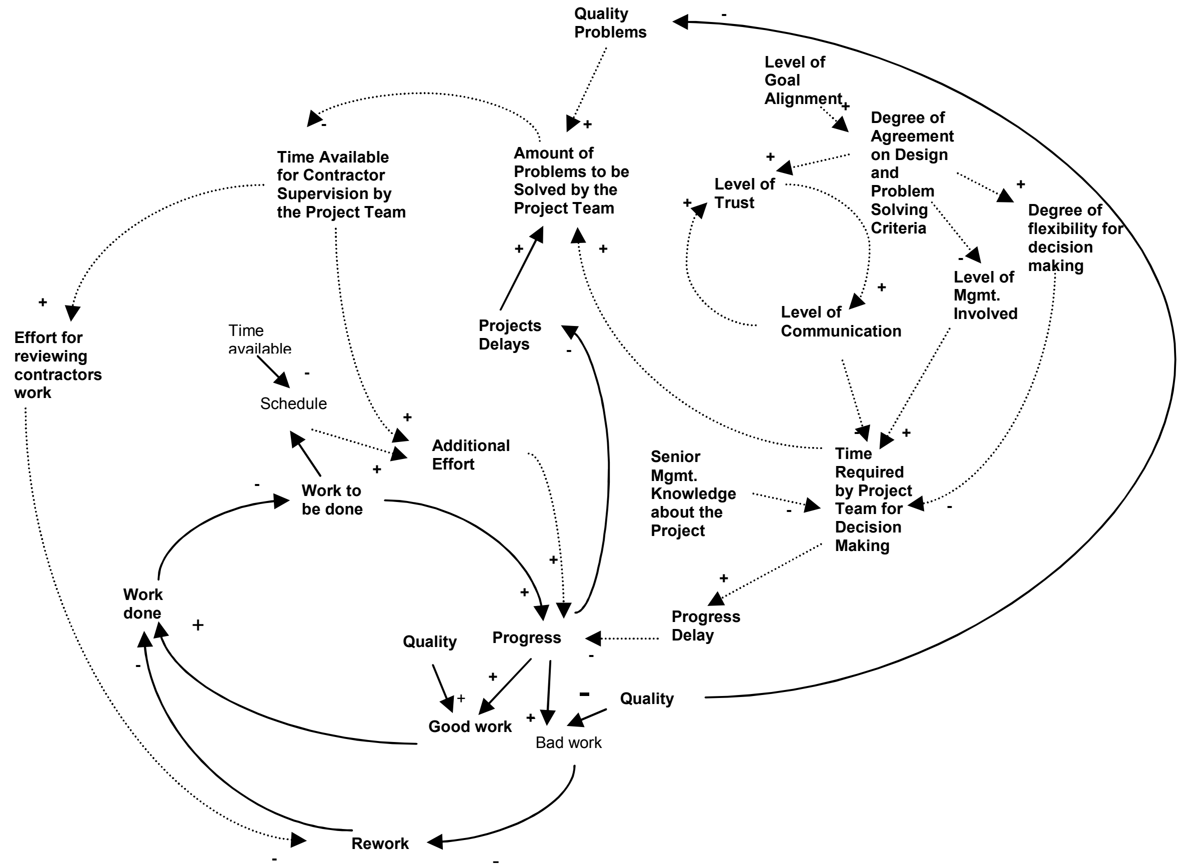


Figure 4-8: The Effect of the Level of Goal Alignment on the Case 2 Rework Structure

production partners were willing to increase project cost in order to start the oil production earlier than originally planned, and the transportation partner was more concerned about the costs than about the starting production date. That goal conflict led that many decisions, which had to be made by the project team, were elevated to senior management. The goal conflict also led to a very strict interpretation of the contracts terms, making more difficult to find negotiated solutions to certain project issues. Hence, low levels of trust and communication between the project team members, added to the senior management interventions -especially when the senior management was not very aware of the project issues- and to the lack of flexibility in the application of the contract terms led to delays in the project team decision making process.

The delays in project team decision making generated an accumulation of problems to solve. That accumulation distracted project team's time and effort from proactively monitoring project progress and from providing feedback to the EPC contractor, causing delays in project progress -the contractor had to wait for project team decisions to perform certain tasks. These delays created more problems to solve, and a reinforcing cycle was developed which delayed project completion for a year.

The lack of time available for monitoring project progress affected the project team ability to foresee incoming schedule and quality problems, thereby affecting the team ability to influence contractor's work planning, and the level of additional effort deployed to mitigate the effects of these problems (see Fig. 4-9). In the cases when the contractor did not deploy the actions required to cope with the schedule or quality problems, project progress was affected, generating more problems to solve, in a reinforcing cycle similar to the one described in the previous section.

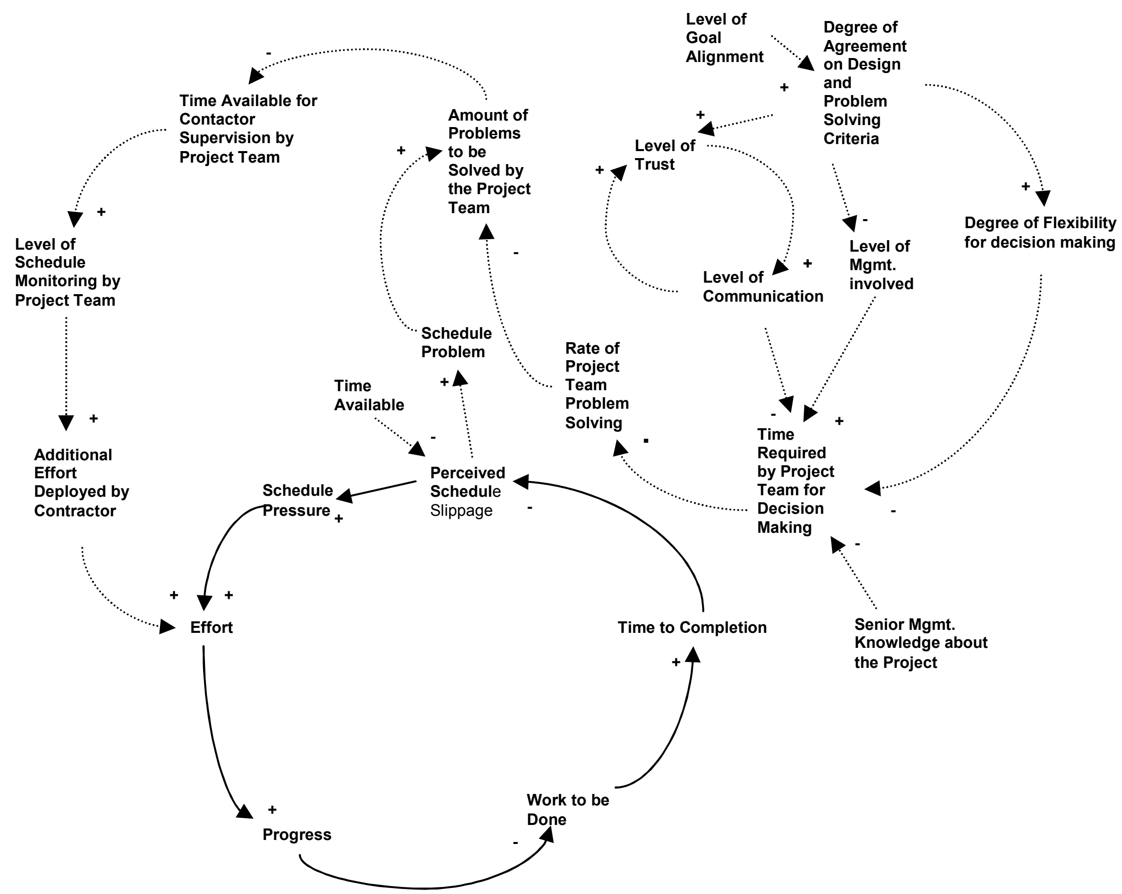


Figure 4-9: The Effect of the Level of Goal Alignment on the Case 2 Effort Structure

4.5 Summary

The data collected in the two cases studied supports the study propositions stating that the level of goal alignment in multi-organizational projects might vary when the business environment for the participating organizations varies, or when the goals are not clearly defined at the beginning of the project. On the other hand, the cases data did not support the study proposition stating that the variations of the level of goal alignment affected project performance by leading partners to reduce the amount of resources deployed when their expectations about other partners' behavior or project outcomes are not fulfilled. Conversely, both cases' data analysis indicated that the level of goal alignment affected project dynamics and performance through its effect on the level of trust and communication between partners. However, the trust and communication mechanism operated in a different way in the cases studied because the projects were structured in disparate ways -in case 1 the project team executed the project, and in case 2 the project team only managed the project. For case 1, the level of trust and communication affected quality and coordination for the deployment of effort -when tasks execution required information exchange- as well as the level of effort used to review other partners' work. These effects affected project dynamics and performance. In case 2, the level of trust and communication affected the project team decision making process and its ability to monitor progress and to react to problems, inducing delays in the work executed by the contractor. The project dynamics discussed in this chapter are the base of the models developed to simulate how the level of goal alignment affected project performance in the cases studied, which is described in the next chapter.

CHAPTER 5: MODELS DESCRIPTION

5.1 Chapter Overview

As discussed in previous sections, the data collected for the study cases was translated into system dynamics models in order to provide a structured way to describe the complex interrelationships among the cases study's variables. The data collected through the case research was verbal, with some ambiguity included. System dynamics modeling contributes to offset that ambiguity, forcing the researcher to be specific and precise in defining the causal dynamics mechanisms and basic assumptions that translate a verbal theory into a simulation model (Hanneman and Patrick, 1997).

In addition, the system dynamics models derived from case studies can be applied to similar phenomena in other contexts to assess the generalizability of the theory developed about the system behavior (Luna, 2004). System dynamics can also help to perform simulation experiments to analyze the impact of changes in relevant variables. Hence, the use of system dynamics models may help to "control" and manipulate system variables that in real life cannot be controlled to assess their individual impact on the system's outcomes, allowing the "testing" of the effects of management policies on the system before they are implemented. Last but not the least, the system dynamics models can become a repository of the participants' experiences and knowledge about the multi-organizational project systems, displayed in an explicit way, facilitating the knowledge transfer to individuals interested in multi-organizational projects dynamics. That repository can evolve and improve with the addition of new experiences by new users in different contexts.

The models to be described are based on typical structures extracted from previously validated project system models, and from the data collected through the cases studied. The models' descriptions start with the definition of the models' boundaries and the level of aggregation used. Then, a detailed description of the models is provided by depicting the inner details of the structure of the models' sectors. In the models' descriptions, the assumptions incorporated are clearly established, as well as the connections between the model structures and the case data collected. The models were developed using the ITHINK™ simulation software.

5.2 Case 1 Model

5.2.1 Case 1 Model Boundaries, Assumptions and Level of Aggregation

The models' scope and focus are depicted in the models' boundaries (Ford, 1995). The model boundary has been set by the elements of the project system mentioned in the data collected. The model boundary is the border of the single multi-organizational project studied in the case. Although the relationships of the studied project with other projects executed by the participant organizations might have had an impact on project performance in other contexts, the case data collected did not reflect that impact. Hence, the focus of the model structure is on variables operating within the project, and not contextual factors, which leads to the following assumptions:

- The project is executed in an environment of stable organizations. No major technological or organizational changes occur outside the project during the simulation period that might affect project team performance -for example, new management policies, process improvement, and new technologies.
- The average skill level of the project team members is constant along the simulation period.
- The organizational contexts and competing projects do not impose resource constraints on the studied project-no restriction on resource supply or resource reallocation to other projects was reported in the case study.
- The participants' goals for the project, the initial levels of trust and communication among the organizations participating in the project, the project's goals, and the level of task interdependence -degree to which partners require other partners' work as input for their own work and have to coordinate effort- are context given variables that affect project dynamics and performance; but they are not affected by the project dynamics. Hence, those variables are excluded from the inner works of the model and are used only as input variables. These context variables are denominated "exogenous variables" in the system dynamics literature.

In the Fig. 5-1, the variables included in the case 1 model structure (endogenous variables), excluded or contextual (exogenous variables), and ignored variables are depicted.

The level of aggregation of the model was defined on the basis of two criteria: First, to serve the model purpose of describing the dynamics within the studied multi-organizational projects and how these dynamics affect project performance

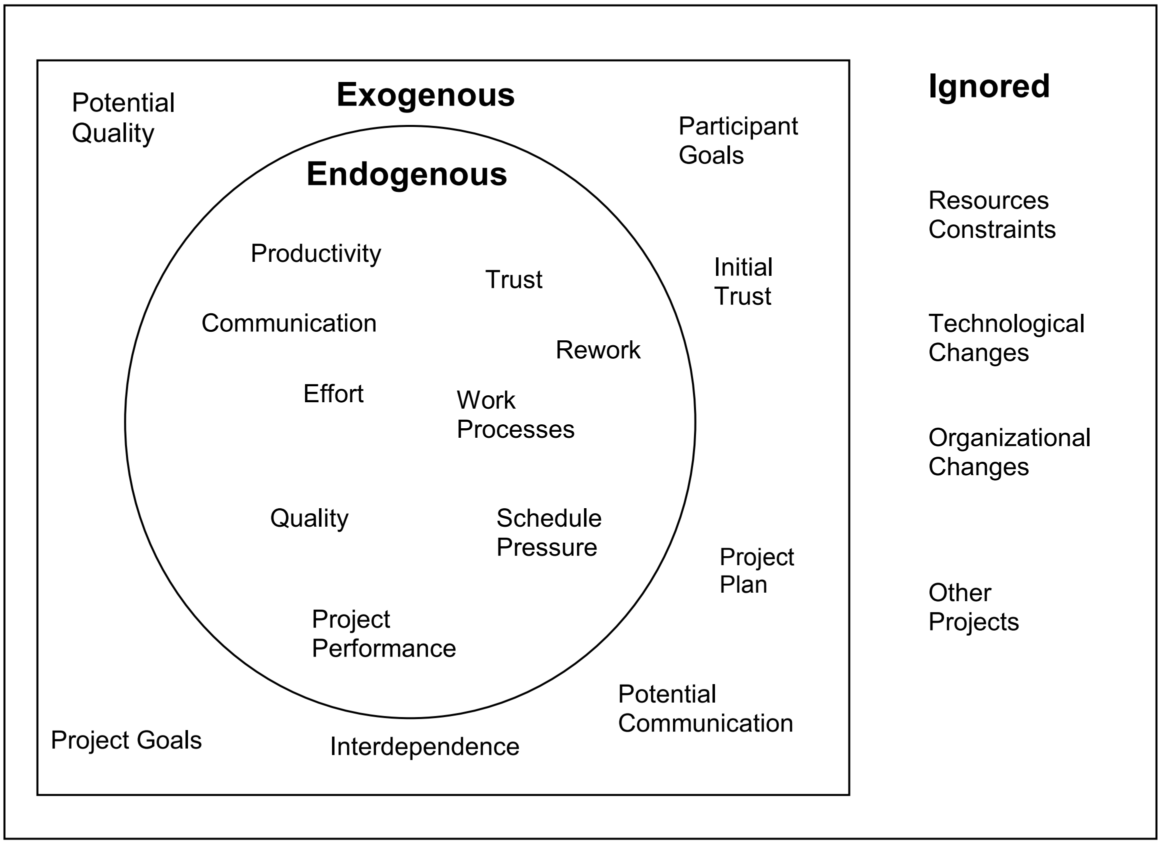


Figure5-1: Endogenous, Exogenous and Ignored Variables for Case 1 Model. Adapted from Ford (1995)

The second criterion is to keep the model as simple as possible while fulfilling its purpose. For example, the variable effort includes the effort performed to do basework (work performed by first time) and internal rework, but does not include the effort required to review the work performed by partners, a variable which is particularly affected by the dynamics associated with the level of goal alignment. Other important aggregation assumptions are listed below:

- Project tasks -including base work, rework, quality assurance, testing, etc.- are of similar size and complexity, therefore can be aggregated in a "work to be done" stock.
- Tasks can be either flawed or correct, but not partially flawed. The tasks that require repairs of all kind can be aggregated in a single stock (rework).
- The use of all types of resources is aggregated in the variable effort.

The boundary and level of aggregation focus the model on the variables and dynamics associated with the data collected during the case study research. The internal structure of the model that attempts to simulate the behavior of the multi-organizational project system as described in case 1 is presented in the following section.

5.2.2 Case 1 Model Description

In order to facilitate its description, the case 1 model is disaggregated in six sectors: progress-rework, schedule, quality, trust-communication, effort, and scope. The progress-rework sector is where project work is performed, as well as the rework of flawed tasks. The schedule sector simulates how the actual work done is compared to the work that, according to the project plan, had to be completed at a certain point, with a negative difference resulting in a certain level of schedule pressure. The quality sector simulates how the level of quality -defined as the probability that the products contain errors or deviate from specifications- is affected by the level of priority given to quality by each partner, the level of communication, and the schedule pressure. The trust-communication sector describes how the level of trust and communication among partners is affected by the initial level of communication and trust, and by the perceived level of alignment. The effort sector describes how the total effort is distributed into effort for progress and rework, additional effort, and effort for reviewing other partners' work. Finally, the scope sector describes to what extent the scope might be reduced to cope with schedule pressure. Before proceeding to describe in detail each sector, it is convenient to explain how the exogenous variables affect the model sectors, and then how the sectors interact among them to produce the dynamics present in the studied multi-organizational projects.

The relationships between the exogenous or input variables and the model sectors are presented in the Fig.5-2. Exogenous variables are depicted in grey boxes. As stated above, these variables influence the variables within the model, but are not influenced by model outputs. In the present case, the level of priority assigned to quality by each partner influences the level of quality of their products within the project, and the perception that the other partners have about their compromise with quality. The differences among those perceptions lead to a perceived level of goal alignment-in this particular case, toward the project quality goals. The perceived level of alignment among partners in the project affects the level of trust and communications between them. The level of trust and communication is also affected by the level of trust and potential communication at the beginning of the project, defined by previous interactions between the participant organizations, and by the organizations' involved cultures, management policies and infrastructure-for example, the fact that the project team is collocated or not, as mentioned in the case interviews.

The level of interdependence between partners is defined by two factors: the degree to which partners require other partners' work as input for their own work, and the degree to which partners need to coordinate efforts to accomplish certain project tasks. The level of interdependence influences the progress-rework sector. The higher the level of interdependence among partners, the higher the impact of communication problems on the execution of project tasks that require the participation of more then one partner. The level of interdependence among partners also influences the effort sector. The higher the level of coordination required for effort deployment, the higher the effect of communication problems on the level of coordinated effort deployed on time (Gladstein, 1984).

The effort planned to be performed by each organization and the level of effort that partners need to coordinate are inputs for the effort sector. Finally, the expected work that has to be completed at a certain point of the project execution is an input of the schedule sector. The expected work completed at a certain point of the project is compared with the work actually done to define if there is schedule slippage or not.

The desegregation of the model in sectors is an artificial one performed only for explanatory purposes. The sectors can be seen as subsystems that interact to produce the dynamics that characterize the multi-organizational project as described in the first study case. Those interactions are depicted in Fig.5-3. The low level of communication affects the progress rework sector in two ways. First, the level of communication affects the speed at which information or products flow between partners. When the input required by partners from other partners does not arrive on time, it creates delays in task execution.

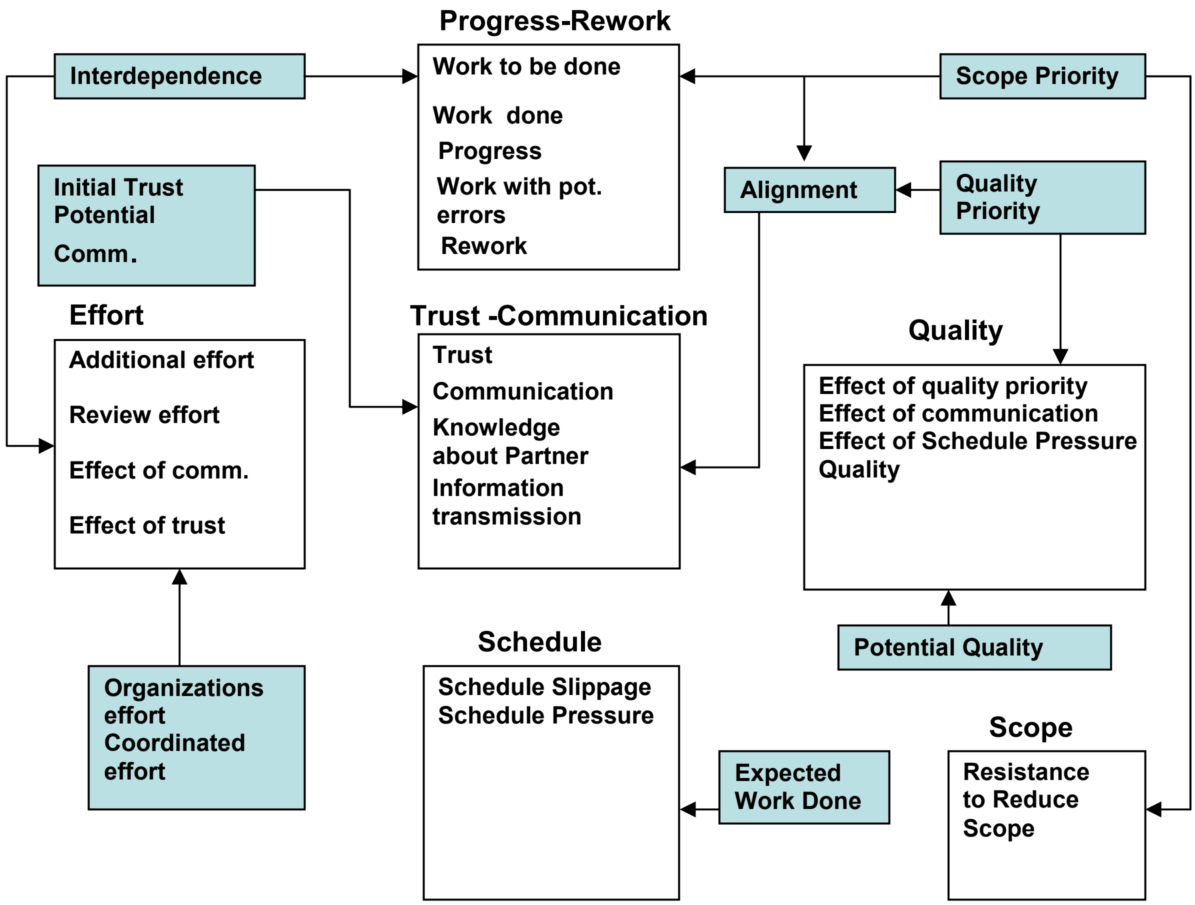


Figure 5-2: Effect of Exogenous Variables on Case 1 Model

Second, a low level of communication affects the tasks' execution when partners are working in parallel on the same tasks, creating problems of incongruence, or when partners are working on tasks different from what was expected.

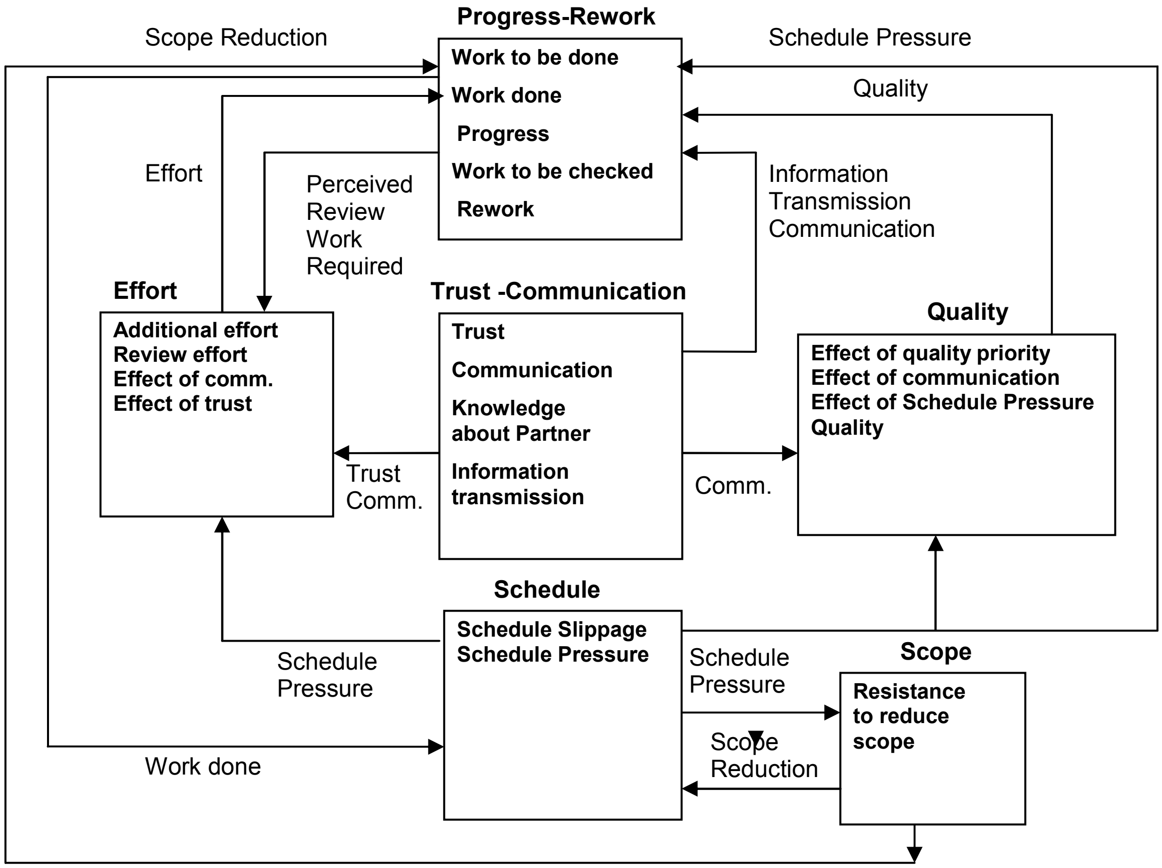


Figure 5-3: Interactions between Case 1 Model Sectors

The level of communication affects the effort sector. The lack of communication and understanding of inter-organizational work processes and of other partners' requirements affects the timeliness of resources' deployment. Moreover, the level of trust affects the allocation of resources to the other partners' review activities. A lower level of trust might induce the assignment of more resources to the review of other partners' activities due to a lack of confidence in partners' capabilities or intentions. The level of communication also affects the quality sector. A low level of communication causes partners to work without reliable and updated information from other partners, affecting the quality of the products.

The effort sector assigns resources to basework; rework and other partners' review tasks, then affecting the progress-rework sector. The level of schedule pressure affects the effort sector, inducing the deployment of additional effort to cope with schedule slippage. The level of schedule pressure also makes the project team work with preliminary information, to work faster, and to diminish the time dedicated to revision before delivering the products, then affecting quality. The level of schedule pressure can also affect the scope of the project (work to be done). In some cases the schedule pressure might lead to a reduction of the scope in order to cope with a perceived schedule slippage. Less work to be done reduces the perceived gap between the work expected to be completed at a certain point of the project execution and the actual work completed, then reducing the schedule pressure.

On the other hand, the progress rework sector affects the schedule sectors because the amount of work completed affects the level of perceived schedule slippage, and then the level of schedule pressure. Moreover, the progress-rework sector has an effect on the effort sector, because the levels of rework and other partners' work to be reviewed influence the decision of allocating effort to do rework or review other partners' work.

Finally, the level of quality has an effect on the progress-rework sector. The level of quality defines the percentage of products that requires rework. In the following section, the case 1 model's sectors are described in further detail, including an exposition of all the assumptions and links of the sector structure with the data collected in the case studied.

Case 1 Model Progress- Rework Sector

The Progress- Rework sector is the backbone of the model. This sector simulates the rate at which tasks are performed, the proportion of tasks that are flawed and require rework and the rate at which rework is performed. For simplicity purposes, only two organizations are included in this model. Each organization has its own progress-rework cycle. Hence, the progress-rework sector is constituted by two progress-rework cycles, and the elements required in connecting both cycles.

Each progress-rework cycle is constituted by a stock of work to be performed (work to be done), a flow of basework performed (progress) , a stock of work potential flaws (work with potential errors), a flow of flawed work (badwork), a flow of work without flaws (goodwork), a flow of rework performed (rework rate) , a stock of work completed (work done), a flow of work out of the work to be done stock, simulating a reduction of the project scope (scope reduction rate), and a stock of reduced scope (scope reduced).

The stock of work to be done is depleted by the execution of work (progress); and the flow of work executed is determined by the following equation:

progress= (work_to_be_done_1/dur_prog)*(1-frac_to_be_coord)+
(work_to_be_done_/dur_prog)*frac_to_be_coord*comm. (1)

Where:

dur progress= average duration of tasks.

comm = level of communication between partners

frac_to_be_coord= fraction of the work to be done that need to be coordinated with the Partner.

The rate at which the work that has to be coordinated with partners is executed is affected by the level of communication between partners. Poor communication leads to poor coordination, according to the case data. In the case studied, poor communication made the information transmission slower, adding to the fact that the project team members were working at different locations. In some cases, due to poor coordination, partners did not work on the tasks they were suppose to be working on, generating delays in the execution of other partners' tasks that require the referred tasks as inputs.

The duration of task execution is defined by the level of effort deployed to perform them (effort). However, the duration of basework tasks is not assumed to be proportional to the allocation of more effort to those activities -the allocation of effort is discussed while describing the effort sector. After a certain amount of effort (resources) has been allocated to certain activities, the effect of additional resources on task duration is reduced by productivity constraints imposed by limitations of the system. Moreover, if additional effort is deployed through overtime, fatigue can significantly impact productivity (Reichelt and Lyneis; 1999). Hence, the relationship between effort and task duration is assumed to be an exponential decay (see model documentation in the appendix C), with a rate of diminishing duration that is reduced as more effort is added.

The basework completed goes to the stock of work with potential errors (work pot errors). As the work progresses, products without flaws go to the stock of work completed, and the products in which errors are discovered go to the rework stock. The fraction of products that do not require rework (goodwork) is defined by the quality level (quality). Hence, the flow of products that do not require rework is simulated by the following equation:

goodwork=(work_pot_errors/dur_prog)*quality (2)

And the flow of products that require rework is simulated as follows:

badwork= (work_pot_errors/dur_prog)*(1-quality) (3)

Rework is performed at a rate simulated by the following equation:

rework rate=rework/dur_rework (4)

The duration of the rework tasks' execution is defined by the level of effort deployed to perform them (effort rew). Again, the duration of basework tasks is not assumed to be proportional to the allocation of more effort to those activities. The shape of the relationship is also assumed to be exponential decay, just like in the case of basework tasks. The flow of reworked tasks will return to the stock of work with potential errors, because mistakes could also be made while performing rework.

The scope of the project (stock of work to be done) can be reduced as a reaction to the perception that the current scope can not be achieved within the deadline (schedule pressure). The scope reduction is simulated by a flow from the stock of work to be done to a stock of scope reduced. The flow rate is determined by the level of schedule pressure (sch press) and the priority assigned to the schedule goal (scope pri). The higher the schedule pressure, the higher the tendency to reduce scope to fix the perceived schedule slippage. On the other hand, that tendency is offset by the level of priority assigned to the scope goal. Hence the flow rate to the scope reduced stock (scope red rate) is simulated by the following equation:

scope red rate= (1-scope_pri)*sch_press (5)

Because two organizations are considered in the model, two parallel progress-rework cycles are included. However, because there is a certain level of interdependence between the two organizations while working on project tasks, the interconnections between the two progress-rework cycles need to be simulated. The first interconnection is considered in the simulation of flow of basework executed. That interconnection deals with the fact that to perform a certain fraction of the project tasks, partners need input from other partners. Hence, the level of communication between partners affects work execution for that fraction of tasks, as reflected in the equations that simulate the flow of basework completed. The second type of interconnection considered in this model, as reflected in the data collected, is the use by a partner of work completed by the other partner as input for the tasks' execution. From the stock of work with potential errors, a flow of basework completed goes to a stock of work to be used by partners. The flow is simulated by the following equation:

work 12= (work_pot_errors 1/inftrandur)*work_1_used_by 2 (6)

Where

work 12: flow of work performed by partner 1 to be used by partner 2

work_pot_errors 1: stock of work performed by 1 with potential errors

inftrandur: average duration of information transmission between partners

work_1_used_by 2: fraction of work performed by 1 to be used by 2

The fraction of work performed by one partner to be used by the other is given by the requirements and the planning of the project. The duration of the information transmission between partners is a function of the level of communication, which is discussed in the description of the trust-communication sector.

The fraction of work completed by Partner 1 that is going to be used by Partner 2 is reviewed by Partner 2. Work without flaws goes from the work to be used by Partner 2 stock to the Partner 2's work to be done stock, because it will be processed by Partner 2**.** Flawed work goes to the work reviewed by 2 with errors (rework 12) stock. The proportion of work with and without flaws is defined by the level of the Partner 1's quality. The flow of flawless work (goodwork12) is then simulated by the following equation:

goodwork 12= (work 1_to_be_used_by_2/durrev 12)*quality 1 (7)

Where:

durrev 12: average duration of the reviewing by 1 of work performed by 2.

Similarly, the flow of work performed by 1 with errors and reviewed by 2 (badwork 12) is simulated by the following equation:

badwork 12 = (work1_to_be_used_by_2/durrev 12)*(1-quality 1) (8)

Finally, from the stock of work reviewed by 2 with errors (rework 12), the flawed work is sent back to Partner 1's rework stock, because Partner 1 needs to do rework on it.

The flow from the stock of work reviewed by 2 with errors to Partner 1's rework stock (rew 12 trans) is simulated by the equation:

rew 12 trans= rework 12/inftrandur (9)

The model includes similar structures for work performed by the Partner 2 to be used by Partner 1. A representation of the progress-rework sector is depicted in Fig. 5-4.

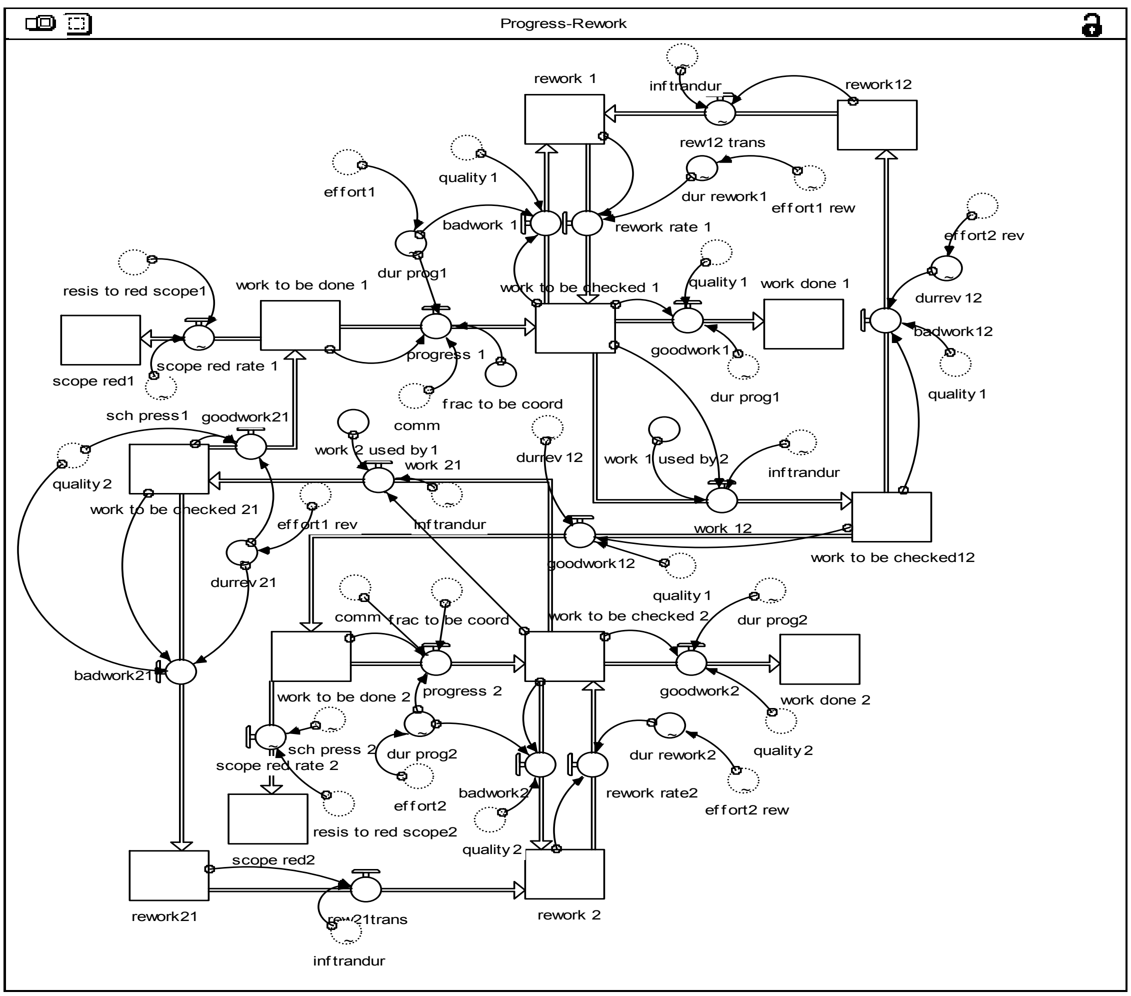


Figure5-4: Case 1 Model Progress-Rework Sector

Case 1 Model Alignment Sector

The variables related to the level of goal alignment are grouped in a sector, despite the fact that they are variables exogenous to the model. These variables are not included in the inner works of the model, and not affected by the model dynamics. However, they affect the model's endogenous variables.

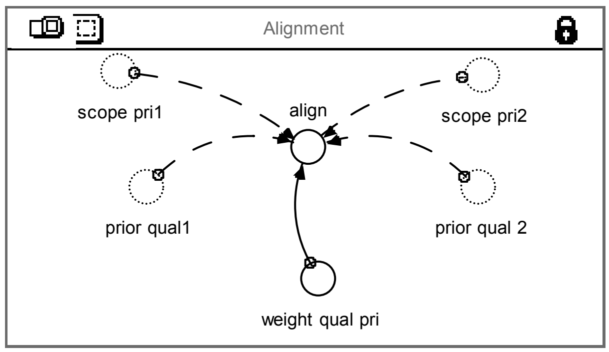


Figure 5-5: Case 1 Model Alignment Sector

For the purposes of this research, goal alignment has been defined as the degree to which participant organizations in multi-organizational projects agree on the level of priority of the quality, scope, cost and schedule goals. According to the data collected for the case study, cost and schedule goals were clearly defined by the project contract and accepted by all participants. Then, the level of goal alignment toward those goals had no impact on project dynamics. On the other hand, as discussed in the case description, there were discrepancies among project participants regarding the level of priority assigned to the project's quality and scope goals. These discrepancies are represented in the model by the differences between the level of priority assigned by each participant in the project to the quality and scope goals (see Fig.5-5). Therefore, the level of goal alignment in this model is described by the following equation:

align=1-((ABS(prior_qualprior_qual_2))*weight_qual_pri+((ABS(scope_pri1scope_pri2))*(1-weight_qual_pri))) **(10)**

Where:

prior_qual1= level of priority assigned to the quality goal by Partner 1

prior_qual_2= level of priority assigned to the quality goal by Partner 2

scope_pri1= level of priority assigned to the scope goal by Partner 1

scope_pri2= level of priority assigned to the scope goal by Partner 2

weight_qual_pri= relative weight in the project of the quality goal with respect to the scope goal.

This equation can be generalized to more goals assigning the relative weights in the project for each goal.

Case 1 Model Trust-Communication Sector

The data collected from the case study shows a mutual relationship between trust and communication, with trust leading to a more open -and frequent- communication, because partners perceive that other partners would not make an improper use of the information provided.

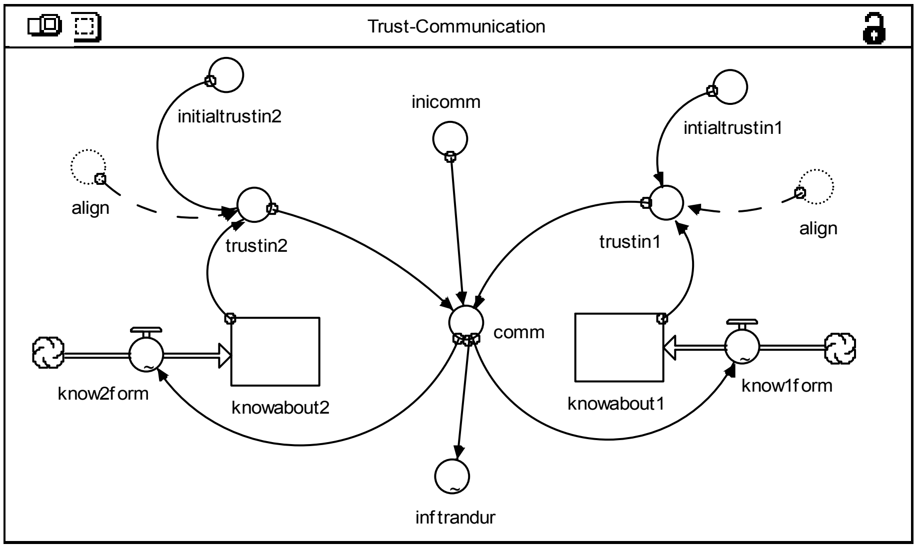


Figure5-6: Case 1 Model Trust-Communication Sector

Moreover, the case's data shows that a high level of communication also leads to a high level of trust, because all partners are more aware of the other partners' intentions, requirements and constraints concerning the project.

To simulate the level of trust in a certain moment between two partners in the studied multi-organizational project, the adaptation of the following equation proposed by Luna et al. (2004) is used.

trust in 1= 2's knowledge about 1* 2's perception of 1's trustworthiness+(1-2's knowledge about 1)* calculative trust **(11)**

In this equation, the calculative component of trust in 1 is conceptualized as a function of the perception of risk of being involved in a collaborative relationship with 1, the interest of 2 in getting involved with 1 and the 2's attitude toward risk. This component has a higher weight in the equation when the 2's knowledge of 1 is low. As the relationship progresses, the more 2 knows about 1, the higher the weight will be of 2's perceptions about 1's trustworthiness in the equation. In other words, as experiences accumulate in the collaborative relationship, partners rely less on the initial conditions that led to the relationship for trusting in the partner, and more on their own perceptions of other partners' behaviors.

In the case of the studied multi-organizational project (see Fig.5-6), the initial conditions are given by a certain level of trust product of previous interactions between partners, leading to certain perceptions of partners' attitudes, values and technical capabilities. The other component of the trust equation is given by the perception of the level of alignment between partners toward the project goals -in this case, quality and scope. The higher the level of perceived alignment, the more partners will be confident about the actions of other partners toward the achievement of project goals. As in the equation proposed by Luna et al., at the beginning of the project the initial level of trust would have a higher weight on the level of trust between partners. As the project progresses and the knowledge about other partners' requirements and objectives for the project increases, the weight of the perception of goal alignment in trust formation also increases. Hence the trust equation adapted for the studied multi-organizational project is a follows:

trust in 1= initialtrustin1* (1- knowabout1) +knowabout1*align (12)

Where:

initialtrustin1= level of trust in Partner 1 at the beginning of the project

knowabout1= accumulated knowledge about 1 during the project

align= level of goal alignment

This equation simulates the level of trust in one partner by other partner at any moment in the project.

As shown in the case data, the level of trust among participants in the multi-organizational project affected the level of communication -frequency and quality of content. Therefore, the level of communication is simulated by the following equation:

comm= inicomm*trustin1*trustin2 **(13)**

Where:

comm= level of communication between Partners 1 and 2

potcomm= potential level of communication between Partners 1 and 2

trustin1= level of trust in 1 by 2

trustin2= level of trust in 2 by 1

The potential level of communication is assumed to be given by contextual factors not related to the level of goal alignment, such as infrastructure, organizations cultures, and management styles and policies. That potential is then affected by the levels of trust among partners. The resulting level of communication affects the speed at which project information is transmitted to partners (inftrandur). The rate at which knowledge about partners is accumulated (know1form) is also assumed to be proportional to the level of communication. The higher the level of communication, the faster partners would know about other partners' requirements and objectives for the project.

Case 1 Model Schedule Sector

In the schedule sector, the work actually done at any point of the project is compared with the work that had to be already completed according to the project plan at that point in order to meet the required deadlines. If the work actually completed is less than what was expected, project team members would perceive a schedule slippage. The perceived schedule slippage leads to schedule pressure on project team members, or the pressure to work more and faster in order to reduce the schedule slippage (Reichelt and Lyneis, 1999; Lyneis et al. 2001). As the case data revealed, the schedule pressure might be relived by reducing scope to the level that it is perceived to be achieved in the time available according to the deadline (see Fig. 5-7)

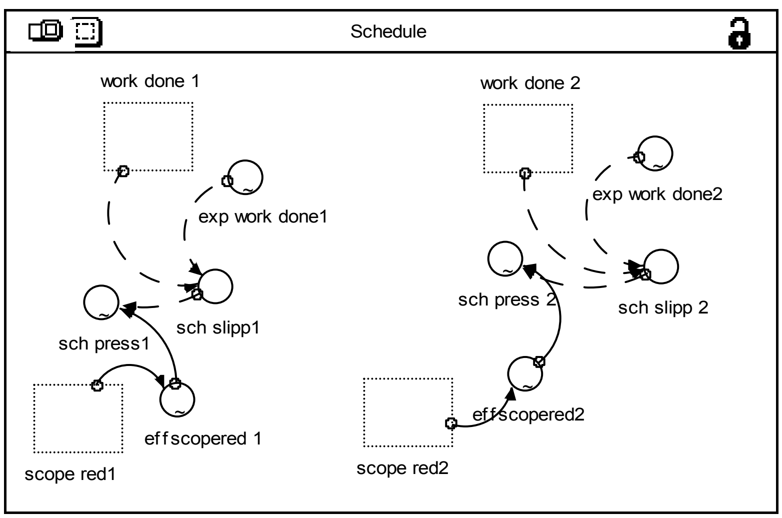


Figure 5-7: Case 1 Model Schedule Sector

Hence, the level of schedule pressure on the project team members belonging to a participant organization in the studied multi-organizational project is simulated by the following equation:

schpress1= (IF(sch_slipp1)<=0THEN(0)ELSE(sch_slipp1))*(1-effscopered_1) **(14)**

Where:

sch_slipp1= schedule slippage perceived by project team member belonging to Partner 1

effscopered_1=effect of the scope reduction on project team members belonging to Partner 1.

The same equation is used for the other partner included in the model. An important assumption is that schedule pressure responds only to perceived schedule slippage and to scope reductions. That assumption is sustainable for the studied case according to the data collected, but might need to be revised in other contexts.

Case 1 Model Quality Sector

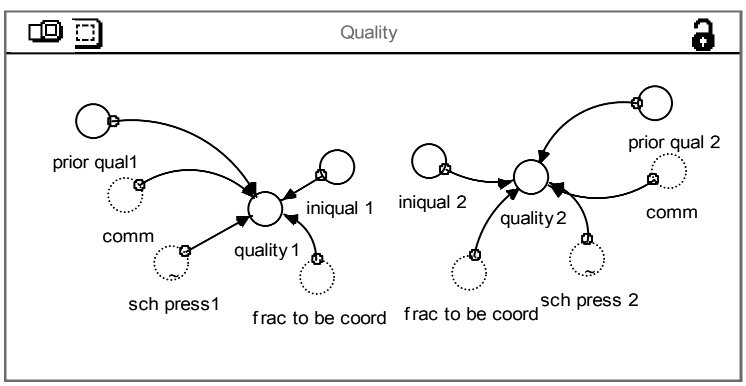


Figure 5-8: Case 1 Quality Sector

The level of quality of the project products completed by the project team members is defined as the probability that the products fulfill user's requirements and do not require rework. The potential quality (iniqual) given by factors, such as project team members' skills and experience, technology used, etc. is also affected by the priority given by each participant organization to the quality goal, the level of communication among partners -effect moderated by the fraction of work that need to be coordinated between partners- and the level of schedule pressure. According to the data collected in the case, the priority given to the project quality goals affected the quality standards used and the effort deployed to assure quality. The level of communications among partners also affected the level of quality. When information needed by a partner from other partners to execute the tasks did not arrive on time or never arrives at all, the partner worked with preliminary information. Then, incongruence between parts of the product elaborated by different partners was probably the result.

Finally, the level of schedule pressure was reported in the case data and in the literature (Ford and Sterman, 1998a; Reichelt and Lyneis, 1999; Lyneis et al. 2001) to affect the level of quality. The higher the schedule pressure, the faster the project team members will work in order to reduce the schedule slippage, dedicating less effort to check the work completed and to care for details. Hence, the level of quality is simulated by the following equation:

quality1=iniqual_1*effcommqual1*effpriqual1*(1effschpressqual1)*frac_to_be_coord+
iniqual_1*effpriqual1*(1-effschpressqual1)*(1-frac_to_be_coord) (15)

Where:

effcommqual1= effect of communication on the level of quality 1

effpriqual1= effect of quality priority 1 on the level of quality 1

effschpressqual1= effect of schedule pressure 1 on quality 1

frac_to_be_coord= fraction of the work to be done that need to be coordinated with the Partner.

The quality sector is depicted in Fig. 5-8.

Case 1 Model Effort Sector

In the model, the effort deployed by the participant organizations in the multi-organizational project to perform the project tasks includes man-hours, computer time, space and all kind of required materials. That effort is categorized in the following types: partner1's effort (org1effort), coordinated effort (cooreffort 1), additional effort (addeffort1), rework effort (effort1 rew), revision effort (effort 1 rev), basework effort (effort 1), and total effort (tot effort1).

The partner effort is the effort that each partner should deploy in the project according to the project plan, which does not require to be coordinated with other partners. On the other hand, the coordinated effort is the effort that requires coordination with other partners to be deployed, which is then affected by the level of communication among partners. Additional effort is the effort deployed in response to a perceived schedule slippage in order to complete the work required by the project plan. Rework effort is the effort deployed to execute the rework required on flawed products. Revision effort is the effort deployed to review the other partners' work. Basework effort is the effort deployed to perform the basework and quality assurance tasks, and total effort is the sum of organizational, coordinated and additional efforts. Because coordinated effort is affected by the level of communication, the level of total effort is simulated by the following equation:

tot effort 1=planeffort1+addeffort1+comm*cooreffort1 **(16)**

According to the case data, the level of revision effort is given by the level of trust in the partner that submits the work -the higher the level of trust, the lower the effort deployed- and the amount of work to review. Therefore, the level of revision effort is simulated by the following equation:

effort1 rev=per_rev_eff1*tot_effort1*(1-trustin2) (17)

The level of effort allocated for rework tasks is a function of the level of perceived rework to be performed, which is assumed to be proportional to the amount of rework to be done accumulated.

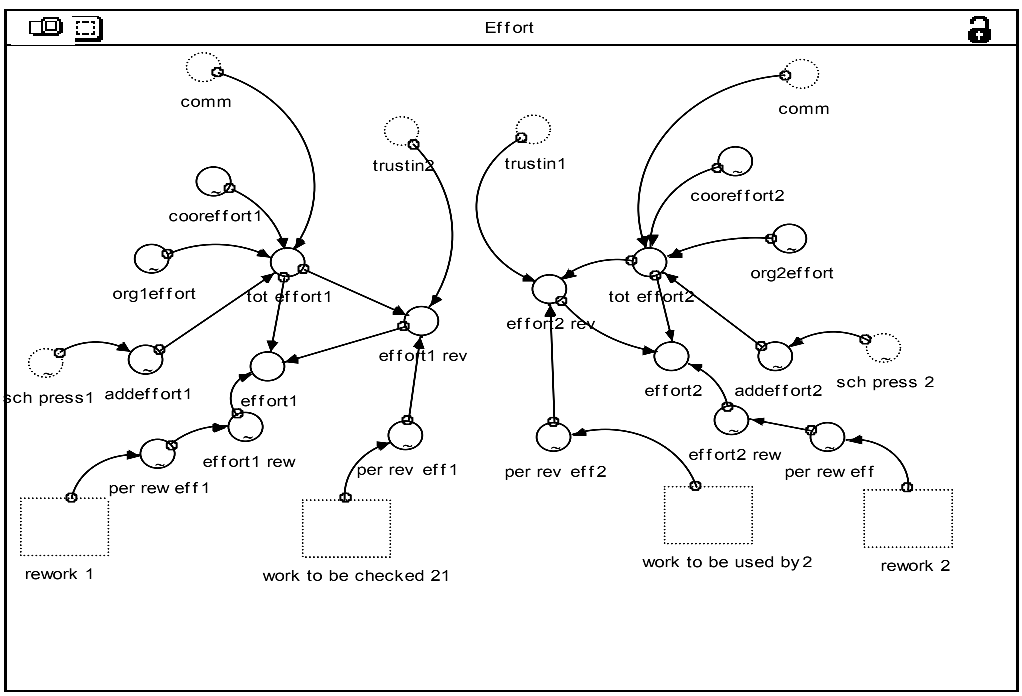


Figure 5-9: Case 1 Model Effort Sector

Assuming that the total effort is allocated to basework, rework, partners' work and revision tasks, the level of effort available to perform basework (effort 1) is simulated by the following equation:

effort1= tot_effort1-effort1_rev-effort1_rew (18)

The effort sector is depicted in Fig. 5-9.

Case 1 Model Scope Sector

The level of priority given by partners to the scope goal (scope pri1, scope pri 2), determines the resistance that project team members belonging to each partner pose to the reduction of project scope to reduce schedule slippage, as shown in the data collected for the case study. Reducing scope would reduce the number of tasks to be completed, allowing the completion of the work on time without adding more effort or reducing quality. The resistance to reduce scope affects the rate of scope reduction in the progress rework sector. The scope sector is depicted in Fig. 5-10.

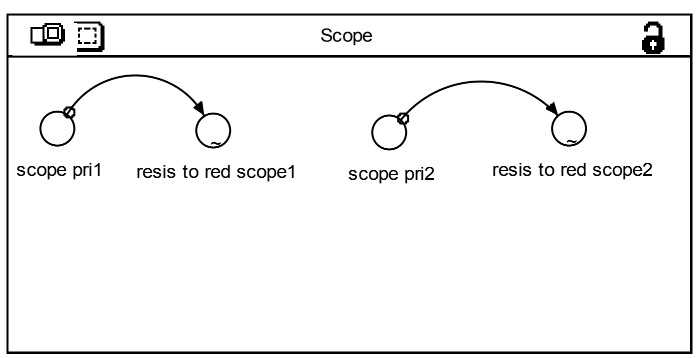


Figure 5-10: Case 1 Model Scope Sector

5.3 Case 2 Model

5.3.1 Case 2 Model Boundaries, Assumptions and Level of Aggregation

The second case studied presented a different situation compared to the first case. In the first case, the project team executed the project, while in the second case the project team only managed the project. Hence, according to the case data collected, the way in which the level of goal alignment affected projects dynamics and performance was different, requiring the construction of two different models. In the case in which the project team manages and executes the project, the two models could be integrated.

As in the first case model, the focus of the second case model is on the inner works of the studied multi-organizational project. Hence, the assumptions made in the first case regarding model boundaries and levels of aggregation are also valid for the second case model. In Fig.5-11, the case 2 model's endogenous variables, exogenous variables and ignored variables are depicted.

The internal structure of the model that attempts to simulate the behavior of the multi-organizational project system as described in the case 2 is presented in the following section.

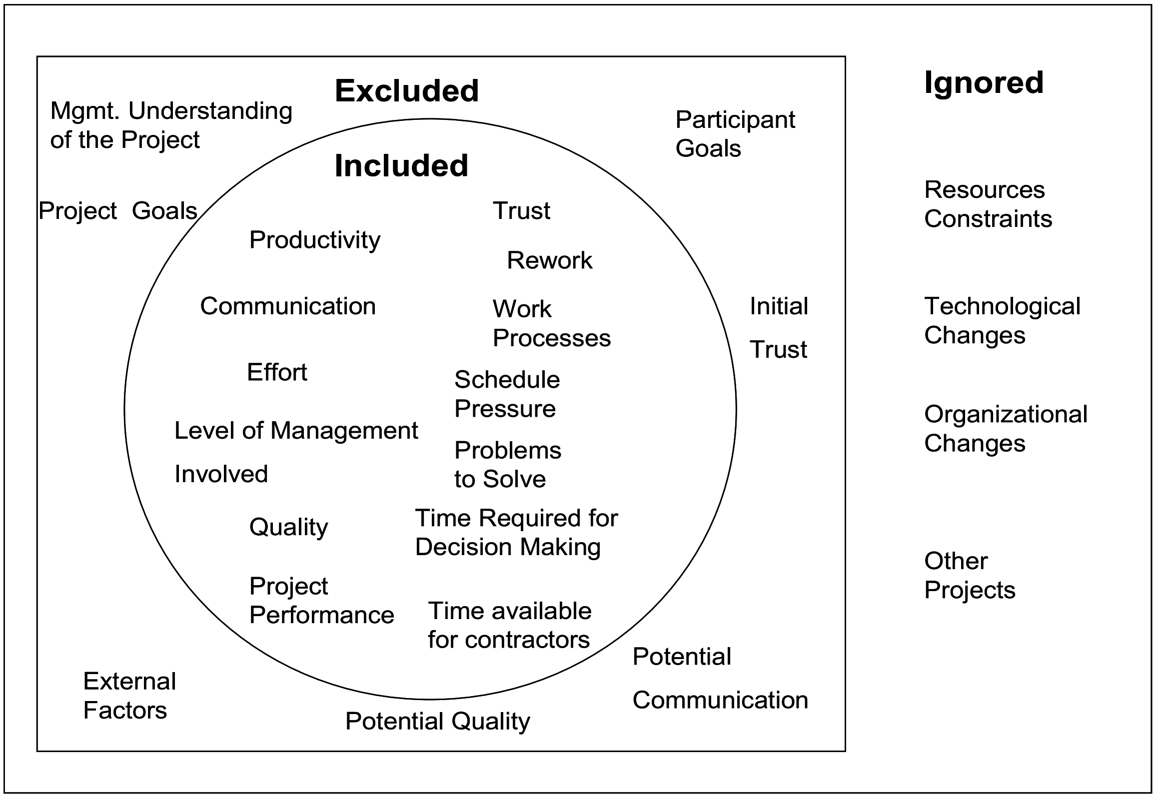


Figure 5-11: Endogenous, Exogenous and Ignored Variables for Case 2 Model. Adapted from Ford (1995)

5.3.2 Case 2 Model Description

As for case 1, the case 2 model is disaggregated in six sectors: progress-rework, schedule, effort, decision making, problem solving, contractors' supervision, and trust-communication. Again, the progress-rework sector is where project work is performed, as well as the rework of tasks with discovered errors. The schedule sector simulates how the work actually completed is compared with the work that had to be completed at a certain point according to the project plan, with a negative difference resulting in a certain level of schedule slippage. The effort sector simulates the allocation of resources to basework and rework tasks, as well as the deployment of additional effort to cope with schedule pressure. The decision making sector simulates how the time required by the team that manages the project is affected by the level of goal alignment between partners and the level of understanding that the senior management of the organizations participating in the project have about it. The problem solving sector simulates how problems to be solved by the project team accumulates as a function of the time they require to make decisions, and of the rate at which new problems appear -such as quality, schedule or other kind of problems. The contractors' supervision sector simulates how the level of problems to be solved by the project team affects the time available to supervise project contractors, then affecting the deployment of effort to review contractors' work, and the prevention of schedule problems. Finally, the trust-communication sector is similar to the one described in case 1, simulating how the level of trust and communication among partners is affected by the initial level of communication and trust and by the perceived level of alignment. Before describing in detail each sector, it is suitable to explain how the exogenous variables affect the model sectors, and how the sectors interact between them to produce the dynamics present in the studied multi-organizational project, just as it was done for the previous case.

The relationships between the exogenous variables and the model sectors are presented in Fig 5-12. The exogenous variables are depicted in gray boxes. These variables influence the variables included in the model, but are not affected by model outputs. In this case, the level of alignment among the participants in the studied multi-organizational project led to a certain level of trust between partners, to the degree of flexibility in the interpretation of contract terms, and to the level of management involved in the decision making process.

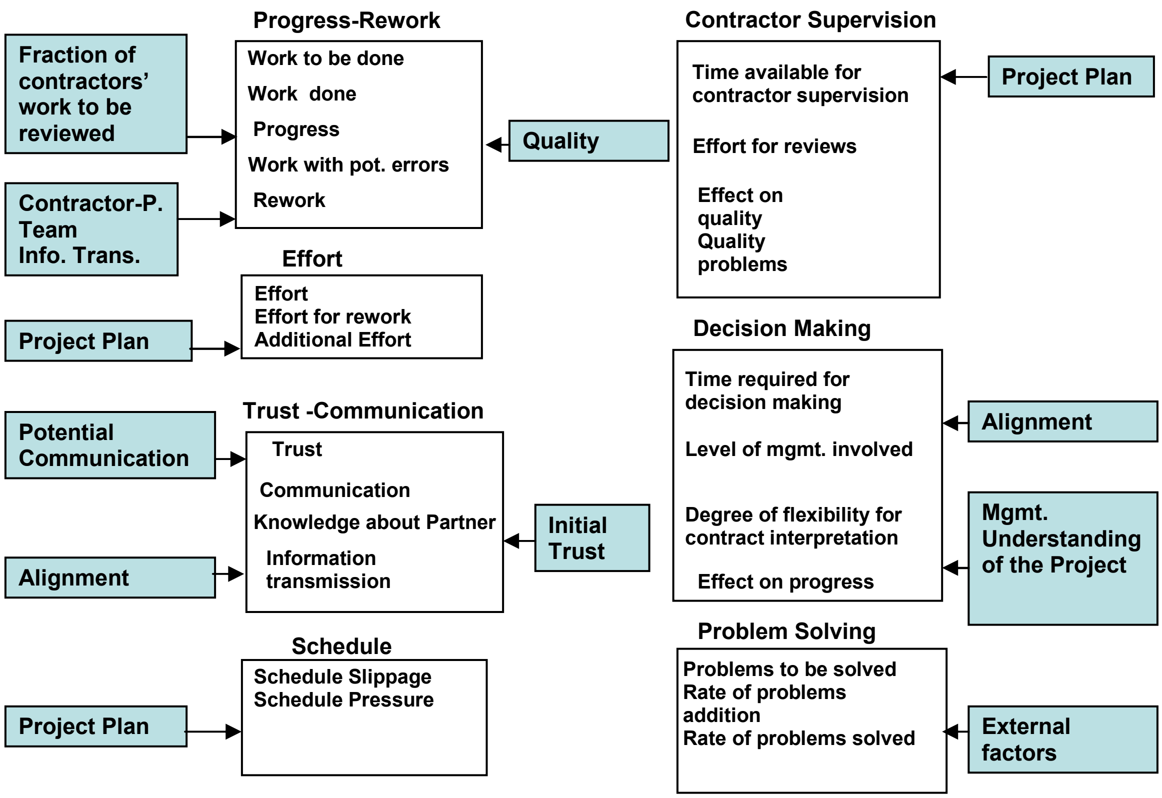


Figure5-12: Effect of Exogenous Variables on Case 2 Model

External factors that partners cannot control -for example, subcontractors failures in delivering products as specified or on time- affect the amount of problems to solve. Planned effort affects the level of effort deployed and the perceived schedule slippage. The fraction of work performed by the contractor to be reviewed by the project team affects the effort required to be deployed for that task, and also the impact of the level of communication between the project team and the contractor on the progress-rework sector. The time required for the transmission of information from the contractor to the project team affects how quick the contractors' work to be reviewed by the project team accumulates in the work to be reviewed stock. Finally, the initial level of trust affects the level of trust between partners, and the level of quality that the contractor is able to deliver affects the level of rework, progress and quality problems.

The relationships between the model sectors are depicted in the Fig. 5-13. The time required for decision making by the project team affects the rate at which problems are solved, and then the accumulation of problems to be solved. The time required for decision making also has an impact on the progress-rework sector. The contractor sometimes needs to wait for decisions that have to be made by the project team, delaying the execution of the associated tasks. The amount of problems to be solved affects the amount of time available to the project team for the supervision of contractors. The amount of time available for the supervision of contractors affects the level of effort deployed by the project team to the review the contractors' work, and the prevention and fixing of schedule problems. The level of schedule pressure generated in the schedule sector affects the deployment of additional effort to fix schedule slippage in the effort sector. The amount of rework to do affects the amount of effort deployed to perform it.

The problem solving sector is affected by schedule slippage. Schedule slippage adds more problems to solve, and also impacts the decision to deploy additional effort to meet deadlines. Finally, the level of communication among the project team members belonging to the different organizations participating in the project affects the time required for decision making. All these causal links affect the progress-rework sector through the timely delivery of instructions to the contractor, and the level of effort deployed. In the following section, the case 2 model sectors and the described relationships between them is described with further detail.

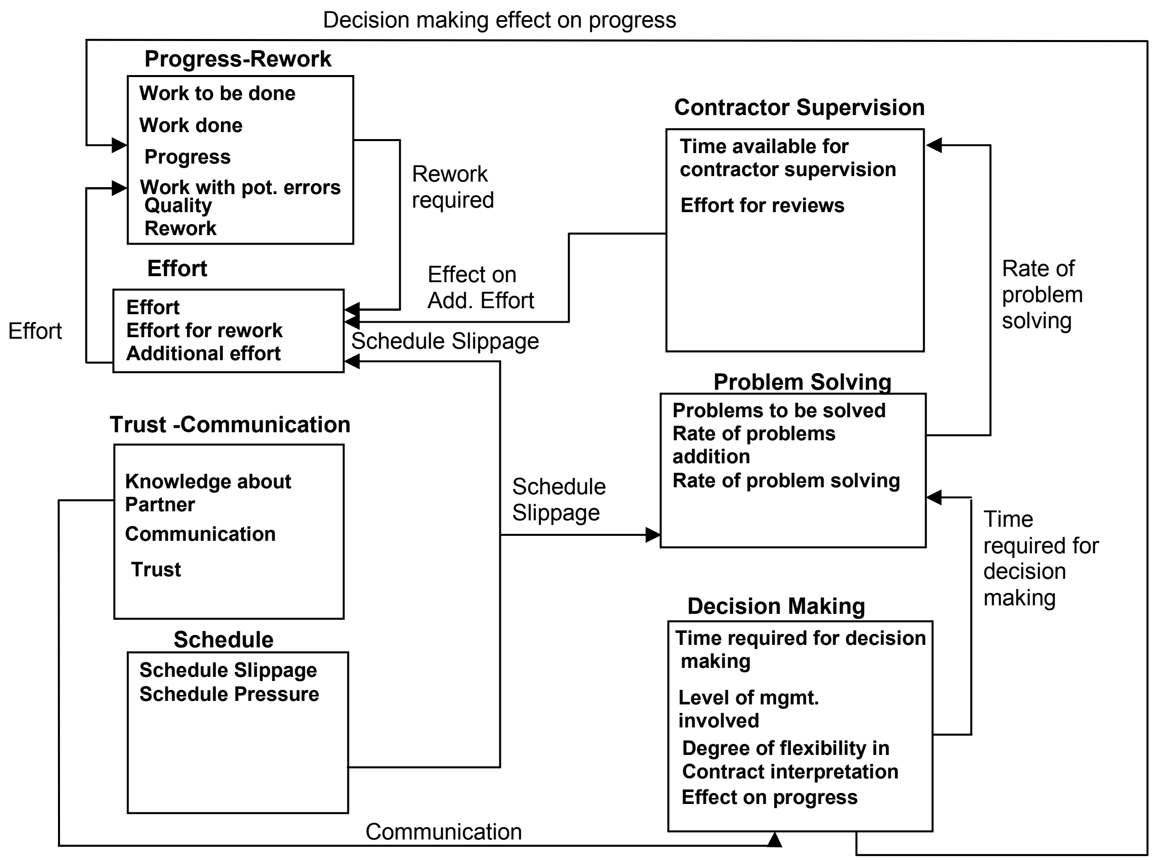


Figure 5-13: Interactions between Case 2 Model Sectors

Case 2 Model Progress-Rework Sector

As in the model corresponding to the first case, the progress- rework sector is at the core of the case 2 model. This sector simulates the rate at which tasks are performed, the proportion of tasks that are flawed and requires rework and the rate at which that rework is performed.

However, because in case 2 the work is performed by a single contractor, there is just one progress-rework cycle instead of the two that were included in the case 1 model. As in case 1, the progress-rework cycle is constituted by a stock of work to be performed (work to be done), a flow of basework performed (progress), a stock of work with potential errors (work with pot errors), a flow of flawed work (badwork), a flow of work without flaws (goodwork), a flow of rework performed (rework rate), and a stock of work completed (work done). There is not a work to be done reduction flow and reduced work to be done stock in the second case model, because no scope reduction was reported in the case data. The progress-rework sector is depicted in Fig. 5-14.

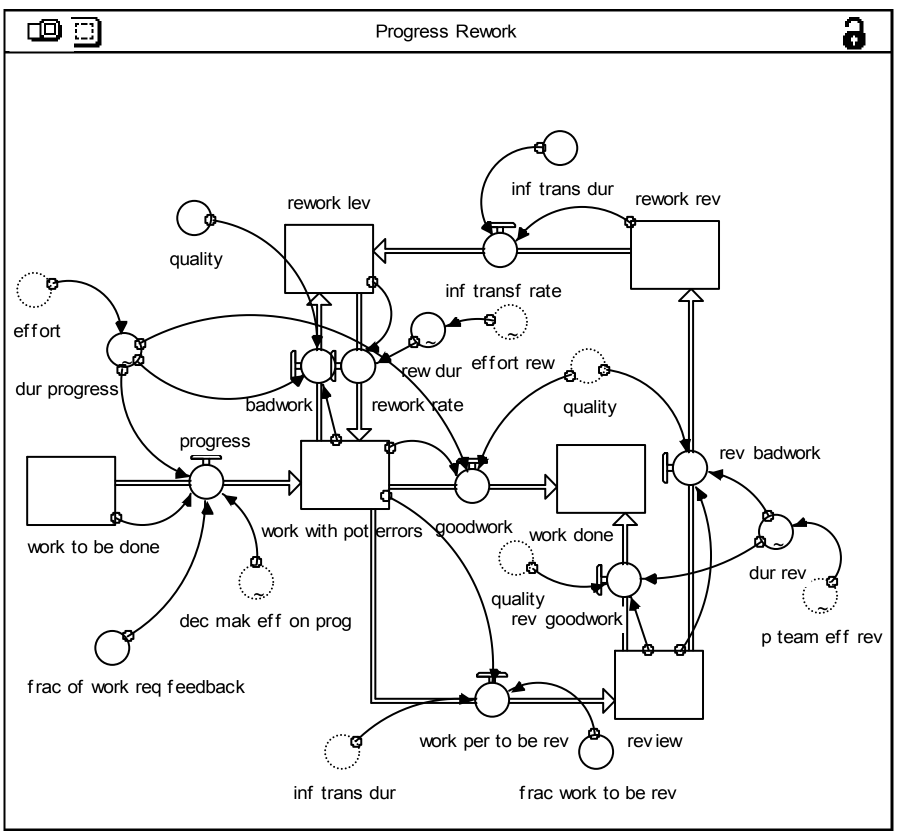


Figure 5-14: Case 2 Model Progress-Rework Sector

The stock of work to be done is reduced by the execution of work. The flow of work executed is determined by the following equation:

progress=(work_to_be_done/dur_progress)*frac_of_work_req_feedback*dec_mak_eff_on_progress+(work_to_be_done/dur_progress)*(1-frac_of_work_req_feedback) **(19)**

Where:

dur progress= average duration of basework tasks

frac_of_work_req_feedback= fraction of the work performed by the contractor that requires feedback from the project team

dec_mak_eff_on_progress= effect of delays in project team decision making on tasks execution

In this case, where the project team does not execute the project but manages a contractor, the progress of tasks execution is affected by delays in project team decision making. However, only the tasks that require feedback or specific instructions from the project team are the ones impacted by such delays.

The duration of tasks' execution is determined by the level of effort deployed to perform them (effort). However, as in the first case, the duration of basework tasks is not assumed to be proportional to the allocation of more effort to those activities -the allocation of effort is discussed while describing the effort sector. The same assumptions as in the first case are made for the second case concerning the relationship between efforts deployed and task duration. Hence, the relationship between effort and task duration is assumed to be an exponential decay, with a rate of decreasing duration that is reduced as more effort is added.

The basework completed flows to the stock of work with potential errors (work pot errors). From there, products without flaws go to the stock of work completed, and the products in which errors are discovered go to the rework stock. The fraction of products that does not require rework (goodwork) is defined by the quality level (quality). According to the data collected, quality is determined in this case only by the level of the contractors' skills and capabilities.

The flow of contractors' work that does not require rework is simulated by the following equation:

goodwork= (work_pot_errors/dur_prog)*quality (20)

And the flow of products that require rework is simulated as follows:

badwork= (work_pot_errors/dur_prog)*(1-quality) (21)

Rework is performed at a rate simulated by the following equation:

rework rate=rework/dur_rework (22)

Where:

rework= level of rework required

dur_rework = average duration of rework tasks

The duration of rework tasks is also determined by the level of effort deployed to perform them (effort rew). The duration of rework tasks is not assumed to be proportional to the allocation of more effort to those activities. The shape of the relationship is assumed to be exponential decay, like in the case of basework tasks. The flow of reworked tasks will return to the stock of work with potential errors, because errors might also be present in reworked tasks.

A fraction of the work with potential errors (frac work to be rev) is reviewed by the project team. That fraction flows to the stock of work to be reviewed by the project team (review) at a rate determined by the average work transmission duration from the contractor to the project team (inf tran dur). Work without flaws is sent to the work done stock, and flawed work goes the work reviewed by the project with discovered errors. The proportion of work without flaws is determined by the level of the contractors' quality. The flows of work with flaws (rev badwork) and without flaws (rev goodwork) are simulated by the following equations:

rev badwork=(review*(1-quality))/dur_rev **(23)**

rev goodwork=(review*quality)/dur_rev **(24)**

Where:

dur rev= average duration of project team reviewing tasks

The average duration of the project team reviewing tasks is determined by the level of reviewing effort deployed by the project team. As in the case of progress and rework effort, the relationship between reviewing effort and reviewing tasks' average duration is also assumed to have an exponential decay shape.

The flow of badwork goes to the work reviewed by the project team that needs rework stock. From there, work that needs rework flows back to the contractor rework stock. That flow is determined by the average duration of information transmission from the project team to the contractor, which is assumed to be the same as in the case of the information flow from the contractor to the project team (inf trans dur).

Case 2 Model Decision Making Sector

According to the data collected in the case study, the average amount of time required by the project team for decision making is increased or decreased by the level of alignment among partners concerning project goals, and the level of understanding that partners' management has about the project. A low level of goal alignment would lead to a low degree of agreement on design and problem solving criteria between the project team members belonging to the different organizations involved. That low level of agreement might create conflicts that lead to the involvement of higher levels of management of the respective participating organizations. The lower the level of knowledge that management has about the project, the larger the amount of time required for decision making -more time has to be invested in presentations, reporting and explanations. Moreover, the lack of common criteria for problem solving could also reduce the degree of flexibility in the interpretation of the contract terms. Project partners might find it difficult to compromise without harming the objectives they have for the project. That could limit the project team's ability to find common ground and the adoption of optimal solutions to problems faced by the project. The decision making sector is depicted in Fig. 5-15.

The increment of the average time required by the project team for decision making (inc time req for dec making) is then simulated by the following equation:

Inc time req for dec making=(1-comm)*(1-mgmt_unders)*(1-deg_of_flex)*lev_of_mgmt **(25)**

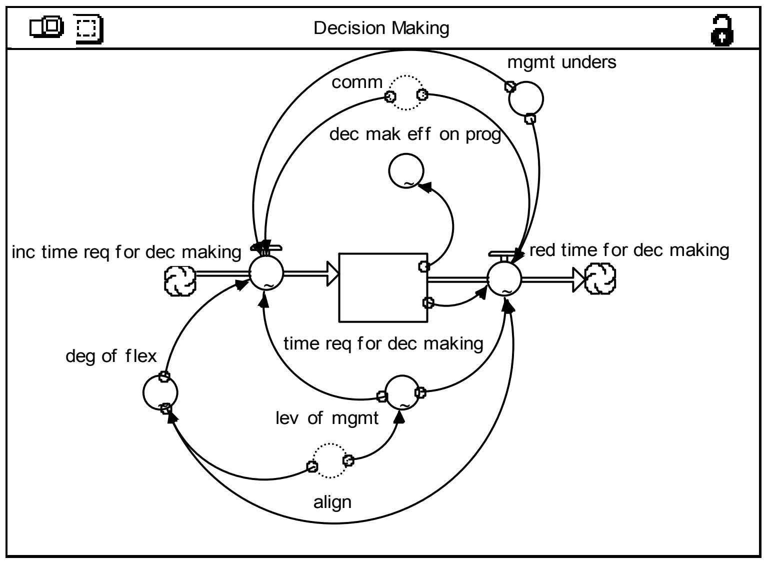


Figure 5-15: Case 2 Model Decision Making Sector

Where:

comm= level of communication between partners

mgmt_unders= level of partners' management understanding of the project

deg_of_flex= degree of flexibility for interpretation of contract terms

lev_of_mgmt= level of management involved

On the other hand, the reduction of the average time required by the project team for decision making (red time for dec making) is simulated by the following equation:

red time for dec making= comm*mgmt_unders*deg_of_flex*(1-lev_of_mgmt) **(26)**

As mentioned in the progress-rework sector, the average amount of time required for decision making affects the execution of the contractor's tasks that require feedback or information from the project team. That effect is simulated by the decision making effect on progress (dec make eff on prog) converters.

Case 2 Model Problem Solving Sector

The rate of addition of problems to be solved by the project team is determined by the amount of quality problems (quality prob), assumed as a proportional to the level of contractor work quality, schedule problems (schedule slipp) and other problems created by external factors -for example, in the case analyzed, there were problems with the quality of certain components manufactured overseas. External factors are not caused by model outcomes, and they are random in nature. Hence, they are simulated by a random function. The problem solving sector is depicted in Fig. 5-16.

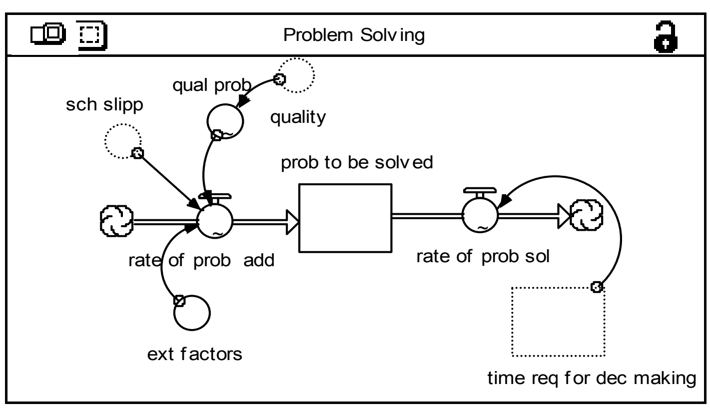


Figure 5-16: Case 2 Model Problem Solving Sector

The rate of addition of new problems is given by the following equation:

rate of prob add= ext_factors+sch_slipp+quality_prob (27)

On the other hand, the rate of problem solving (rate of prob sol) is given by the time required for decision making. If the rate at which new problems are added is higher than the rate at which problems are solved, problems will start to accumulate in the stock problems to be solved (prob to be solved).

Model Contractor Supervision Sector

The case data shows that the accumulation of problems to solve reduces the amount of time available to the project team for contract supervision (time ava for contrac). The availability of time for contractor supervision affects the level of effort deployed by the project team to review the contractor's work (see Fig. 5-17).

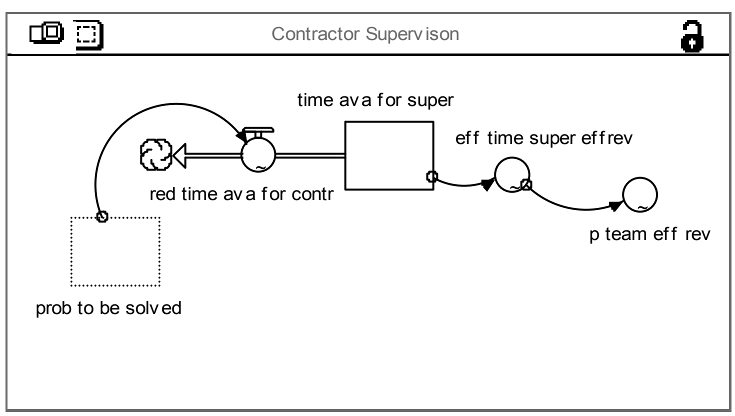


Figure 5-17: Case 2 Model Contractor Supervision Sector

Case 2 Model Schedule Sector

In the schedule sector, the work actually completed at a certain point of the project execution by the contractor (work done) is compared to the work expected to be completed at that point according to the project plan (exp work done), in order to meet the required deadlines. If the work actually completed is less than the work expected to be completed, then there is a schedule slippage (see Fig. 5-18).

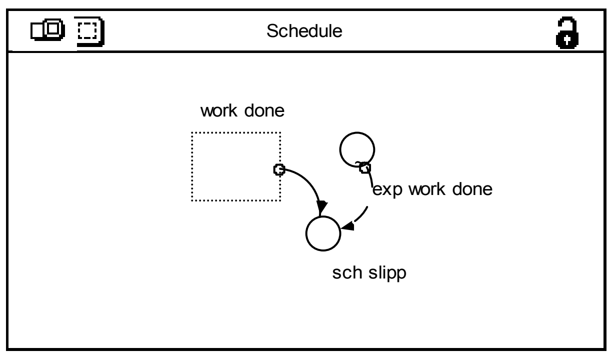


Figure 5-18: Case 2 Schedule Sector

Case 2 Model Effort Sector

Effort is deployed by the contractor according to the project plan (plan effort). However, additional effort (add eff) is also deployed to cope with schedule slippage (eff sch slipp add eff). Hence, the total effort (tot effort) deployed is the addition of planned effort and additional effort. According to the case data, the supervision exerted by the project team (eff time super add eff) contributes to the opportune detection of project delays, and then to the deployment of additional effort on a timely basis.

A certain part of the effort deployed by the contractor goes to basework (effort), and the other part goes to execute rework tasks (effort rew). The amount of effort allocated to rework tasks is a function of the perception that the contractor has of the amount of rework tasks that need to be executed. The effort sector is depicted in Fig.5-19.

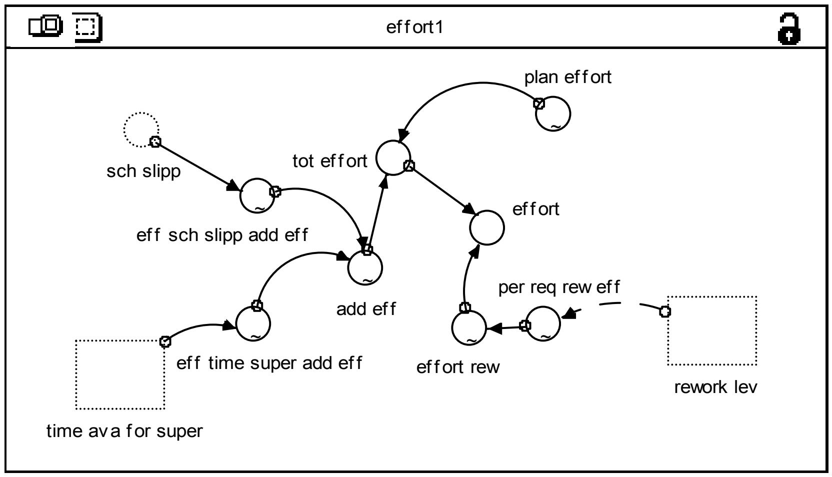


Figure 5-19: Case 2 Model Effort Sector

Case 2 Trust-Communication Sector

This sector is similar to the trust-communication sector described in the case 1 model. In the case 2 model, the equation proposed by Luna et al. (2004) is used again to simulate the level of trust in a certain moment between partners in the studied multi-organizational project.

trust in 1= 2's knowledge about 1*2's perception of 1's trustworthiness+ (1-2's knowledge about 1)* calculative trust (11)

The trust equation adapted for the studied multi-organizational project is a follows:

trust in 1= initialtrustin1* (1- knowabout1) +knowabout1*align (12)

Where:

Initialtrustin1= level of trust in Partner 1 at the beginning of the project

Knowabout1= accumulated knowledge about Partner 1 during the project

align= level of goal alignment

This equation simulates the level of trust in one partner by other partner at any moment in the project.

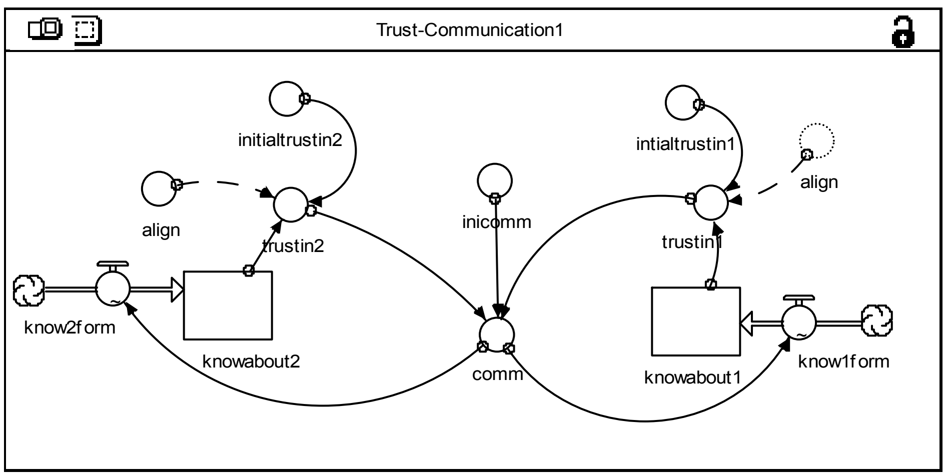


Figure5-20: Case 2 Model Trust-Communication Sector

According to the case data, the level of trust among participants in the multi-organizational project affected the level of communication. Hence, the level of communication is simulated by the following equation:

comm= inicomm*trustin1*trustin2 (13)

Where:

comm= level of communication between partners 1 and 2

potcomm= potential level of communication between 1 and 2

trustin1= level of trust in 1 by 2

trustin2= level of trust in 2 by 1

The potential level of communication is assumed to be given by factors not related to the level of goal alignment, such as infrastructure, organizations' cultures, management styles and policies. The potential level of communication is then affected by the levels of trust between partners. The resulting level of communication affects the rate at which knowledge about partners is accumulated (know1form). The higher the level of communication, the faster partners would know about other partners' requirements and objectives for the project. The trust-communication sector is depicted in Fig. 5-20.

5.4 Summary

In this chapter, the scope, assumptions, variables and mathematical formulation of the models developed were discussed, as well as the support of that formulation on the case data and previous project system dynamics models. This discussion constitutes the model documentation, and is intended to assist future researchers who would try to build on these models to develop other models adapted to different projects' contexts, and to inform these researchers or other users about the assumptions made and their limitations. In the next section, the potential validity of the described models is discussed.

CHAPTER 6: MODELS VALIDATION AND BEHAVIOR ANALYSIS

6.1 Chapter Overview.

In this research effort, the approach suggested by Barlas (1996) to system dynamics models validation is used. According to Barlas, a model is valid in the extent to which it serves its purpose. Because the purpose of the elaboration of the models presented above is to represent the project system dynamics as described in the case data collected, it is required to determine to what extent the models are capable of reproducing these dynamics. To do so, two basic verifications are required. First, it is required to assess the validity of the model structure. To accomplish that validation, an empirical structure oriented test as suggested by Forrester and Senge (1980) was used, consisting of the review of the model structure by participants in the studied projects.

Second, it is required to assess to what extent the project system's behaviors as simulated by the models developed resemble plausible project behaviors according the case data. To accomplish that assessment, a sensitivity analysis was performed on the models. Because the focus of this research is to investigate how the level of goal alignment affects project performance, the sensitivity analysis was based on the observation of model behavior when the level of goal alignment among the organizations participating in the project is varied, including extreme conditions tests (Barlas, 1996). In addition, possible moderating effects of the models' exogenous variables were explored.

Moreover, in order to perform an initial assessment of the extent to which the model could represent how the level of goal alignment affects project dynamics and performance in other multi-organizational projects, a panel of individuals with experience in several multi-organizational projects compared the model structures to their experiences. Also, theoretical validation test were conducted, which consisted in comparing the models' structures to previous research findings concerning project and collaborative work systems.

6.2 Models Validation

6.2.1 Models Structures Validation by Participants in the Studied Projects

A questionnaire -depicting the basic model structures both in graphics and verbal statements- was submitted to the project participants who collaborated with the study (see questionnaires in the Appendix B). Participants were asked to assess to what extent the models' structures reflected their experiences in the multi-organizational project studied. Participants were requested to write their assessment of each verbal statement describing a part of the model structure, pointing out what had to be added, eliminated or modified. Participants were also allowed to add comments not related specifically to any verbal statement.

Unfortunately, despite several requests for assistance, only two out of the five interviewed case 1's participants responded the questionnaire. The two respondents agreed with all the questionnaire statements.

On the other hand, all four case 2's participants completed the questionnaire. Three of them supported all questionnaire statements. One participant disagreed with statements 7, 8 and 9, mainly because he perceived that the amount of problems accumulated to be solved by the project team had no significant impact on the level of supervision on contractor, because supervisory tasks always have preeminence over other problem solving activities. That perception might be related to the participant's role in the project, which was the manager of the EPC contractor team, not directly involved in the partners' project management team dynamics. Because all other three interviewed participants supported these statements, they are considered supported. However, further refinements of the model in different contexts should question to what extent the accumulation of problems divert attention form monitoring project progress on each case.

In conclusion, the assessment of the basic models structures by participants in the project provides confidence to a significant degree on these structures. In addition, one comment was provided about the structures that should be considered for further model refinements or adaptations to different contexts. In the next two sections, the assessment of the models structures by a panel of individuals with experience in different multi-organizational projects is discussed. Also, the model structures are contrasted with past research findings in related areas. These analyses allow the evaluation of the potential validity of the model structures in contexts different from the studied projects.

6.2.2 Models Structures Validation by a Panel of Individuals with Experience in Multi-Organizational Projects

A panel of five individuals with experience in diverse multi-organizational projects was asked to answer a questionnaire which included a graphic depiction of both models and their correspondent verbal statements. That was done with the purpose of assessing to what degree the models developed were useful to describe how the level of goal alignment might affect multi-organizational projects performance in contexts different from the projects studied. The panel was selected from a larger pool of individuals with project management experience in diverse industries. Individuals with project management experience in more than one multi-organizational project in different industries -energy, pharmaceutical and chemical- were selected to complete the questionnaire. Because the two models reflect different project situations -project executed by the project team in case 1, and project managed by project team in case 2- the subjects were asked to assess only the statements of the models that correspond to the situations in which they have experience. All subjects assessed both models.

Table 6-1 presents a table reflecting the percentage of support given to each model statement.

Model 1 Statements	% **Support**	**Model 2 Statements**	% **Support**
The level of goal alignment leads to the degree of agreement on the design and problem solving criteria (or the criteria to perform the trade-offs between the project cost, schedule, quality and scope priorities)	100%	The level of goal alignment leads to the degree of agreement on the design and problem solving criteria (or the criteria to perform the trade-offs between the project cost, schedule, quality and scope priorities)	80%
The degree of agreement on design and project solving criteria leads to the degree of Partners' satisfaction with the trade-offs performed in the project concerning the cost, schedule, quality and scope priorities.	80%	A low degree of agreement on design and problem solving criteria among partners leads to the involvement of a higher level of management in the decision making process	80%
Lack of satisfaction with the trade- offs performed in the project lead to animosity and to personal conflicts among the project team members, affecting the level of communication.	60%	A low degree of agreement on design and problem solving criteria among partners provides a low degree of flexibility for decision making (requiring a stricter adherence to written agreements).	80%
Personal conflicts and low level of communication among the project team members produce delays in information exchange and products reviews. That hinders the project progress, or leads to work based on preliminary information, that in turns leads to low quality, rework, schedule pressure and reduced progress.	60%	The level of trust among partners is influenced by the experiences lived during the negotiations and project planning phases (initial level of trust) and by the degree of agreement on design and problem solving criteria. The level of trust affects the level of communication (communications are driven in part by the expectations about the outcomes of the exchange). On the other hand, open communication (leading to understanding of Partners' expectations and behaviors), generates higher levels of trust.	80%
The level of trust among the project team members is a function of past experiences with the same Partners (initial level of trust) and of the degree of agreement on design and project solving criteria. The level of trust affects the level of communication (communications are driven in part by the expectations about the outcomes of the exchange). On the other hand, open communication -leading to understanding of Partners' behaviors, motivations and project developments- generates higher levels of trust.	80%	The level of communication among partners, the level of management involved, the management's level of understanding of the project problems, and the degree of decision flexibility available influence the amount of time required for decision making.	60%

Table 6-1: Percentage of Panel Members Supporting Models Statements

Model 1 Statements	**% Support**	**Model 2 Statements**	**% Support**
The level of communication among partners affects the level of understanding of the inputs required by the other Partners to perform their work, the adequacy of activities planning and the deployment of resources on a timely basis. The deployment of resources on a timely basis affects the level of effort and project progress	80%	The amount of time required for decision making determines the progress in problem solving, and then the accumulation of problems to solve	80%
The level of communication among partners affects the level of coordination when partners are working in a parallel or concurrent way. This might affect the sub-products' integration later in the project. Problems with sub-products integration could generate rework, schedule pressure and possible scope reduction, affecting project progress	80%	The accumulation of problems to solve defines the amount of time available to partners for the supervision of contractors and for project schedule monitoring.	60%
The level of trust among partners affects the level of effort allocated to review partners' work. A higher level of effort allocated to review partners' products might take resources from doing work, generating delays and affecting project progress.	60%	Longer decision making times and less time available for contract supervision leads to delays in product reviews and in communications with the contractors, affecting creating project delays.	60%
		Less time available for schedule monitoring prevents partners to proactively identify causes of potential project delays, increasing their probability of occurrence	60%
		Quality problems, project delays and external factors create new problems to solve.	80%

Table 6-1: Percentage of Panel Members Supporting Models Statements (Continued)

As can be observed in Table 6-1, the minimum support for a statement is 60%, which provides some sustain to the idea that the project dynamics observed in the cases studied as responses to the level of goal alignment resemble the dynamics experienced in other multi-organizational projects. Moreover, the support observed for the models developed encourage to some extent their use as a departing point for the analysis of the dynamics induced by the level of goal alignment in other multi-organizational projects.

Nonetheless, the subjects were instructed not only to provide support or challenge the model statements, but also to comment on their reasons for that support or challenge. These comments and their implication for the model structure and future research are discussed below.

A comment regarding trust formation was that trust is an inter-personal and not an inter-organizational phenomenon, and that trust formation required direct personal observation of partners' behavior. In other words, trust can be developed between persons and not between organizations. According to this observation, the level of trust in project team members belonging to partners' organizations can vary among the different project team members belonging to the same organization. Zaheer et al. (1998) defined two different constructs of trust in an inter-organizational context: "interpersonal" trust and "interorganizational" trust. Interpersonal trust is defined as the degree to which a boundary spanning agent trusts his or her counterpart in the partner organization. Interorganizational trust concerns to the extent of trust placed in the partner organization as a whole by the members of a focal organization.

Zaheer et al. conducted an empirical study in 107 different buyer-supplier relationships to determine the roles of interpersonal and interorganizational trusts on the relationship performance. The study concluded that interpersonal and interorganizational trust are different but related constructs, and play different roles in exchange performance. Interpersonal and inter-organizational trust seemed to reinforce one another, and interorganizational trust seemed to have a larger influence on exchange performance. The study also concluded that the aggregation of the levels of interpersonal trust should not be used as a proxy for inter-organizational trust. In the context of the cases studied in this dissertation, the level of perceived goal alignment influenced the extent to which a partner's project team member trusted the other partners' organizations, then influencing the level of interpersonal trust. In other words, the level of goal alignment affected the level of interorganizational trust, which in turn affected the level of interpersonal trust. Hence, although the distinction between interpersonal and inter-organizational trust should be always considered while analyzing multi-organizational relationships, in the cases studied in this research it does not represent a problem for the proposed model structures.

A panel member challenged the model statements according to which the low level of goal alignment led to conflict, which then might lead to animosity between project team members then hindering communication and trust for case 1, and to the delay of the project team decision making process in case 2. The panel member stated that in some cases conflicts can be positive, leading to the generation of innovative solutions to certain problems. Intra-team conflict literature supports the idea that, to some degree, task and process conflicts can be beneficial for team performance, because teams seems to benefit from differences of opinions about the work being done (Eisenhardt and Schoonhoven,1990; Shah and Jehn,1993; Jehn,1995; Jehn and Mannix, 2001). However, the particular context of the multi-organizational projects studied made the relationships between project team members to be both inter-team and intra-team in nature. They are intra-team because project team members belonged to a particular team, with the objective of accomplishing certain goals in an interdependent way. However, project team members' relationships can be also characterized as inter-team because project team members belonged to different organizations -they even stay in their original locations. Inter-team conflict has been seen in the literature as negative for organizational performance (Putnam, 1997; Richter et al. 2005) Besides, experimental social psychology research findings suggests that goal conflict intensifies hostile inter-team behavior (Schopler et al. 2001).

Research findings also suggest that relationship or affective conflict in the form of interpersonal animosity lead to anxiety that might inhibit cognitive processing and then problem solving processes (Staw et al., 1981; Roseman et al., 1994). In case 1, lack of goal alignment led to a high level of animosity between the project team members belonging to different organizations. Finally, problem solving activities are more constructive when they seek a settlement that integrates the goals of all the parties involved (Lawrence and Lorsh, 1967; Thomas, 1992; Nauta and Sanders, 2000). As a conclusion, it seems that, in the particular case of multi-organizational projects, conflicts rooted in lack of goal alignment might not be favorable for project team process performance.

Another model 2 statement challenged was that the low time available for contractor supervision might be detrimental to the project team ability of monitoring project progress, and then of the ability of influencing contractor's resources allocation strategy to prevent schedule slippage problems. The panel member suggested that too much supervision might interfere with the contractor's work. That claim also has support in the literature. Minimizing interference and giving autonomy to the organizations most responsive to problems increases efficiency in task execution (Lawrence and Lorsh, 1967). Moreover, Rodrigues and Williams (1998) suggest that a client too involved in day to day project activities might end up demanding too many progress reports, which might divert contractor effort from real progress work. Hence, the observation advanced by the panel member is pertinent and should be considered when analyzing other multi-organizational projects. However, in case 2 what was influencing project performance was not the lack of time available for monitoring day to day contractor activities, but the lack of time available for analyzing potential problems and providing contractor with input about how to deal with them, as well as with constructive feedback about project progress, in order to ensure the achievement of project objectives.

Other comments were formulated by the panel, but not challenging the proposed model structures. Conversely, the comments point out particular situations that might enhance the support for the causal effects described in these structures. One comment referred to the fact that in some cases the senior management of the participant organizations could block the decision making process while trying to impose a solution to a problem which was not acceptable for other partners. Another related comment was that in some cases delays in project team decision making process are aggravated by having too many possible alternatives. That observation is shared by Thomsen et al. (2005), who suggests that the lack of distinct alternatives might reduce the likelihood of conflict of desired alternatives rooted in goal incongruence. A comment was issued suggesting that a high level of role definition, through which partners would know exactly what to do and when to do it, might reduce the level of interdependence and then the necessity of a high level of communication. That comment is also supported by the literature. High levels of task interdependence have been related to an intensification of the goal incongruence effects (Schmidt and Kochan, 1972; Gladstein, 1984). A final comment stated that cultural issues in international multi-organizational projects -in particular when Asian and Western organizations are involved- add to the communication difficulties generated by the low level of goal alignment.

To summarize, the assessment of the basic model structures by the panel of individuals with experience in multi-organizational projects provided supported the idea that these structures could be useful to develop models for other multi-organizational projects. On the other hand, comments were provided by the panel members about the structures that should be considered for further model refinements or adaptations to different contexts.

6.2.3 Comparison of the Models' Structures to Past Research Findings in Related Areas

Forrester and Senge (1980) suggest that system dynamics models verification may comprise comparing model assumptions to descriptions of organizational relationships or decision making processes included in relevant literature. Then, to advance further in the assessment of the degree to which the developed model structures could be valid for other contexts, they were compared with previous descriptions of the relationships between variables affecting performance in multi-organizational collaborative efforts. Because, to the best of my knowledge, there is no previous research addressing exactly the same question concerning how the level of goal alignment affects project performance in multi-organizational projects, model structures derived from the data collected were compared to findings in past research in related areas such as multi-organizational collaborative relationships, trust formation and its effect on team performance, effects of goal incongruence on project teams and project systems dynamics. Given that the research works reviewed do not directly address the question of how the level of goal alignment affects project performance in multi-organizational projects, caution was upheld while using those previous research findings in other contexts to sustain or question the models' assumptions.

O'Sullivan Work

O'Sullivan (2003) studied the effect of the imposition of administrative standards for work content and timing on the performance of a virtual multi-organizational product development project. Based on a literature review, Sullivan suggested that a major challenge faced by a virtual team (not co-located) is the absence of a shared work context. Shared work context includes norms and routines (Ancona and Chong, 1996) time horizons (Doughberty, 1992), and work pace (Gersick, 1989). The placement of project team members in different geographic locations might lead, according to O' Sullivan, to a " contextual depletion" of people's work, which might affect negatively that work whenever it is interdependent. Lack of verbal and non-verbal cues might lead to problems in the control of the conversational exchanges and feedback. These problems can be reflected in a lack of synchronicity in team communications, which could lead to disorganized discussion or coordination problems (Montoya-Weiss et al. 2001).

Beside the problems described a in the previous paragraph, a multi organizational virtual team, the focus of O'Sullivan research, might be affected by two additional issues. First, because team members stay in the same location within their organizations, they are subject to their influence and also to the influence of the project team. These influences might be contradictory and a source of conflict. Second, project team members need to establish collaborative activities with other team members working in remote locations. Because product development activities are usually knowledge-intensive and highly interdependent (Perlow, 1999), a significant number of interactions between project team members might be important for critical design decisions. That could make synchronicity in the flow of information fundamental for design quality and project performance. Hence, managing the effect of contextual influences on communication and coordination among the project team members is critical to facilitate the development of integrative work configurations and project performance.

O' Sullivan conducted his research through a case study analyzing work patterns in an aerospace product development project, in which a leading organization worked with 20 suppliers, located in different geographical sites. To accomplish the project objectives, the leading organization deployed two strategies. The first was a modularization of the design, which reduced the amount of interfaces and interdependence between the suppliers, and defined standards for the performance of each subsystem. The second was a profound standardization of the work patterns, including how, where and when the work should be performed. To achieve that standardization, the leading organization made use of four tools. First, a digital model based in a specific design software application, which had to be employed by all suppliers. Second, direct communications were standardized through a 'coordinating memo' template. Third, a master schedule was devised and implemented, matching and integrating all suppliers' and individuals' schedules, to ensure the proper work synchronization. Forth, the suppliers' project managers were required to be co-located for a period of time at the beginning of the project to ensure they learn and internalize the work standards.

The O'Sullivan study findings and their relevance for this dissertation are discussed below. The studied project was reported as a success, and the researcher attributes that success to the following factors. First, the project team members achieved a mutual adaptation of the work configurations. That adaptation was ensured by the leading organization by making the standardized contextual information available to all participants, and reinforced by the partial co-location of the project managers. Second, the early definition of the standardized interactions between the subsystems, as well as of the performance standards, facilitated the success of the modularization strategy. Third, the master schedule had a significant positive effect on work synchronization, but created a tension between a work rhythm based on the reality of events and a work rhythm based on a calendar. According to the study findings, that tension was addressed by adding more resources to the project by the suppliers. Finally, O'Sullivan concluded that a significant part of the success of the studied multi-organizational project could be explained by the early identification of what information needed to be shared among the participants, reducing the need of communication and coordination. The development effort meant different things for the diverse participants, but they were able to define a joint outcome in terms of shared deliverables and deadlines, providing the required common social context.

O'Sullivan's work is relevant to this dissertation because it studied the case of a multi-organizational project, and analyzed some of the factors related to work design that affected performance. In particular, O'Sullivan findings emphasize the importance of communication, coordination and synchronization of work in multi-organizational projects. The success of the project was attributed in a significant part to the work standardization that the leading organization put in place to ensure that coordination. In this dissertation research, specifically in case 1, communication, coordination and synchronization of work were found fundamental to explain the level of project performance as affected by the level of goal alignment. However, because there was not apparent goal misalignment among the participating organizations in the case studied by O'Sullivan, lack of goal alignment was not a factor that hindered the achievement of the required level of communication between partners. Hence, every project team member received the information required on time, and that information was clear on what the design requirements were and when the deliverables were needed by other project team members. That contrasts with what was observed in case 1, where the low level of goal alignment led to a low level of trust and communication, preventing in some cases the opportune deployment of effort ,and making team members work with preliminary information, impacting negatively the level of quality.

The Thomsen, Jin, Levitt, Nass, Chistiansen, and Kunz Work

Thomsen, Jin, Levitt, Nass, Chistiansen, and Kunz developed a computational organizational analysis tool denominated Virtual Design Team (VDT) (Jin and Levitt, 1996; Levitt et al., 1999). Based on Galbraith's (1973) information processing view of the organization, VDT simulates team participants as information–processing units with skill sets, experience, and explicitly modeled by lateral interdependences between activities. VDT is based on the assumption that coordination work takes time and effort, with the potential of delaying work completion, increasing costs, and affecting quality. VDT contains three basic representational entities. First, there are actors, modeled as informational processing units, who perform tasks within a team. Second, there is an organizational hierarchy, defining supervisor-supervisee relationships and how exceptions to routine work are handled. Third, there is a representation of work processes. Activities are assigned to actors, and actors communicate in response to exceptions, or to accomplish interdependent tasks. In the VDT simulation engine, organizations are conceptualized as a network of communication channels. Information is processed at nodes (actors) and different types of communications-like decisions or exceptions- are transmitted.

The VDT concept was extended to analyze project situations in which team members are involved in non-routine tasks, with a certain degree of flexibility on how they can be executed. Moreover, project team members could bring potentially incongruent goals to the project. This extension resulted in the Virtual Team Alliance (VTA) (Thomsen et al, 2005). Based on organizational theory and experimental social psychology, VTA accounts for factors that could moderate the effect of goal incongruence on the development of task conflicts and participants' behavioral responses. These factors are: activity flexibility -the size of the space of possible solutions that could satisfy activity requirements-activities interdependence, disparity in participants' competence, team experience in working together and supervisors' preference for micro-management.

VTA considers that higher activity flexibility would amplify the effect of goal incongruence, because the lack of alternatives would reduce the likelihood of conflict. Goal incongruence would have an effect on the actors involved in a relationship only if they are mutually interdependent (Thomson, 1967). One actor's awareness of his higher competence and skills in a particular area would make him avoid wasting time in a conflict with the other part perceived as less competent. The actor with higher expertise would simply appeal to a higher authority to resolve the conflict (Pfeffer, 1981). Team members with a high amount of experience working together would be more willing to cooperate with other team members. Because team members lack of knowledge about partners' future behaviors, they would rely on past experiences to assess them, thereby being more willing to compromise in case of conflict (March, 1995). Finally, managers with a tendency to micromanage would probably engage more in monitoring activities, reducing project team problem solving capabilities by reducing project team' s autonomy in case of high goal incongruence.

VTA also relies on actors' "canonical information processing micro-behaviors" to simulate project participants' behaviors while reacting to goal incongruence and conflict. These micro-behaviors are listed and described below.

- Exception Generation. Exceptions occur when the information available to an actor responsible for a certain activity is less than the information required. Exceptions can be technical errors or non-conformances. Non-conformances are originated in goal incongruence between supervisor and subordinate. Exceptions are forwarded to an appropriate supervisor who would decide how to handle it.
- Selective Delegation of Authority. Higher goal incongruence would lead managers to request a larger fraction of exceptions to be reported to them for decisions making.
- Information Exchange. VTA includes five "canonical interaction micro-behavioral processes" that actors develop in response to goal incongruence. These five processes are: monitoring, which incorporates all the specific activities managers develop to exert control; peer communication, including "steamrolling" -an actor appeals to a higher authority to force a partner to perform an action- and politicking -an actor persuades a partner to perform an action based on a promise of future concessions searching for alternatives to conflict, and goal clarification.

A VTA macro-behavior emerges as a product of the interaction between a certain level of goal incongruence, the "canonical micro-behaviors", and the factors that moderate the effect of goal incongruence on actors' behaviors. For low to intermediate levels of goal incongruence the diversity of behavioral selections available to the project team can be increased, improving project performance. However, higher levels of goal incongruence might lead to time consuming discussions and arguments, negatively impacting project performance. Hence, VTA predicts a U shape relationship between the level of goal incongruence and project performance. VDT and VTA have been validated in several test cases (Thomsen et al. 1998a, 1998b, 1998c).

VDT and VTA were developed under the premise that project team members belong to a single organization. However, the fact that the simulation models deal with how goal incongruence within a project team might affect project performance makes those models amenable for comparison to the models developed in this dissertation.

There are several similarities between the VDT/VTA models and the models developed as a product of the present research effort. Regarding the participants' behaviors as reactions to goal incongruence, the selective delegation of authority included in the VDT/VTA models was also found in our case 2. According to case 2 data, the lower the level of alignment -or higher the level of goal incongruence- the higher the level of management that needs to be involved to solve the goal conflict. The same is valid for monitoring behaviors. No evidence of the steamrolling and politicking mechanisms described in the VDT/VTA models was found in the cases studied here. Probably, the fact that in our cases the project team members belonged to different organizations made it more difficult to use those mechanisms, because there was a low level of trust induced by the low level of goal alignment. However, the searching of alternatives and goal clarification was in place in the cases studied here, but it was disrupted to some extent by the low level of trust and communication between the project team members.

Another fundamental difference between the VDT/VTA models and the findings of this research is that, in the VDT/VTA models' case, the level of communication increases to a certain point as the level of goal incongruence increases, because actors engage in the search for alternatives to solve the conflict. In the cases studied here, lower levels of alignment -or higher goal incongruence- would lead to lower levels of trust and communication. Again, this discrepancy could be attributed to the fact that in our cases project team members belong to different organizations and no relationship conflict was considered. However, this discrepancy should be subject of further research.

Concerning the contingency factors that might moderate the effect of goal incongruence on project team members' behaviors, the level of activity interdependence is significant for both VDT/VTA models and this dissertation models. A higher level of interdependence leads to a higher need of coordination and communication, amplifying the effect of goal incongruence (Gladstein, 1984). The disparity in actors' competence affected actors in case 1 in a different way from that assumed in the VDT/VTA models. The disparity in competence in case1 contributed to a low level of trust, and then to a higher level of effort in reviewing partners' work. On the other hand, the amount of experience that team members have accumulated working together seems to have a similar effect in the VDT/VDA models and the cases studied in this research. Higher levels of experience working together would allow partners to substitute direct knowledge of other partners' intentions for the project with inferences from past partners' behavior, determining the initial level of trust, communication and willingness to cooperate.

Finally, there is another difference between the VDT/VTA models and the models proposed in this dissertation. In case 1, the level of goal alignment affected project dynamics through the determination of a level of trust, communication and quality, as well as the ability to coordinate the deployment of effort when required. In case 2, the level of alignment affected trust and communication, and then the project team's ability to make opportune decisions that affected the deployment of effort. Conversely, VDT/VTA models emphasize the project team members' ability to find solutions to conflicts originated in goal incongruence in an efficient way.

The Bstieler Work

Bstieler (2006) examined the antecedents of trust formation and the effect of trust on new product development partnerships. Based on previous research, Bstieler suggested a model in which the level of communication, shared problem solving, perceived fairness, level of conflicts and the presence of egoistic behaviors are the antecedents of partnership efficacy and project performance. Trust plays the role of mediator between the aforementioned antecedents and the outcomes. To test the model, Bstieler conducted an empirical study of medium-size to large machinery manufacturers. Data for 44 new products developed through partnerships was collected from 34 different manufacturers.

The study findings support the significant impact of communications on trust formation. Timely and reliable information exchange permits partners to capture and understand other partners' thoughts, context and needs concerning the project, allowing the achievement of high levels of trust. Perceived fairness through a balanced distribution of project benefits also affects trust formation. On the other hand, the absence of conflicts was found to be the most important factor in trust development.

Trust was found to affect positively the performance measures employed in the study -product performance in the market, time efficiency and partnership satisfaction.

Trust was also found to act as a "balancing mechanism" mitigating the negative impact of conflicts on project performance. Finally, trust seems to positively impact the quality of communication between partners.

Although the Bstieler study is not focused on the effect of goal alignment on project performance, it is still relevant for this dissertation research because it shows that conflicts -lack of goal alignment is a source of conflicts in the cases studied- are a determinant factor in trust formation, and that trust has a positive impact on the quality of communication between partners and on project performance. Moreover, the level of communications between partners has a positive effect on the level of trust, completing the reinforcing loop described in this dissertation. These relationships are fundamental in the structure of the models developed in this dissertation, explaining how the level of goal alignment affects project performance in a multi-organizational project.

The Rodrigues and Williams Work

A study particularly relevant to the case 2 model is the one conducted by Rodrigues and Williams (1998). In that study, a system dynamic model was developed to analyze the impact of clients' behaviors on project performance. The authors developed their model based on previous system dynamic models aimed to illustrate and quantify the impact of disturbances introduced by one of the parties involved in a project (Cooper, 1980; Weil and Etherton, 1990; Willliams et al., 1995), in order to assist the other party in a dispute resolution. These models characterized the relationship between client and contractor by two communication processes: the continuous reporting of progress and achievement of major milestones, and the continuous revision of the product definition and functionality.

According to the data collected from the previous models, the report of progress toward milestones might generate dynamics in response to external disturbances that could affect project performance. In the case that the contractor fails to meet certain milestones, the level of client trust on the contractor would decrease. The contractor's way to recover from the schedule slippage could lead to worse overruns later. On the other hand, the client may not be willing to accept delays early in the project to favor success at later stages, leading the contractor to tamper solutions or to hide the delays. As a consequence, communications between contractor and client deteriorate, and conflicts become more counter-productive.

The continuous review of product specifications might also lead to communication problems between client and contractor. As the product is developed, intermediate sub-products are assessed by the client and the contractor. That assessment process is intended to identify misunderstandings concerning system requirements. However, the outcome of the process might be a growing disagreement between the parties. Clients tend to demand more functionality in the product that the contractors think they have agreed to, especially because of ambiguities in the contract. Differences in the criteria to approach the cost-functionality trade offs would lead to a reduction in the level of trust.

Rodrigues and Williams used these previously validated dynamics as assumptions for their model. However, the authors also collected data from another case to complete the model describing the influence of client behavior on project performance. The case was the development of a “Command and Fire” control system for the Korean Navy. The data collected from the case add the following dynamics to the model. First, the introduction of changes and the delay in approving design documents by the client leads the contractor to perform work out of sequence, deteriorating the level of quality. As more errors start to be detected, the contractor’s staff loses trust in the current definition of product specifications, which leads to a reduced productivity, affecting progress and inducing schedule slippages and schedule pressure. The schedule slippage tended to cause the deterioration of the client trust in the contractor’s project team, making the client to demand more and more reports, distracting the project team’s attention from project tasks to reporting tasks, reducing progress and creating more schedule slippage, in a reinforcing feedback loop of trust deterioration and productivity loss.

The model developed by Rodrigues and Williams was calibrated to real project data in a “post-mortem” analysis, and it was able to reproduce to a large extent the observed project behaviors, which provides confidence in its validity. The Rodrigues and Williams’ model has various implications for the models developed for this dissertation. First, in the particular case of the case 2 model, the impact of delays in approving documents by the client on project dynamics and performance observed by Rodrigues and Williams validates to some degree the case 2 model’s structure. A significant part of the impact of the level of goal alignment on project performance in the case 2 model is through delays in the client project team decision making process, which might lead to delays in the contractor work.

Second, the impact of a continuous revision of product specifications by the client as described by Rodrigues and Williams is to some degree similar to the impact of one of the partners' behavior in case 1, who is contractor and product user at the same time. That partner always wanted to stretch the product capabilities to the largest extent possible in order to satisfy all its requirements, even beyond cost and contractual considerations. As in the case studied by Rodrigues and Williams, the disagreement in the way to approach the product functionality -cost trade off - due to a low level of quality goal alignment- led to a deterioration of the level of trust and communication among the case 1's project partners, leading to lower levels of quality, more rework, schedule pressure and then to more quality problems, as well as difficulties in coordinating the deployment of the effort required on a timely basis.

The Black and Luna Work

In the literature review discussed in this dissertation, a mention was made of a system dynamics model attempting to represent the interaction between collaboration, trust and knowledge sharing in a multi-organizational project setting (Black et al., 2003). That model was the product of a case studying the development of an information system by an agency of the New York State government in collaboration with state funded housing services providers. The main assumption of the model is that collaborative work is entrenched in a series of reinforcing processes associated with participants learning partners' roles, needs, restrictions and objectives concerning the project work. The model encompasses three main parts: a project model simulating the dynamics of performing work -similar to the progress-rework cycles of the models developed in this dissertation- the stocks of knowledge of participants own and other partners' work with the resultant levels of trust and engagement to continue the collaborative effort, and the influence of a facilitator on the communicational exchanges between the participants.

The basic dynamics represented in the model are described as follows. A participant's engagement in the collaborative effort depends on her sense of progress and level of trust in other participants. The level of trust depends on how much a participant knows about other participants' roles, needs, constraints and objectives for the project. That knowledge accumulates as participants work together, and the higher the level of knowledge, the lower the probability of making mistakes, diminishing the amount of rework required, increasing productivity, progress and the level of engagement. The higher the level of engagement, the more partners work together, increasing their level of knowledge about their roles, constraints and objectives. Moreover, higher levels of trust lead to a higher probability of information sharing, increasing the level of knowledge about participants' roles, constraints and objectives in the project.

Even though the Black et al. model does not consider the effect of a possible lack of goal alignment in the collaborative effort, it is still relevant for this research effort because it provides evidence of the mutual relationship between trust and communication in a multi-organizational project setting, as well as of the influence of the level of communication between the participants in the project on quality and productivity.

A significant difference between the Black et al. model and the models proposed in this dissertation is the relationship between the levels of trust among participants in the project, the sense of progress and the participants' engagement in the collaborative effort. Black et al. found evidence in their case that the level of engagement of the entities participating in the project depended on the perception that the project objectives are being achieved, and on the level of trust between participants. On the other hand, in the cases studied in this dissertation research, that evidence was not found. In the cases studied here the level of trust affects the level of communication between partners, but not the level of engagement or effort deployed on the project. A possible explanation of that discrepancy is that the project studied by Black et al. was a completely collaborative one, where participants were involved in a "voluntary" way. Conversely, in the cases studied in this dissertation, the participants were "obliged" to participate and deliver products according to a contract. Hence, participants were not able to restrain effort if their objectives for the project were not accomplished because they were legally forced to do so.

The Andres and Zmud Work

Andres and Zmud (2002) advanced a research model suggesting that goal conflict, task interdependence and coordination strategies significantly affect productivity and satisfaction in software design projects. In their literature review the authors found that goal conflict can disrupt information exchange, undermine commitment, reduce team cohesion, and the team's ability to adapt to changes and to solve problems (Boehem and Ross, 1989; Amason and Schweiger, 1997). Hence, a hypothesis was proposed suggesting that software design activities characterized by low goal conflict would be more successful than software design activities characterized by high goal conflict conditions.

Task interdependence was another factor considered in the model. In the literature review, Andres and Zmud found that high levels of task interdependence required higher level of information exchange in order to clarify roles, assignments, project requirements, and progress. Productivity was reduced because of the efforts required to establish shared mental models concerning task requirements, which are needed for successful effort integration (Straus and McGrath, 1994). Moreover, the progress of a team member was often held up while waiting for an output produced by other team member (Saavedra et al., 1993). Then, a hypothesis was advanced suggesting that software activities characterized by low task interdependence are more successful than software design activities characterized by high task interdependence.

Concerning coordination strategies, Andres and Zmud used the characterization suggested by Burns and Stalker (1961) which classifies coordination strategies in organic -reflecting an informal, cooperative and decentralized strategy- and mechanistic - reflecting a formal, controlling and centralized strategy. Informal horizontal communications favor the performance of jointed problem solving activities, as well as task clarification, task sequencing and synchronization of activities. Moreover, a decentralized decision making strategy allows the decisions to be made at the most sensitive levels, minimizing decision making delays and increasing task performance efficiency. Hence, Andres and Zmud stated the following hypothesis: software design activities managed with a centralized coordination strategy are less successful than software design activities managed with an organic coordination strategy.

Andres and Zmud also advanced hypothesis concerning possible interactions between coordination strategy and task interdependence, and between coordination strategy and goal conflict. The model was tested through a 2x2x2 factorial experimental design, using MBA and MIS students as subjects. The experiment results showed that projects characterized by low task interdependence displayed higher productivity than projects with higher tasks interdependence. Projects managed with an organic coordination strategy were more productive than projects managed with a mechanistic coordination strategy. Organic coordination was more successful in projects characterized for high tasks interdependence than in projects with low tasks interdependence.

As predicted, goal conflict was found negatively associated with productivity, although not in statistically significant way. However, the findings regarding the interaction between goal conflict and task interdependence contrasted with the hypotheses formulated. The effect of goal conflict on productivity was not found to be exacerbated by higher levels of task interdependence, as the proposed hypothesis suggested. Andres and Zmud offered an explanation for the absence of the expected interaction. They suggest that larger task durations were required to develop the negative effects of goal conflict, including reduced effort commitment and task integration difficulties.

The Andres and Zmud's work explores relationships included in the structures of the models proposed in this dissertation, although not in a multi-organizational project setting. The study findings underline the effect of the level of communication between project team members on productivity, in particular when the tasks performed are highly interdependent. Moreover, the relationship between a more autonomous decision making and task performing productivity is also supported -relevant in particular for model 2.

However, the study findings concerning the interaction between task interdependence and goal conflict are not in line with the structure of the models developed in this dissertation, in which higher levels of interdependence amplify the effects of goal conflict. The fact that the model developed by Andres and Zmud was tested in an experimental setting and not in a real life multi-organizational project could also contribute to explain the non- significant effect of goal conflict on productivity. That also could explain the fact that the effect of higher levels of goal conflict did not seem to be intensified by higher levels of tasks interdependence. In a real multi-organizational project, the intensity of a real goal conflict can be much higher, because project participants need to support and defend their organizations' goals for the project.

The Green and Keogh Work

To complete the comparison of the models' structures with relationships described in related past research, the results of an analysis conducted on 63 conference papers describing practitioners' experiences in alliances (Green and Keogh,2000) is discussed. These alliances were constituted to accomplish large oil production projects in the North Sea. In these 63 papers presented between 1993 and 1998, the factors related to alliances' success that were more frequently mentioned were: shared vision and objectives (37 times), open communications at all levels, without hidden agendas (27 times), integrated teams (27 times), high level of trust (23 times), senior management involvement (21), and risk –reward structures to enable goal alignment (19).

These factors mentioned by the practitioners as critical for multi-organizational projects' success, are to a large degree similar to the concepts contained in the structure of the models developed in this dissertation to explain how the level of alignment might affect multi-organizational project performance. In particular, trust and communication between partners, as well as management involvement in project problems, are fundamental factors in the structure of the models developed. In spite of the fact that the experiences captured in the studied papers are particular to the North Sea oil production projects -and that the data analysis does not provide an explanation about "how" those factors affect project performance- these experiences provide support for some of the relationships that constitute the basic structures of the models' advance in this dissertation.

As a conclusion, there is evidence in the literature that provides support for most of the relationships between the factors involved in the dynamics observed within the studied multi-organizational projects. These relationships constitute the structures of the models that attempt to represent the projects' system behaviors responding to variations in the level of goal alignment among the participating organizations. A table summarizing the reviewed literature and how its findings support or contradict the model structures is presented below.

Authors	**Research Question**	**Methodology**	**Independent Variables**	**Dependent Variables**	**Findings**	**Models Structures Supported or Challenged**
O Sullivan (2003)	How does the imposition of administrative standards for work content and timing affect the performance of a virtual multi-organizational product development project?	Action Case Study	Implementation of: Modularization Work Standardization Master Schedule Co-location	Levels of: Participants mutual adaptation Work synchronization Need for communication Project performance	The implementation of modularization, work standardization , master schedule and co-location of project managers permitted the reduction of the need for communication, a higher work synchronization, an early definition of requirements and higher project performance	Effect of communications on coordination, work synchronization, requirements definition and then on project performance
Jin and Levitt (1996) Thomsen ,Levitt and Nass (2005)	How does the level of goal incongruence affect actors' behaviors and project performance?	Development of a simulation model based on theoretical assumptions, and tested later in cases studies	Level of goal incongruence. Moderators: Activities flexibility Activities interdependence Disparity in participants' competence Team experience in working together Supervisors' preference for micro-management.	Project performance: Schedule Quality Cost	For low to intermediate levels of goal incongruence the diversity of behavioral selections available to the project team can be increased, improving project performance. However, higher levels of goal incongruence might lead to time consuming discussions and arguments, impacting negatively project performance	High goal incongruence leads to higher levels of management involved in decision making Moderating effects of tasks interdependence, Previous experience working together and disparity in levels of actors competence Challenge: Positive effect of intermediate levels of goal incongruence on performance

Table 6-2: Summary of the Reviewed Literature for the Assessment of the Models Structures

Authors	Research Question	Methodology	Independent Variables	Dependent Variables	Findings	Models Structures Supported or Challenged
Bstieler (2006)	What are the antecedents of trust formation and their effect of trust on new product development Partnerships?	Survey, cross-sectional research	Level of communication, shared problem solving, perceived fairness, the level of conflicts and the presence of egoistic behaviors	Partnership efficacy and project performance Mediator: Level of trust	There is a Positive impact of communications on trust formation. Perceived fairness through a balanced distribution of project benefits also affects trust formation. The absence of conflicts was found to be the most important factor in trust development. Trust was found to affect positively the performance measures employed in the study. Finally, trust seems to positively impact the quality of communication between partners.	Conflicts are a determinant factor in trust formation, and that trust has a positive impact on the quality of communication between partners and on project performance. The level of communications between partners has a positive effect on the level of trust, completing the reinforcing loop described in this dissertation.

Table6-2: Summary of the Reviewed Literature for the Assessment of the Models Structures (Continued)

Authors	Research Question	Methodology	Independent Variables	Dependent Variables	Findings	Models Structures Supported or Challenged
Rodrigues and Williams (1998)	How client's behaviors affect project performance?	Case study, system dynamics modeling.	Introduction of changes. Delays in client decision making process	Project Performance	The introduction of changes and the delay in approving design documents by the client lead the contractor to do work out of sequence, deteriorating the level of quality. Contractor's staff loses trust in the current definition of product specifications, leading to a reduced productivity, and progress. The schedule slippage reduces the client trust in the contractor's project team, making the client to demand more and more reports, distracting project team's attention from project tasks to reporting tasks, reducing progress and leading to more trust and productivity loses.	A part of the impact of the level of goal alignment on project performance in case 2 is through delays in the client project team decision making process, reducing progress rate. The impact of a continuous revision of product specifications by the client is similar to the impact of one of partners' behavior in case 1. That partner always wanted to increase the product capabilities, even beyond cost considerations. That led to a deterioration of the level of trust and communication, and to more quality problems, as well as to difficulties in coordinating the deployment of effort.

Table6-2: Summary of the Reviewed Literature for the Assessment of the Models Structures (Continued)

Authors	Research Question	Methodology	Independent Variables	Dependent Variables	Findings	Models Structures Supported or Challenged
Black et al. (2002).	How does collaborative work in multi-organizational projects is affected by reinforcing processes associated with mutual trust, and participants learning Partners' roles, needs, restrictions and objectives concerning the project work?	Case study, system dynamics modeling.	Level of mutual trust. Sense of progress Knowledge about Partners roles, intentions, constraints and objectives	Level of engagement in collaborative work Project Performance	A participant engagement in the collaborative effort depends on her sense of progress and level of trust in other participants. The level of trust depends on how much a participant knows about other participants' roles, needs, constraints and objectives for the project. That knowledge accumulates as participants work together, and the higher the level of knowledge, the higher the quality level, diminishing the amount of rework required, increasing productivity, progress and the level of engagement Higher levels of trust lead to a higher probability of information sharing, increasing the level of knowledge about participants' roles, constraints and objectives in the project.	This study provides evidence of the mutual relationship between trust and communication in a multi-organizational project setting, as well as of the influence of the level of communication between the participants in the project on quality and productivity. Challenge: Black et al. found evidence in their case that the level of engagement of the entities participating in the project depended on the perception that the project objectives are being achieved, and on the level of trust between participants. On the other hand, in the cases studied in this dissertation research, that evidence was not found

Table6-2: Summary of the Reviewed Literature for the Assessment of the Models Structures (Continued)

Authors	Research Question	Methodology	Independent Variables	Dependent Variables	Findings	Models Structures Supported or Challenged
Andres and Zmud (2002)	Does goal conflict, task interdependence and coordination strategy significantly affect productivity and satisfaction in software design projects?	2x2x2 factorial experiment	Goal conflict Tasks interdependence Coordination strategies Interaction between goal conflict and coordination strategy Interaction between task interdependence and coordination strategy.	Productivity Project team member satisfaction	Goal conflict was found negatively associated with productivity, although not in statistically significant way. The effect of goal conflict on productivity was not found to be intensified by higher levels of task interdependence Projects characterized by low task interdependence displayed higher productivity than projects with higher tasks interdependence Projects managed with an organic coordination strategy were more productive than projects managed with a mechanistic coordination strategy., in particular l in projects characterized for high tasks interdependence	The study findings underline the effect of the level of communication between project team members on productivity, in particular when the tasks performed are highly interdependent. Moreover, the relationship between a more autonomous decision making and task performing productivity is also supported (relevant in particular for model 2). Challenge: The study findings concerning the interaction between task interdependence and goal conflict are not in line with the structure of the models developed in this dissertation.
Green and Keogh (2000)	What are the factors associated to alliances success, according to practitioners' experiences in north sea projects alliances?	Analysis of papers submitted by practitioners in conferences between 1993 and 1998.			The most mentioned factors are: Shared vision and objectives, open communications at all levels without hidden agendas, integrated teams, high level of, senior management involvement, and risk –reward strategies for goal alignment.	Trust and communication between partners, as well as management involvement in project problems, are fundamental concepts in the structure of the models developed in this dissertation.

Table 6-2: Summary of the Reviewed Literature for the Assessment of the Models Structures (Continued)

6.3 Model Simulations and Model Behavior Analysis

The qualitative data collected through the case interviews provided the base for the models' structure. However, to perform the model simulations quantitative data is required to define the shape of the relationships between model variables. The shape of the relationships between variables might have a significant impact on system dynamics model behaviors (Luna, 2004). As mentioned in the research methodology section, it was not possible to collect quantitative data during the cases studies that would allow the definition of those relationships. Hence, a strategy developed by Ford (1995) was adapted to define the shape of the relationships between model variables to be used during the simulations.

The strategy consists of devising three possible scenarios for setting the relationship shapes: positive, linear or neutral, and negative. In the positive scenario, relationship shapes would improve, according to the model structure, measures of project performance. In the neutral or linear scenario, all relationships between variables are assumed linear. Finally, in the negative scenario relationship shapes are set in a way that might worsen measures of project performance. The shapes of the relationships are assumed to be exponential, linear or hyperbolic (see Fig. 6-1)

Once the relationships had been set for each scenario, a sensitivity analysis was performed, setting the level of goal alignment between partners at a low, intermediate and high level. Then, the variations observed in measures of project performance-quality, effort deployed, scope reduced, and work completed-while varying the level of goal alignment in the case of each scenario were compared and analyzed.

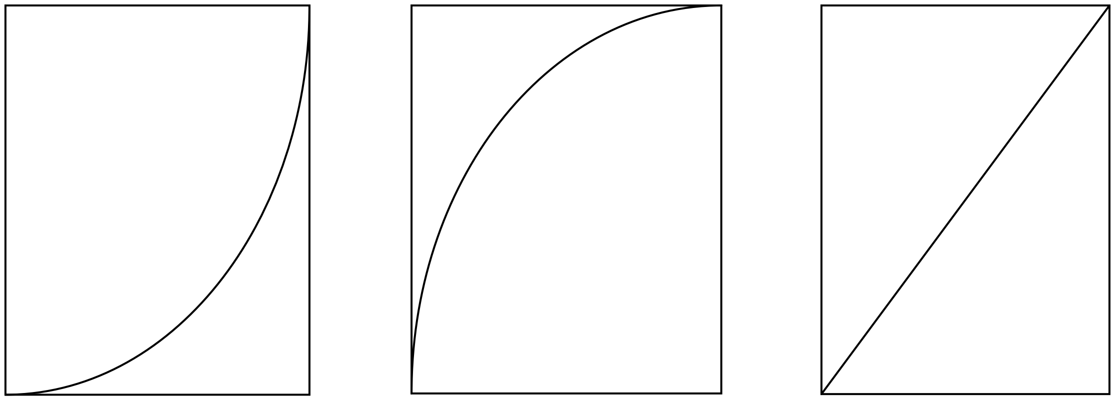


Figure 6-1: Proposed Models Relationships Shapes.

The scenario in which the measures of project performance were less affected in a negative way by variations in the level of goal alignment was selected to perform that sensitivity analysis. Because the purpose of the model is to illustrate how the level of goal alignment might affect project performance, that scenario was more conservative in the sense that it presents those effects in the most positive way. Once the scenario had been selected and the relationships between model variables had been set, further sensitivity analysis can be performed to investigate possible moderating effects of exogenous variables on the dynamics mediating between the level of goal alignment and project performance. In the next section, the relationships between variables are defined for each model.

Definition of Relationships Shapes for Case 1 Model

The relationships which shapes needed to be defined to perform the sensitivity analysis and to study project behavior are shown in Table 6-3 , as well as the shape of each relationship associated to the positive, neutral or negative scenarios. Relationship shapes were assigned to the scenarios according to their potential effect on measures of project performance.

For example, in the case of the positive scenario for model 1, the relationship between level of communication and quality was assigned with a hyperbolic shape. Because higher levels of communication lead to higher quality according to the case data, a hyperbolic shape of the relationship would intensify that positive effect because at each level of communication the hyperbolic shape returns a higher level of quality than the linear or exponential shapes. On the other hand, the effect of schedule pressure on quality was assigned with an exponential shape for the positive scenario. In this case, higher levels of schedule pressure lead to lower levels of quality. Hence, an exponential shape would diminish the effect of schedule pressure on quality, which is required in the positive scenario.

To define the scenario that provides better project performance measures, the following sensitivity analysis was performed. Model parameters were set at an average level, except the level of priority assigned to the quality goal by Partner 1, which was set at low, intermediate and high levels. Because the level of priority assigned to the quality goal by the Partner 2 was fixed at an intermediate level, high, intermediate and low levels of alignment were generated.

Relationship	Negative	Neutral	Positive
Effect of communication on quality	exp	lin	hyper
Effect of schedule pressure on quality	hyper	lin	exp
Effect of quality priority on quality	exp	lin	hyper
Effect of communication on coordinated effort	exp	lin	hyper
Effect of schedule pressure on additional effort	exp	lin	hyper
Effect of trust on communication	exp	lin	hyper
Effect of scope priority on resistance to reduce scope	exp	lin	hyper
Effect of scope reduction on schedule pressure	exp	lin	hyper
Relationship between schedule slippage. and schedule pressure	hyper	lin	exp
Relationship between communication and inf. trans. Duration	hyper	lin	exp
Relationship between schedule pressure, resistance to reduce scope and scope reduction rate	hyper	lin	exp

Table 6-3: Relationships Shapes for each Case 1 Scenario

The following parameters were used for the sensitivity analysis:

Scope Priority 2 =0.5
Scope priority1= 0.5
Quality Priority2=0.5
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=0.5
Initial Trust in 2=0.5
Potential communication=0.5
Fraction of work to be coordinated=0.5
Fraction of work done by 1 and used by 2=0.5
Fraction of work done by 2 and used by 2=0.5

Quality Priority1 is set at 0.1, 0.5, and 0.9

The output of the sensitivity analysis is presented in Table 6-4. The project performance measures -work done, quality, total effort deployed and scope reduced- are better for the positive scenario when compared to the linear and negative scenarios. In order to be conservative in depicting the effects of goal alignment on the studied multi-organizational projects performance, the relationships associated to the positive scenario were selected for further use in the exploration of model behavior.

Scenario	Positive			Linear			Negative		
Level of Alignment	0.1	0.5	0.9	0.1	0.5	0.9	0.1	0.5	0.9
Work done 1	22.72	68.22	70.48	1.98	17.98	34.58	0.18	1.49	6.30
Work done 2	81.11	87.99	86.63	38.41	39.98	39.44	3.67	3.68	3.68
Quality1	0.18	0.62	0.72	0.02	0.15	0.30	0.00	0.01	0.06
Quality2	0.51	0.53	0.51	0.18	0.19	0.18	0.02	0.02	0.02
Total effort 1	156.22	137.77	133.72	175.48	164.44	152.37	183.15	182.23	178.29
Total effort 2	127.81	128.22	126.36	130.19	130.00	129.38	161.00	161.00	160.98
Scope reduction1	0.26	0.04	0.03	16.86	14.15	11.13	17.83	17.62	16.81
Scope reduction2	0.03	0.01	0.01	9.89	10.82	12.28	11.64	11.60	11.75

Table 6-4: Sensitivity Analysis Output for each Case 1 Scenario

The selection of the positive scenario is conservative in the sense that it minimizes the potential negative impact of variations in the level of goal alignment on project performance.

Definition of Relationships Shapes for Case 2 Model

The shapes of the relationships between model 2 variables were defined in a similar way as the model 1 case. The relationships which shapes needed to be defined are shown in Table 6-5, as well as the shape of each relationship associated to the positive, neutral or negative scenarios. As in the model 1 case, to define the scenario that provides better project performance measures, a sensitivity analysis was performed.

Relationship	positive	neutral	negative
Increment in time required for decision making	exp	lin	hyper
Reduction in time required for decision making	hyper	lin	exp
Decision making effect on progress	hyper	lin	exp
Rate of problem solving	hyper	lin	exp
Reduction in time available for contractor supervision	exp	lin	hyper
Effect of time available for contractor supervision on project team effort for reviewing contractors' work	hyper	lin	exp
Effect of time available for contractor supervision on additional effort deployment	hyper	lin	exp
Effect of schedule slippage on additional effort deployment	hyper	lin	exp
Effect of trust on communication	hyper	lin	exp

Table 6-5: Relationships Shapes for each Case 2 Scenario

Model parameters were set at an average level, except the level of goal alignment, which was set at a low, intermediate and high level. The following parameters were used for the sensitivity analysis:

Potential Quality=1
Potential Communication among Partners= 0.5
Management understanding of the project=0.5
Fraction of contractor work to be reviewed by the project team=0.5
Initial level of trust between Partners=0.5
Project team-contractor information transmission duration=3
Fraction of contractor work that requires feedback=0.5

Alignment levels=0.1, 0.5, 0.9

Scenario	Positive			Linear			Negative		
Level of Alignment	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done	95.07	96.20	97.70	78.32	84.06	87.76	62.89	66.18	69.47
Quality	0.86	0.90	0.95	0.61	0.68	0.75	0.53	0.56	0.59
Total effort	149.05	142.51	133.54	182.46	178.03	172.03	161.09	159.98	158.91

Table 6-6: Sensitivity Analysis Output for each Case 1 Scenario

Again, the simulation output shows that the project performance measures are better -showing the lesser negative impact on project performance- for the positive scenario when compared to the linear and negative scenarios (see Table 6-6). Hence, the relationship shapes associated to the positive scenario were selected for further model's behavior exploration.

6.3.1 Case 1 Model Behavior Analysis

Case 1 Basic Model Behavior

The purpose of the model is to represent the behavior of the multi-organizational project studied in case 1 under different levels of participant organizations' goal alignment. In the specific case of model 1, the project work is executed by the project team, which is constituted by personnel coming from the two participant organizations. Assessing the validity of the model is assessing to what extent the model accomplishes its purpose (Barlas, 1996). Hence, it is required to evaluate to what extent the model displays plausible behaviors in agreement with the case data while performing a sensitivity analysis. To perform the analysis, the level of goal alignment was varied, and then the effect of that variation on project performance indicators -work performed, quality, effort required, and scope reduction- was evaluated. The model would be useful to its purpose of representing the behavior of the studied multi-organizational project system if it is able to reproduce to a significant degree the behavior described in the data collected during the case study.

Because the model behavior is also affected by the rest of the variables -level of interdependence between partners for task execution, potential quality, initial trust and potential communication- the sensitivity analysis was performed in two stages. First, the model behavior was simulated under the exogenous variables' average conditions. In that case, most exogenous variables were assumed to be at an intermediate level of their range -all exogenous variables were assumed to vary in a 0-1 range. In the second stage, the exogenous variables were assigned extreme values, just like in the extreme conditions test described in Chapter 3. These conditions are assumed to be positive and negative. Positive condition would reinforce the effects of goal alignment on improving project performance. On then other hand, negative conditions would reinforce the effects of goal alignment that hinder project performance. In the following section, those conditions and their effect on how the level of goal affects project performance are described.

Analysis of Case 1 Model's Behavior under Average Conditions and Scope Priority Fixed

As mentioned above, for the average conditions the exogenous variables assume an intermediate value. In the model 1's case, the level of goal alignment among the partners is determined by the level of agreement on the priority assigned by each partner to the quality and scope goals. Hence, for each condition -average, positive and negative- two scenarios were analyzed. In one scenario, the scope priority was fixed at the same level for both participants, while the quality priority was fixed for one participant, and set at three different levels for the other, generating three different levels of quality goal alignment. In the second scenario, the quality priority was fixed at the same level for the two participants, while the scope priority was fixed for one participant, and set at three different levels for the other, generating three different levels of scope goal alignment.

Average Conditions (Scope Priority fixed):

Scope Priority 2 =0.5
Scope Priority1= 0.5
Quality Priority2=0.5
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=0.5
Initial Trust in 2=0.5
Potential communication=0.5
Fraction of work to be coordinated=0.5
Fraction of work done by 1 and used by 2=0.5
Fraction of work done by 2 and used by 2=0.5
Quality Priority1 is set at 0.1, 0.5, and 0.9

In the average conditions, the model's parameters related to the exogenous variables -level of interdependence, potential communication between partners, and initial level of trust among them- were set at an intermediate value. Only the value of potential quality was set at the maximum value, assuming that the resources available to perform project tasks -personnel and technology- fit tasks' requirements. Because the Quality Priority 2 was set at a 0.5 level, when Quality Priority 1 was also set a 0.5 level, the level of goal alignment reached the highest value. On the other hand, when the Quality Priority value was set at 0.1, and 0.9, the level of alignment was lower.

According to the case data, the level of alignment influences the level of communication between partners. In the Fig. 6-2, it can be seen that the maximum potential level of communication is kept for the case of maximum alignment (curve 2). Lower levels of alignment lead to a reduced level of trust among partners, and then to a lower level of communication (curves 1 and 3).

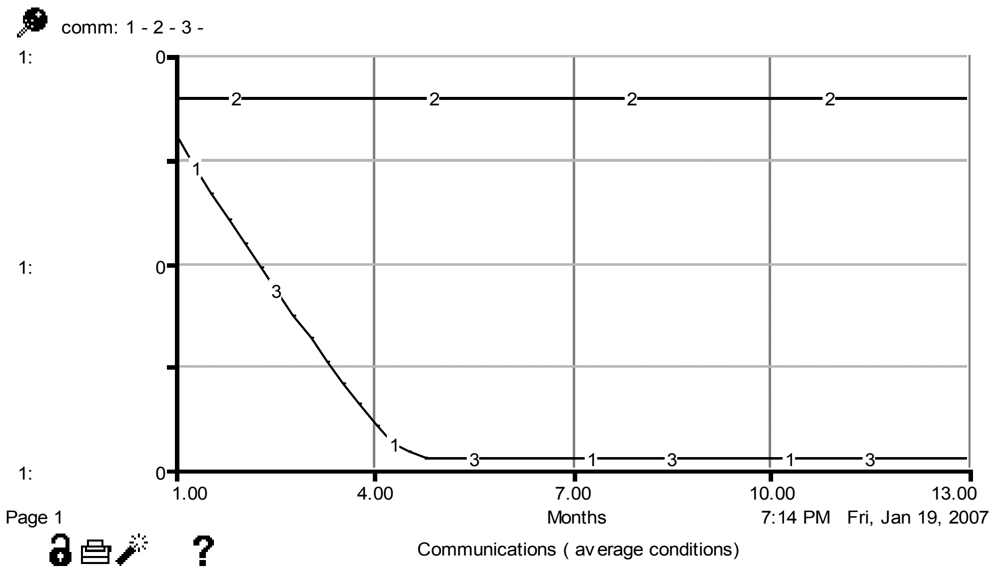
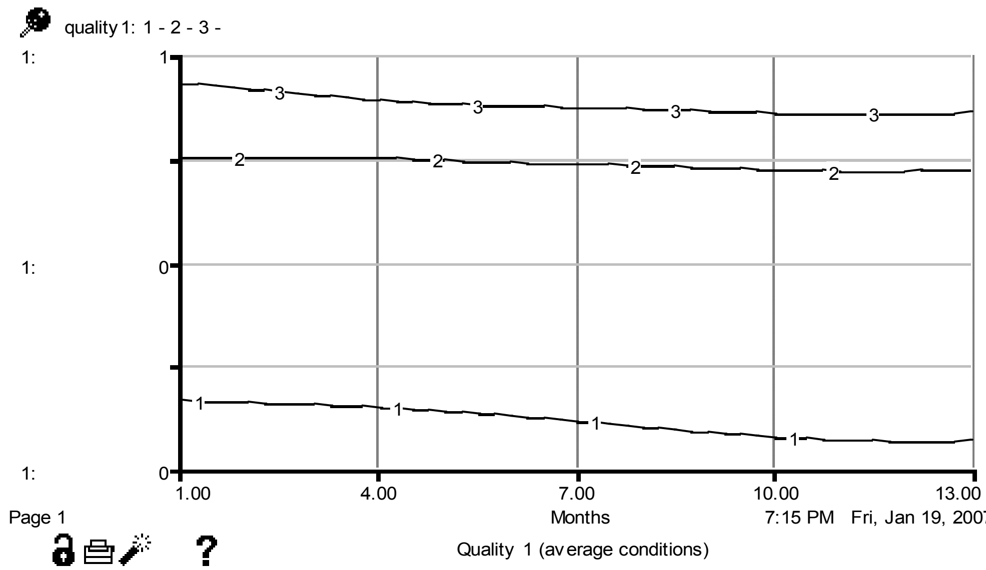


Figure 6-2: Case 1 Level of Communications (Avg. Conditions and Scope Priority Fixed)

As the knowledge about partner's intentions and objectives for the project accumulates during project execution, the weight of the initial trust in the trust formation equation is reduced, while the weight of the perceived level of goal alignment increases. Hence, when the level of alignment is low, the levels of trust and communication between partners decrease as project progresses.

In the Figs. 6-3 and 6-4, the behavior of the quality variable for both partners is shown. The quality priority for Partner 2 (Quality Priority2) was set at an intermediate level (0.5). Therefore, the level of quality goal alignment has a relatively higher weight in quality formation for Partner 2 than the level of priority of the quality goal. In consequence, the maximum level of quality is reached at the highest level of alignment (curve 2). For the lower levels of alignment (curves 2 and 3), the lower level of communication between partners leads to a continuous reduction in the quality level.



. Figure 6-3: Case 1 Level of Quality 1 (Avg. Conditions and Scope Priority Fixed)

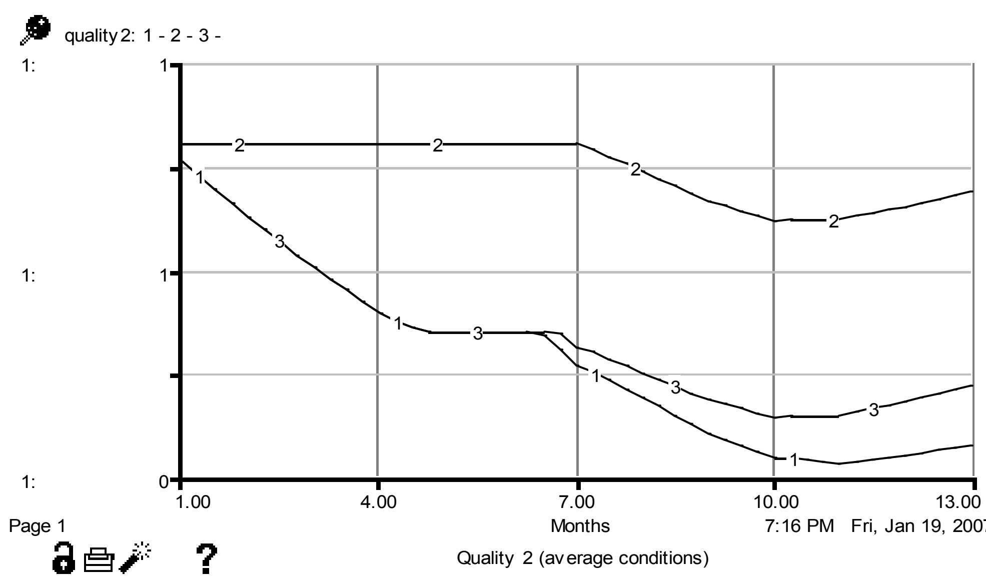


Figure 6-4: Case 1 Level of Quality 2 (Avg. Conditions and Scope Priority Fixed)

On the other hand, the level of quality priority for Partner 1 (Quality Priority1) is set at three different levels. In this case, each level of quality priority is associated with a level of quality. The highest level of quality is achieved when Quality Priority 1 was set at the highest level (curve 3 in Fig. 6-3). The second level of quality is achieved with the second level of quality priority and with the additional support of the highest level of alignment -both Quality Priority1 and Quality Priority 2 were set at the same level of 0.5. The higher level of alignment explains the fact that curve 2 is much closer to curve 3 than to curve 1, which corresponds to the lowest level of quality priority.

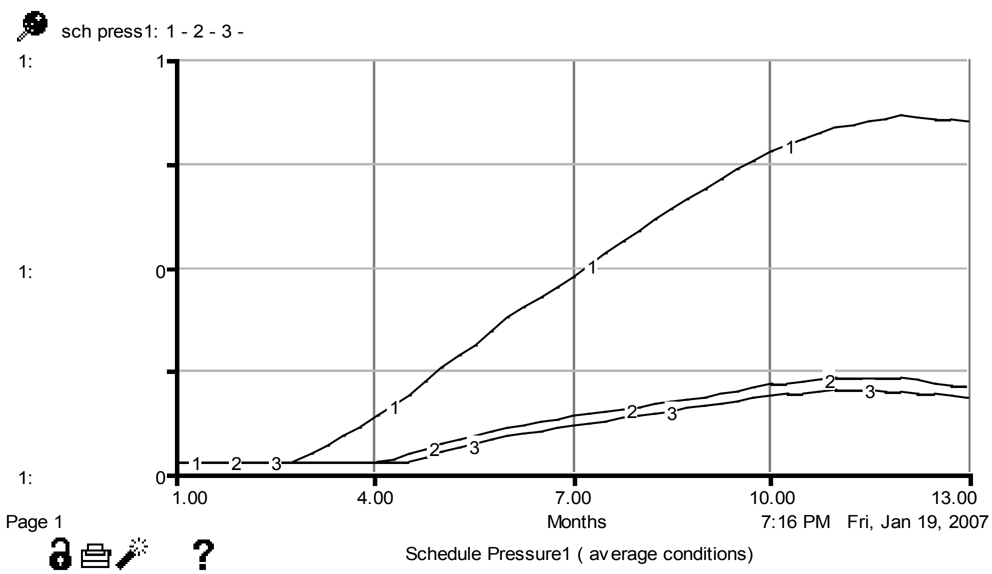


Figure 6-5: Case 1 Level of Schedule Pressure 1 (Avg. Conditions and Scope Priority Fixed)

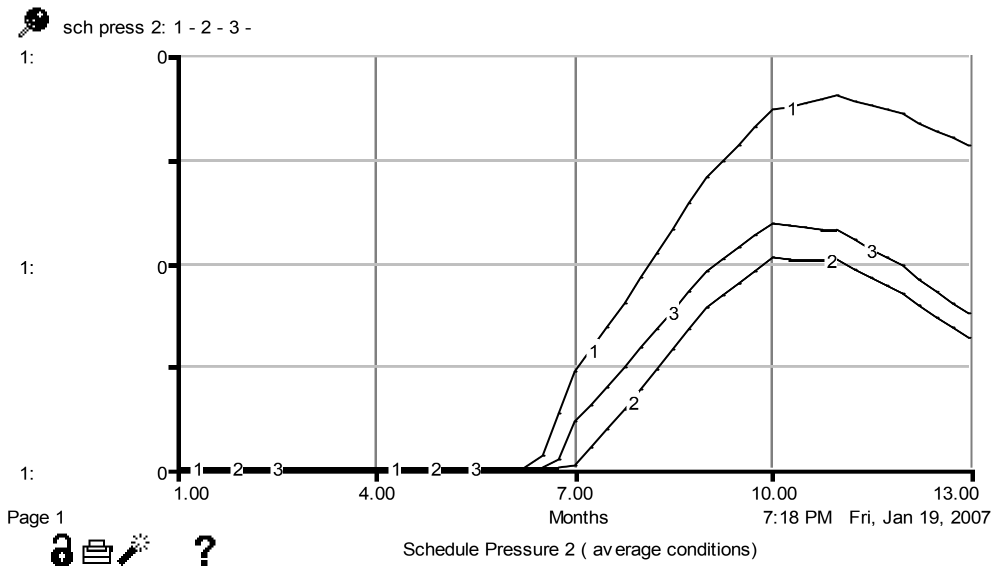


Figure 6-6: Case 1 Level of Schedule Pressure 2 (Avg. Conditions and Scope Priority Fixed)

If at a certain point of the execution of the project the amount of work performed is less than the expected at that point, schedule slippage and schedule pressure are generated (see Figs. 6-5 and 6-6). The schedule pressure on Partner 1 (sch press1) is much higher when the level of Quality Priority 1 was set at the minimum level (curve 1 in Fig .6-5). Because the level of quality is low due to low quality priority and a low level of alignment, more work performed requires rework, reducing progress and then leading to schedule slippage. The intermediate level of Quality Priority 1 leads to higher alignment, higher level of partners' communication and higher quality, therefore reducing the level of schedule pressure. The high level of Quality Priority 1 leads to higher quality and less rework, schedule slippage and schedule pressure.

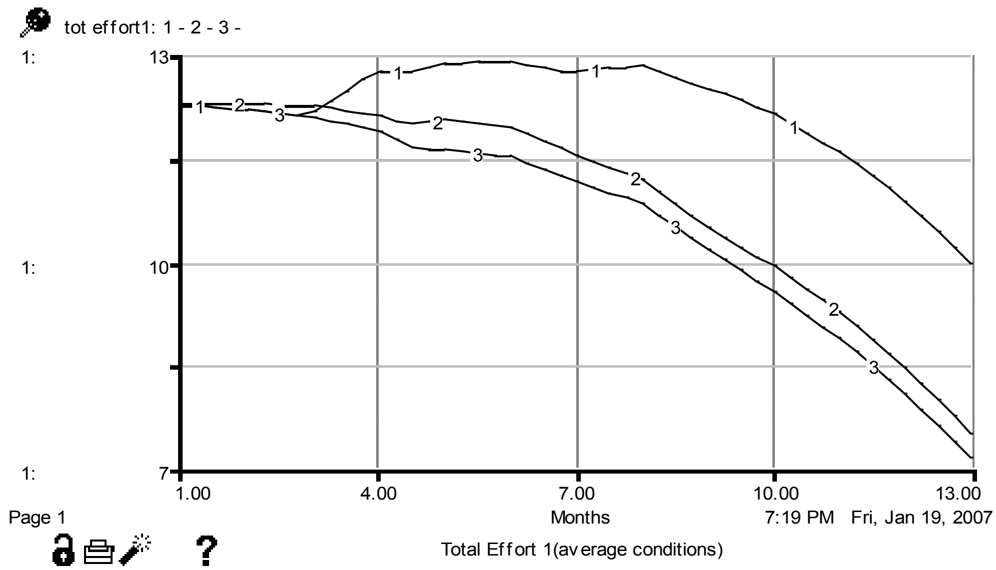


Figure 6-7: Case 1 Level of Total Effort 1 (Avg. Conditions and Scope Priority Fixed)

The amount of effort required to complete project tasks is associated with project cost performance. In the case of Partner 1, the effect of the level of quality priority is added to the effect of the level of goal alignment to generate the level of quality. The higher level of quality generated by the high level of quality priority reduces the necessity of rework and of additional effort to cope with schedule slippage, and then the total effort deployed (curve 3, Fig. 6-7). The high level of alignment -both partners have the same level of quality priority- and the intermediate level of quality priority also lead to a high level of quality, less rework and less effort deployed (curve 2 in Fig. 6-7). Conversely, the low level of alignment and the low level of quality lead to a low level of quality, more rework and more additional effort required to complete the project tasks (curve 1 in Fig.6-7).

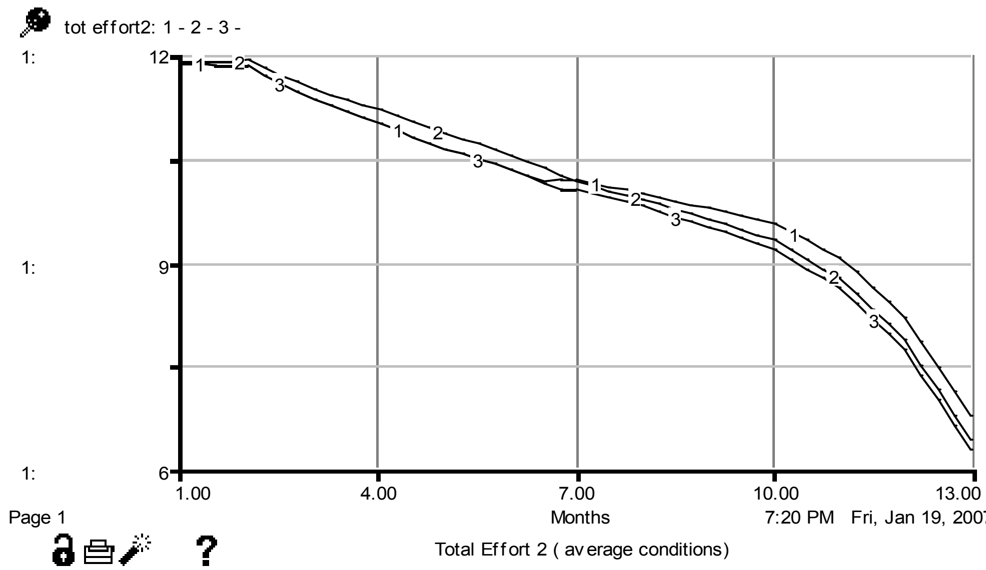


Figure 6-8: Case 1 Level of Total Effort 2 (Avg. Conditions and Scope Priority Fixed)

In the case of Partner 2, there is no significant difference between the amounts of effort deployed when the Partner 1's quality priority is varied. The low level of alignment generated by the low level assigned to the quality goal by the Partner 1 lead to a low level of trust and then to a higher effort deployed by Partner 2 to review Partner 1's work (see curve 1, Fig. 6-8). On the other hand, the higher level of communication generated by the higher level of alignment (curve 2, Fig.6-8) affects positively the level of effort that requires coordination between partners. Hence, the level of total effort deployed by Partner 2 did not vary significantly when the level of quality goal alignment changes.

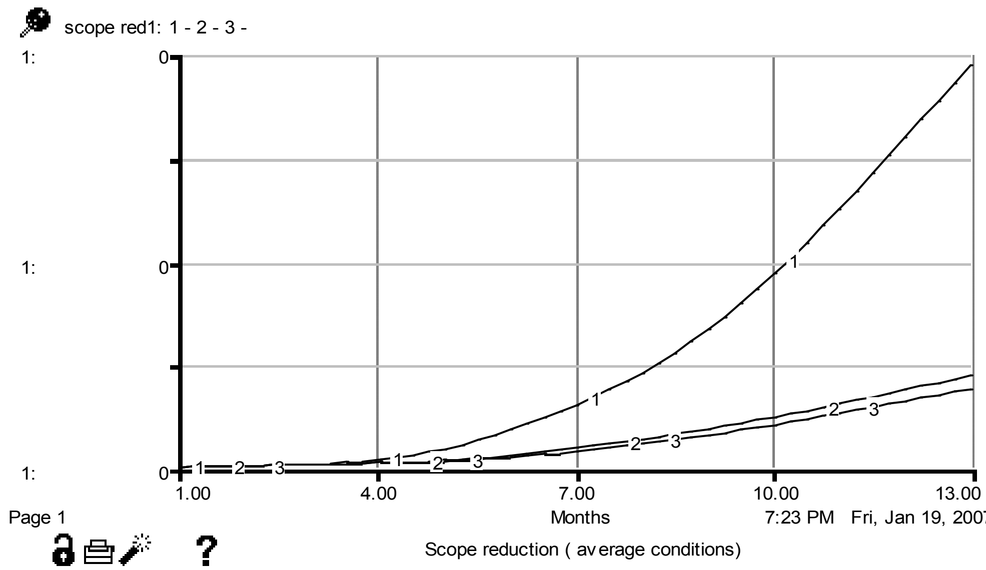


Figure 6-9: Case 1 Level of Scope Reduction 1(Avg. Conditions and Scope Priority Fixed)

Concerning scope reduction, it is not significant for any of the two partners. However, for Partner 1 the amount of scope reduced is higher for the lowest quality priority (curve 1 in Fig.6-9). The scope reduction in this case is a response to the higher level of schedule pressure generated by the schedule slippage associated to a higher amount of rework required.

For Partner 2, the amount of scope reduction is also associated to the level of schedule pressure. However, in Partner 2's case the difference between the amounts of scope reduced is less significant when the level of quality goal alignment is varied (see Fig. 6-10). These variations are the product of changes in the level of alignment and trust between partners, which affect quality, rework, schedule slippage and schedule pressure. Hence, the minimal amount of scope reduction is produced when both partners assign the same level of priority to quality goals and the level of alignment is maximized (see curve 2 in Fig. 6-10).

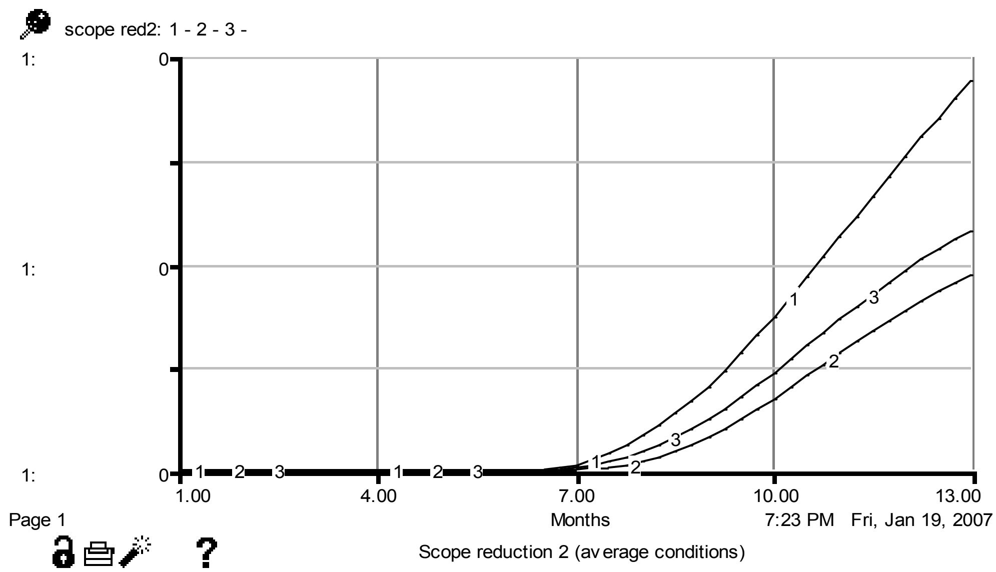


Figure 6-10: Case 1 Level of Scope Reduction 2 (Avg. Conditions and Scope Priority Fixed)

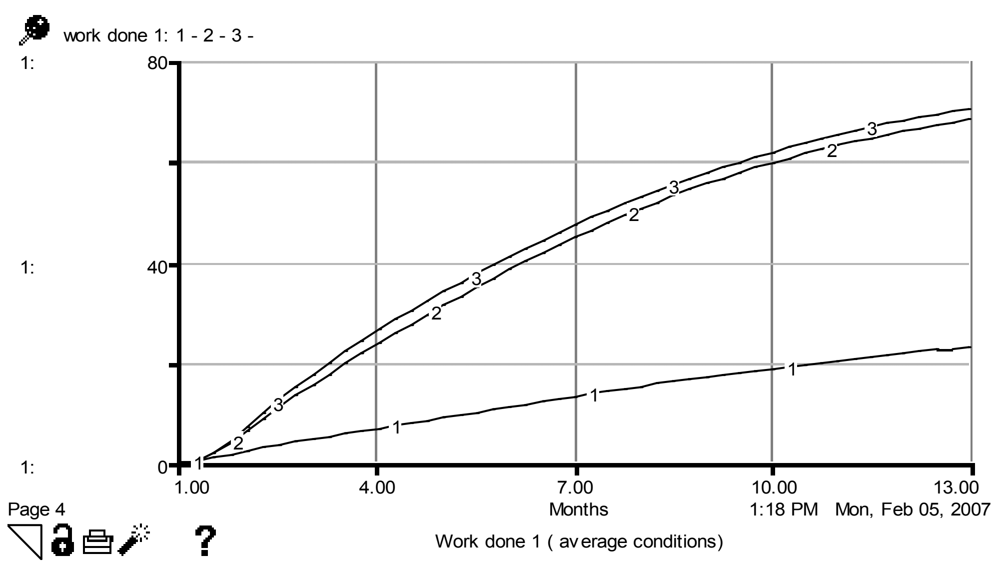


Figure 6-11: Case 1 Level of Work Done 1 (Avg. Conditions and Scope Priority Fixed)

As a consequence of the behaviors described above, the amount of work completed in the case of Partner 1 is higher when the quality priority is maximized (curve 3 in Fig. 6-11) and when the level of alignment is maximized (curve 2 in Fig. 6-11). Because the level of quality priority is fixed at an average value in the case of Partner 2, the differences in work completed generated by the variation of the level of Partner 1's quality priority can be attributed only to the variation of the level of goal alignment. Hence, those differences are less significant than the differences observed for Partner 1.

Analysis of Case 1 Model's Behavior under Average Conditions and Quality Priority Fixed

In this average conditions scenario, the level of quality priority was fixed for both project participants, and the level of priority assigned to the scope goal by Partner 1 was set at low (0.1), intermediate (0.5), and high (0.9) levels. The level of scope priority was fixed at an intermediate (0.5) level for Partner 2.

Average Conditions (Quality Priority fixed):

Scope Priority 2 =0.5
Quality Priority1= 0.5
Quality Priority2=0.5
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=0.5
Initial Trust in 2=0.5
Potential communication=0.5
Fraction of work to be coordinated=0.5
Fraction of work done by 1 and used by 2=0.5
Fraction of work done by 2 and used by 2=0.5
Scope Priority 1 is set at 0.1, 0.5, 0.9

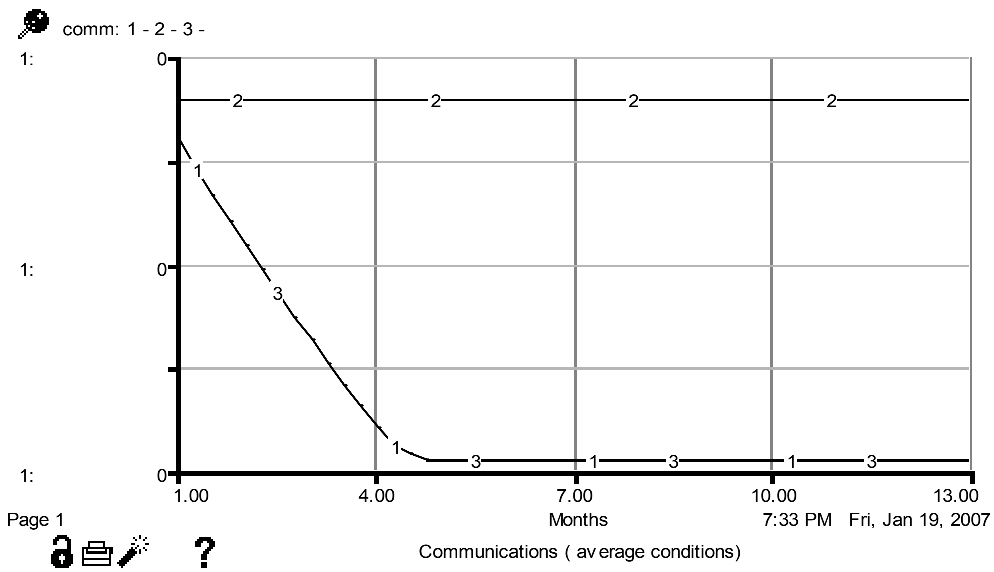


Figure 6-12: Case 1 Level of Communication (Avg. Conditions and Quality Priority Fixed)

In this case, the level of communication between partners and the level of quality are products of the level of goal alignment. Maximum levels of communication and quality are achieved when the level of priority assigned to the scope goals are the same for both partners (curve 2 in Fig. 6-12, 6-13, 6-14). Other variations in the levels of quality could be attributed to schedule pressure.

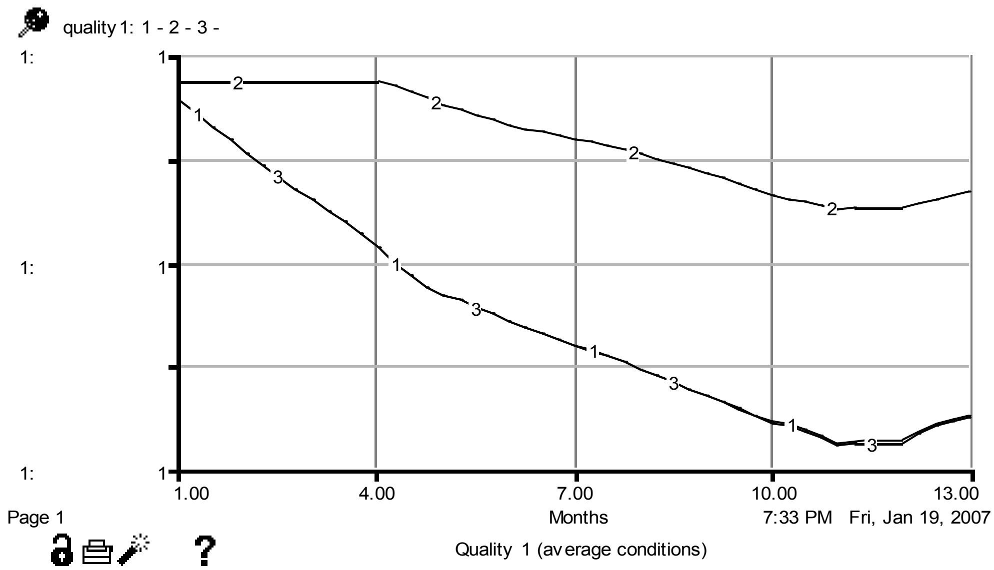


Figure 6-13: Case 1 Level of Quality 1 (Avg. Conditions and Quality Priority Fixed)

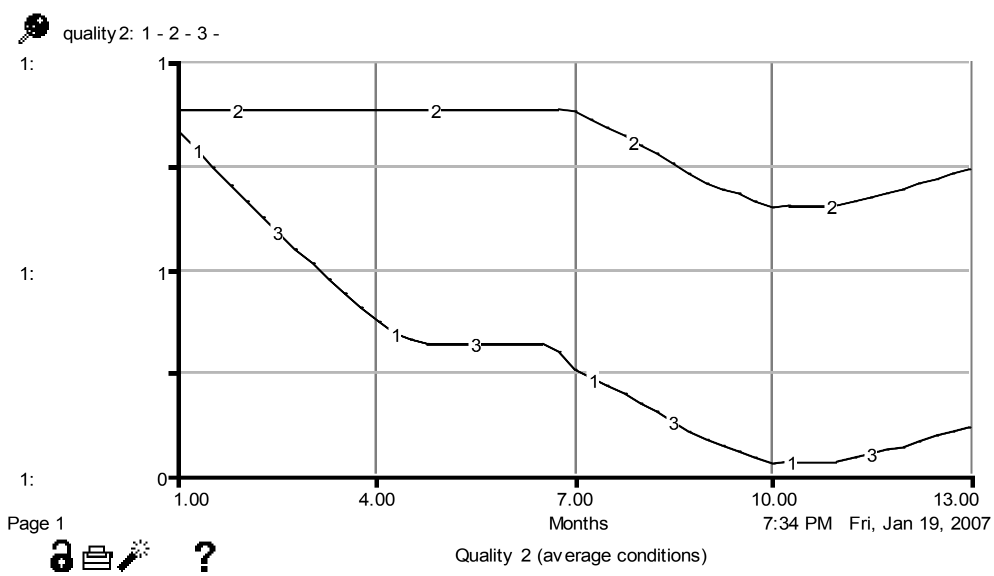


Figure 6-14: Case 1 Level of Quality 2 (Avg. Conditions and Quality Priority Fixed)

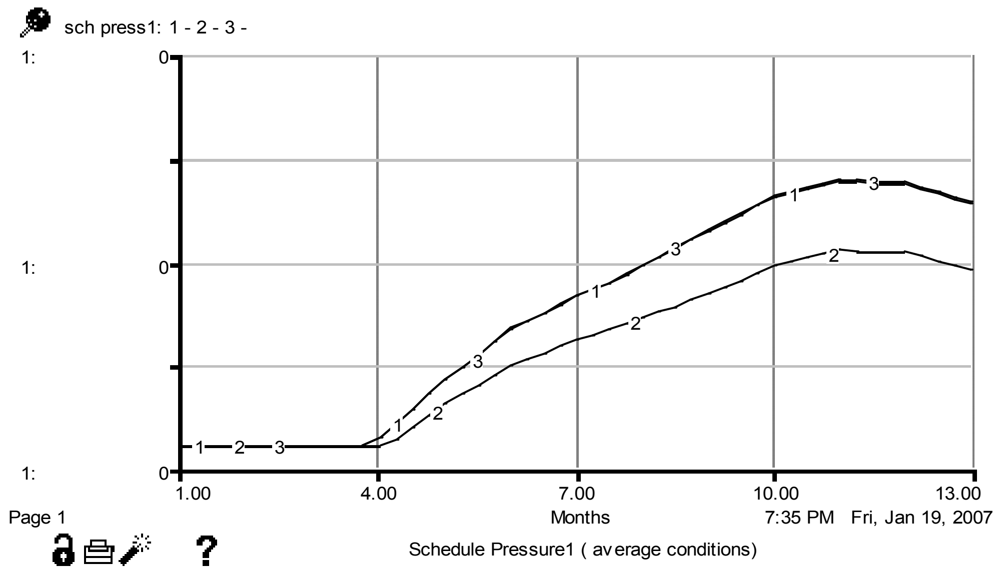


Figure 6-15: Case 1 Level of Schedule Pressure 1 (Avg. Conditions and Quality Priority Fixed)

Conversely, the level of schedule pressure is a product of the level of quality and rework required which hinders progress and creates schedule slippage. Again, the level of schedule pressure is minimized when the level of scope goal alignment is maximized (curve 2 in Fig. 6-15, 6-16).

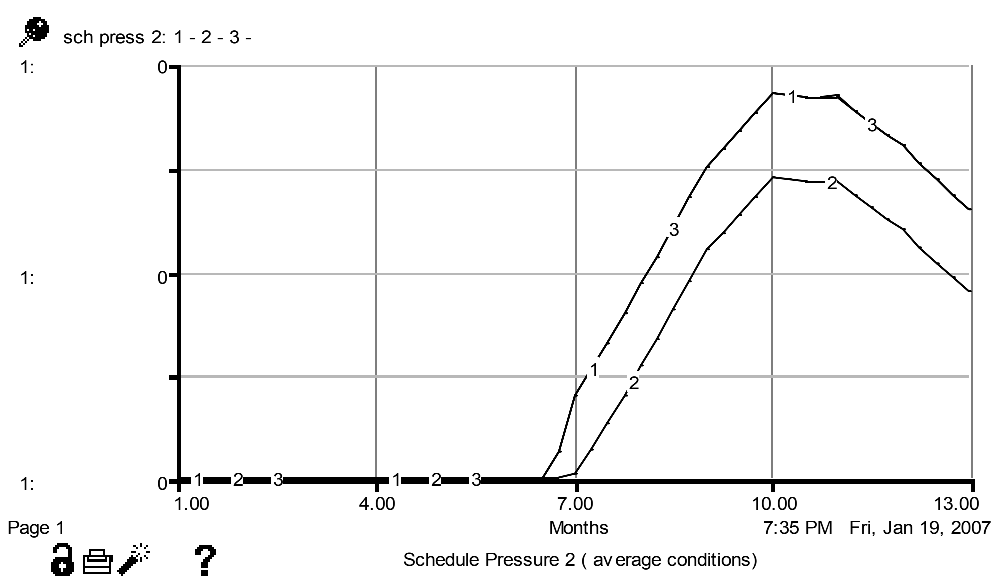


Figure 6-16: Case 1 Level of Schedule Pressure 2(Avg. Cond. and Quality Priority Fixed)

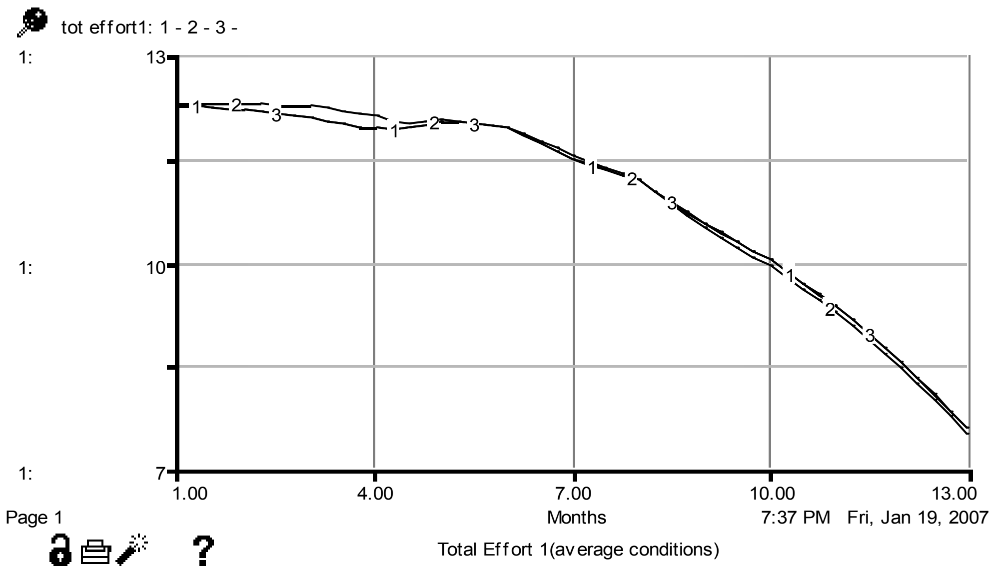


Figure 6-17: Case 1 Level of Total Effort 1 (Avg. Conditions and Quality Priority Fixed)

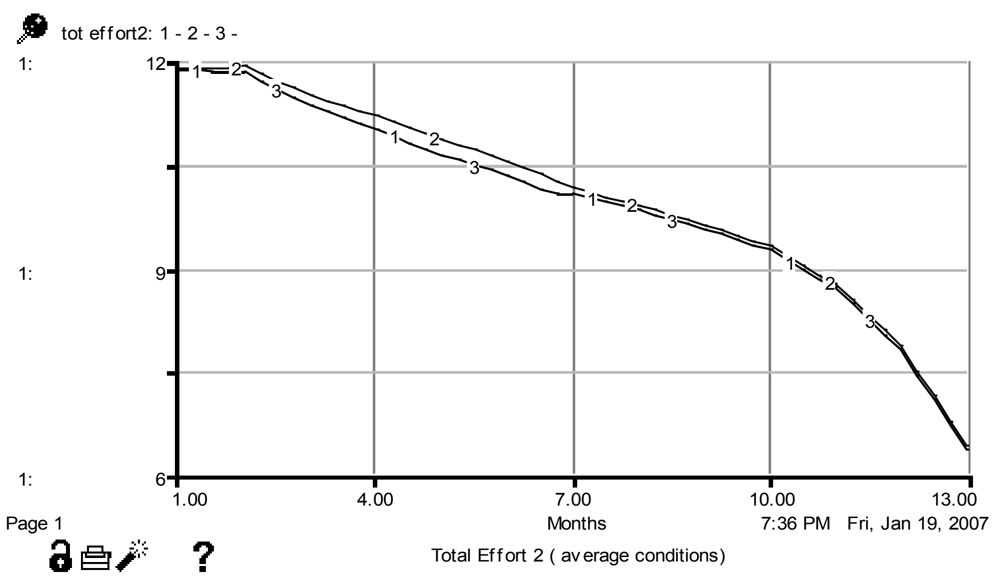


Figure 6-18: Case 1 Level of Total Effort 2(Avg. Cond. and Quality Priority Fixed)

The differences in total effort between the different levels of scope goal alignment are not significant. That is because the higher levels of rework and review effort that need to be deployed due to the lower level of alignment are compensated by the higher level of coordinated effort deployed when goal alignment is maximized.

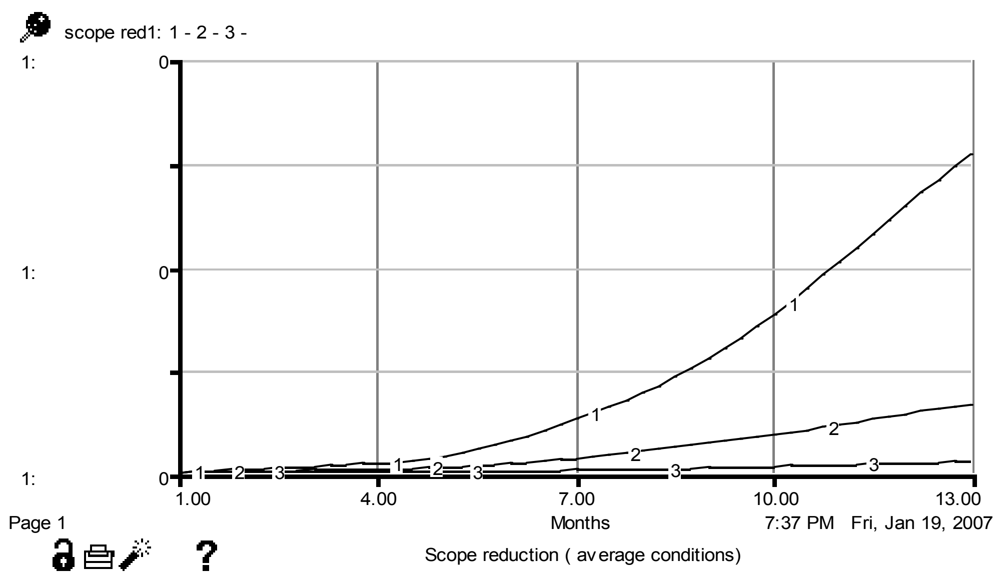


Figure 6-19: Case 1 Level of Scope Reduction 1 (Avg. Cond. and Quality Priority Fixed)

For Partner 1, the level of scope reduction is given by the variation in the level of priority assigned to the scope goal and the level of scope goal alignment among partners -which leads to a certain level of communication, quality, rework, schedule slippage and schedule pressure. Hence the level of scope reduction is higher when the levels of scope priority and scope goal alignment are minimum (curve 1 in Fig. 6-19, 6-20).

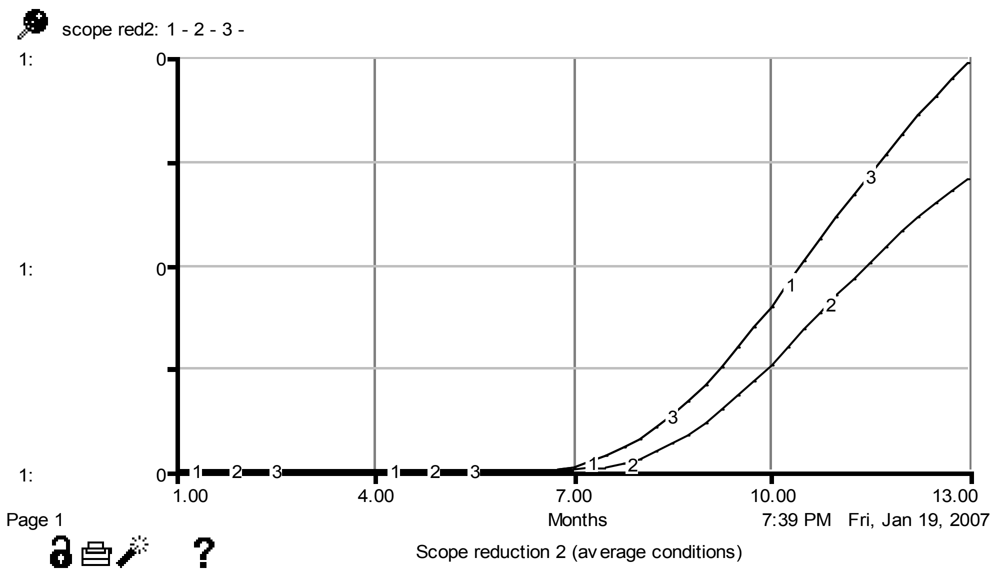


Figure 6-20: Case 1 Level of Scope Reduction 2(Avg. Conditions and Quality Priority Fixed)

On the other hand, the level of scope reduction for Partner 2 is only a function of the level of scope goal alignment among partners, because the level of scope priority is fixed. A higher level of goal alignment leads to better communication, higher quality, less schedule slippage, less schedule pressure and to a lesser need to reduce scope (curve 2 in Fig. 6-20). Again, the level of work completed is a consequence of the behaviors described above.

For both partners, the higher level of work completed is accomplished when the level of scope goal alignment is maximized (curve 2 in Fig.6-21, 6-22). Because the level of schedule pressure during project execution for both partners was low, the effect of scope reduction is very limited.

Figure 6-21: Case 1 Level of Work Done1 (Avg. Conditions and Quality Priority Fixed)

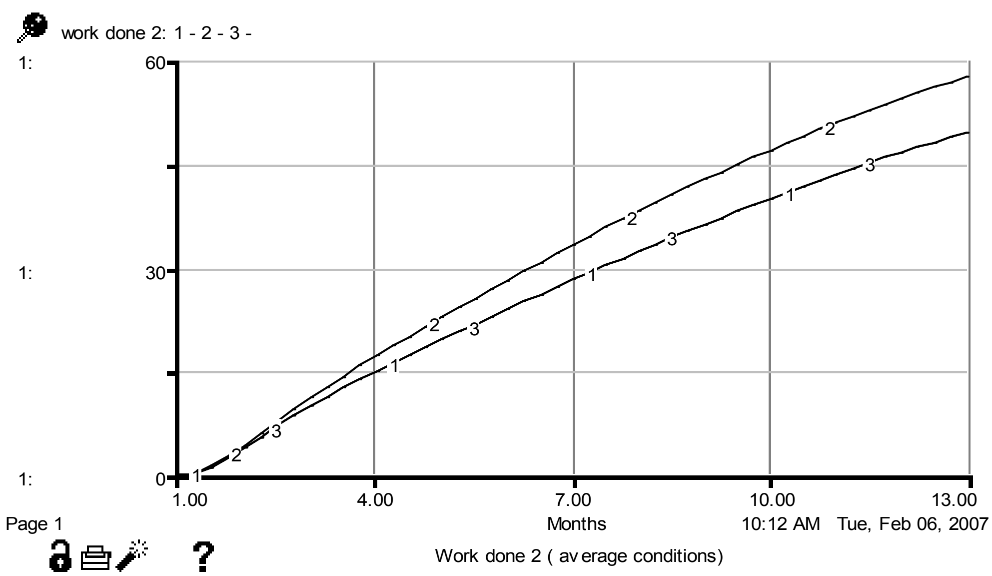


Figure 6-22: Case 1 Level of Work Done 2 (Avg. Conditions and Quality Priority Fixed)

Analysis of Case 1 Model's Behavior under Extreme Positive Conditions and Scope Priority Fixed

As mentioned above, extreme conditions can be positive -conditions that favor the effect of goal alignment on improving project performance- or negative -reinforcing the effects of goal alignment that hinder project performance. Positive conditions include maximizing scope priority -when quality priority is varied- and quality priority- when scope priority is varied. Initial quality, trust and potential communications are also maximized. Moreover, a minimum level of interdependence between partners would minimize the communications and coordination requirements, reducing the impact of those variables on project performance. Communication and coordination between partners are, according to the case data, highly impacted by the level of alignment. Hence, the fraction of work to be coordinated between partners, and the fraction of partners' work used by the other partner are minimized for positive extreme conditions.

The negative conditions include minimizing scope priority -when quality priority is varied- and quality priority -when scope priority is varied. Initial trust and potential communications are also minimized. Moreover, negative conditions imply maximum level of interdependence between partners, which maximizes the communications and coordination requirements between partners. Hence, the fraction of work to be coordinated between partners, and the fraction of partners' work used by the other partner are maximized.

As in the average conditions case, the behavior of the model was explored for two scenarios: the scope priority fixed scenario and the quality priority fixed scenario.

Positive conditions (Scope Priority fixed):

Scope priority 2 =1
Scope priority1=1
Quality Priority2=1
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=1
Initial Trust in 2=1
Potential communication=1
Fraction of work to be coordinated=0.1,
Fraction of work done by 1 and used by 2=0.1
Fraction of work done by 2 and used by 1=0.1
Quality Priority1 is set at 0.1, 0.5, and 0.9

As expected, the maximum level of trust and communication between partners is reached when the level of goal alignment is maximized -when quality priority 1 is set at 0.9 and quality priority 2 is set at 1. Moreover, the level of communication between partners under the positive conditions is higher than the level of communication obtained under average conditions.

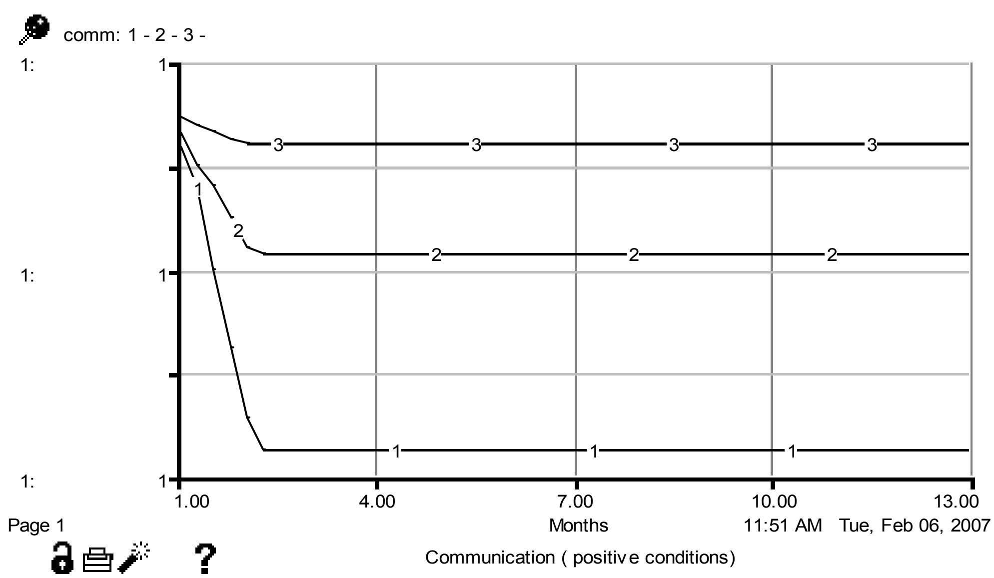


Figure 6-23: Case 1 Level of Communication (Positive Cond. and Scope Priority Fixed)

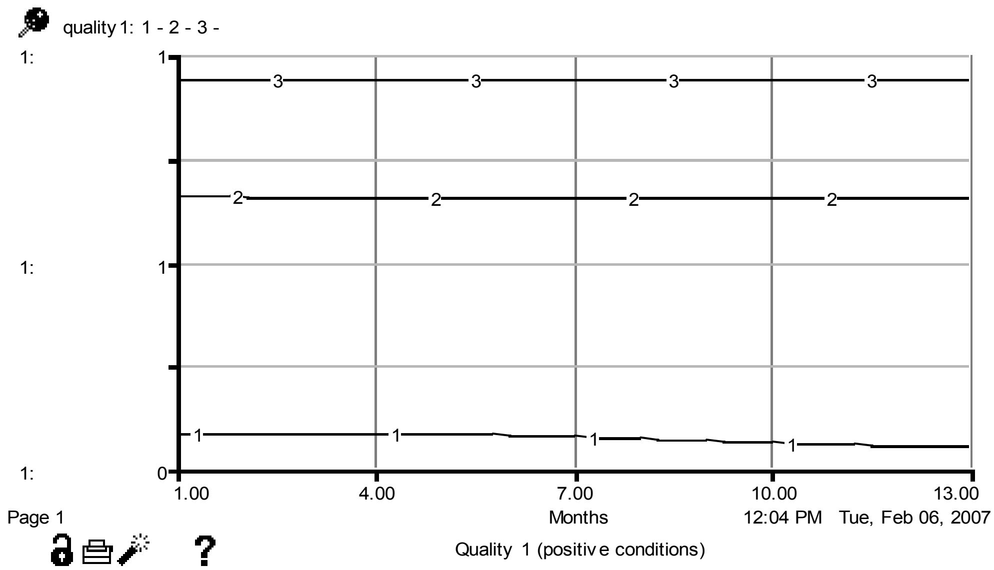


Figure 6-24: Case 1 Level of Quality 1(Positive Conditions and Scope Priority Fixed)

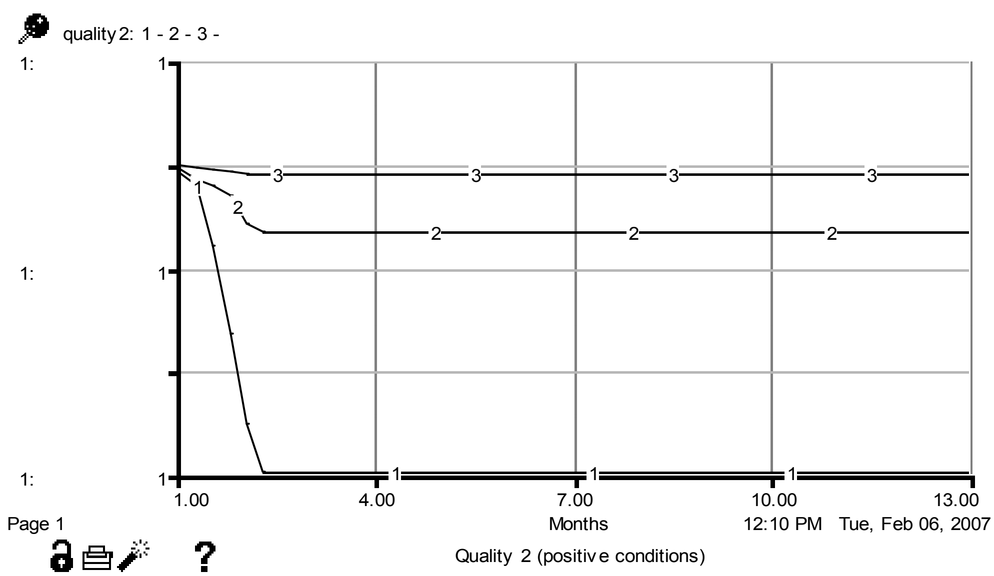


Figure 6-25: Case 1 Level of Quality 2 (Positive Conditions and Scope Priority Fixed)

For Partner 1, the level of quality is determined mostly by the level of quality priority and to a lesser extent by the level of goal alignment. On the other hand, for Partner 2 the level of goal alignment is the factor that determines the level of quality, because the level of quality priority was fixed. However, the impact of goal alignment on quality for Partner 2 is less significant than in the case of average conditions, because in this case partners are less interdependent and require less communication to perform their work.

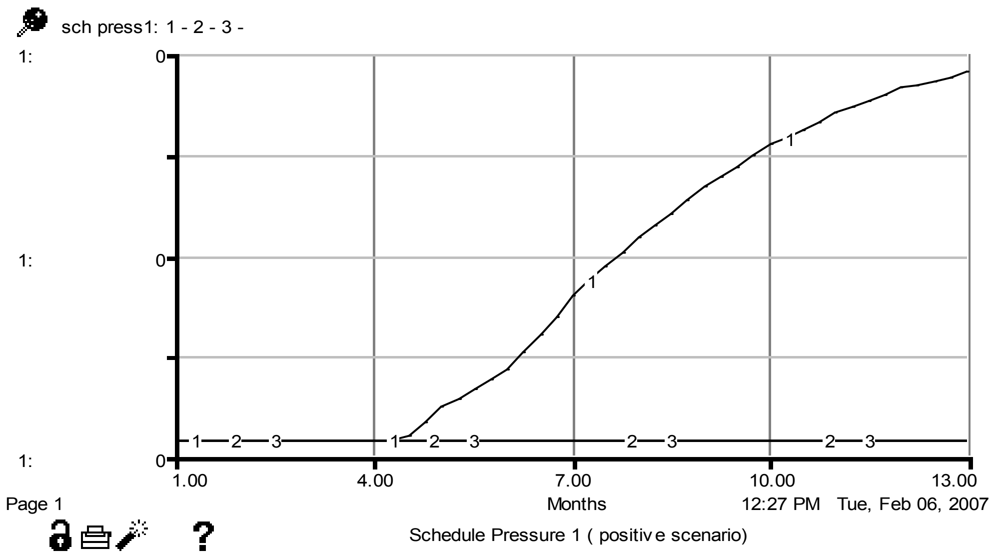


Figure 6-26: Case 1 Level of Schedule Pressure 1(Positive Cond. and Scope Priority Fixed)

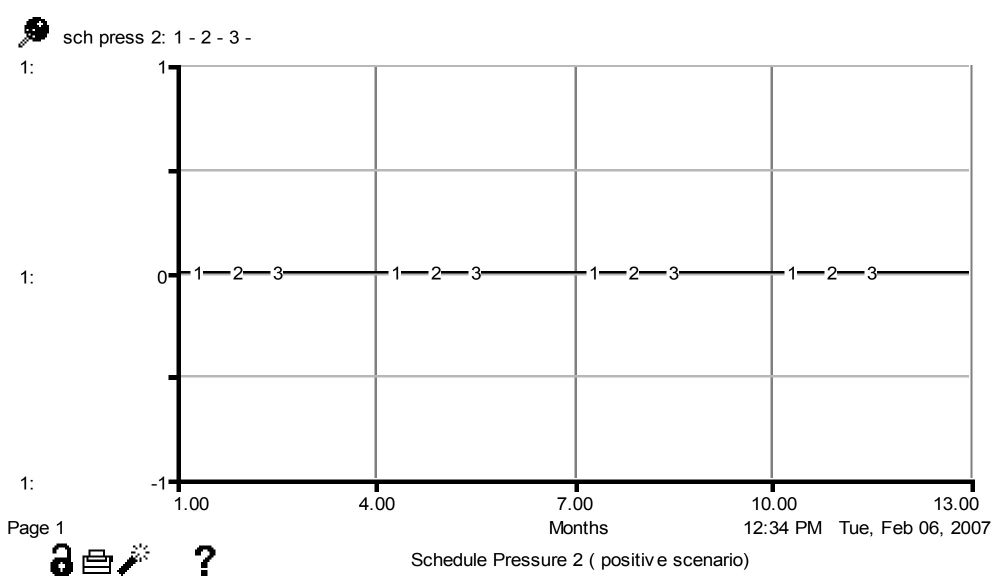


Figure 6-27: Case 1 Level of Schedule Press. 2 (Positive Cond. and Scope Priority Fixed)

Schedule pressure for Partner 1 is determined by the level of quality. For high and intermediate levels of quality priority, the higher level of quality leads to lower rework, and minimal schedule slippage and schedule pressure (curves 2 and 3 in Fig. 6-26). For Partner 2, because the level of quality priority was fixed and the effect of goal alignment is attenuated by positive conditions, quality remains at high level for all levels of Partner1's quality priority, and then the level of schedule pressure also remains minimal.

Total effort deployed by Partner 1 is higher when the level of quality priority is minimal (curve 1 in Fig 6-28), due to the amount of rework required. For intermediate and high levels of quality priority, as well as for Partner 2, the difference between the total effort deployed when the quality priority 1 was varied is not significant, because the effect of goal alignment is reduced by the effect of positive conditions on communications and quality.

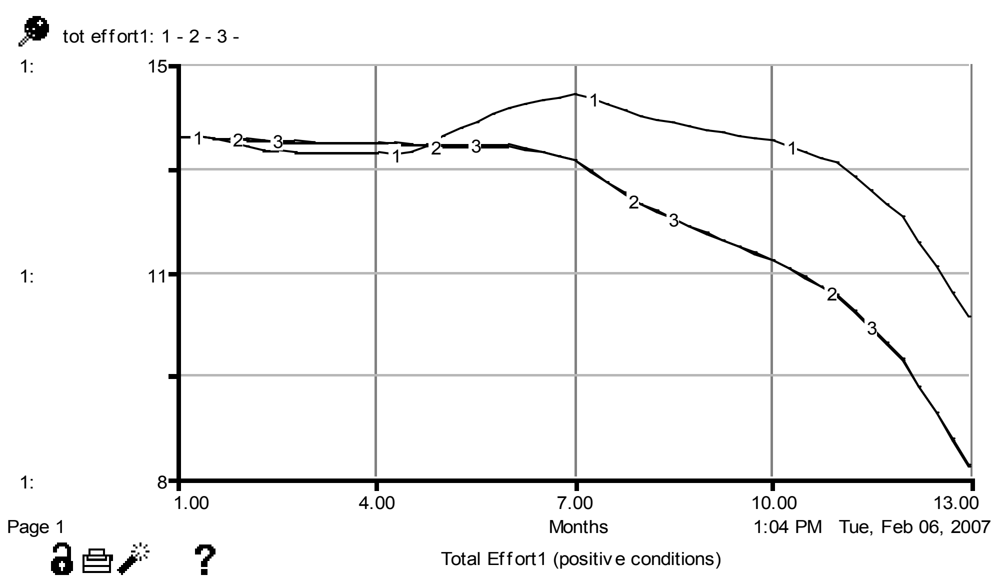


Figure 6-28: Case 1 Level of Total Effort 1(Positive Cond. and Scope Priority Fixed)

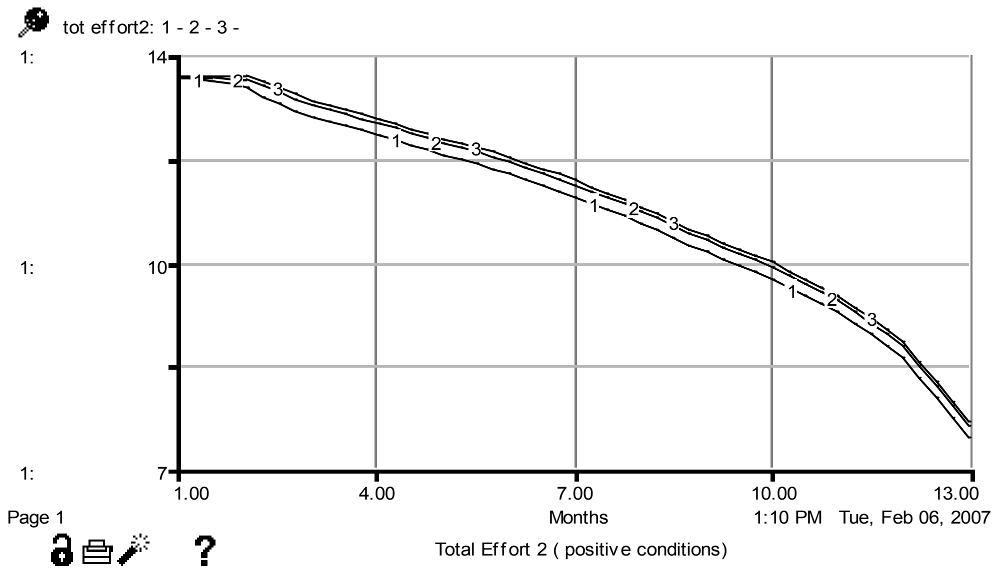


Figure 6-29: Case 1 Level of Total Effort 2 (Positive Cond. and Scope Priority Fixed)

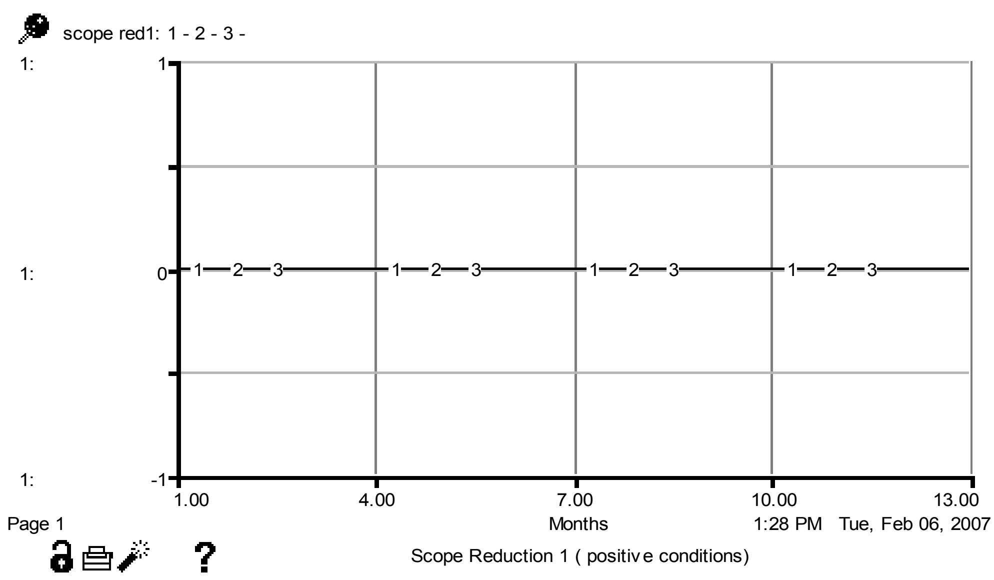


Figure 6-30: Case 1 Level of Scope Reduction1 (Positive Cond. and Scope Priority Fixed)

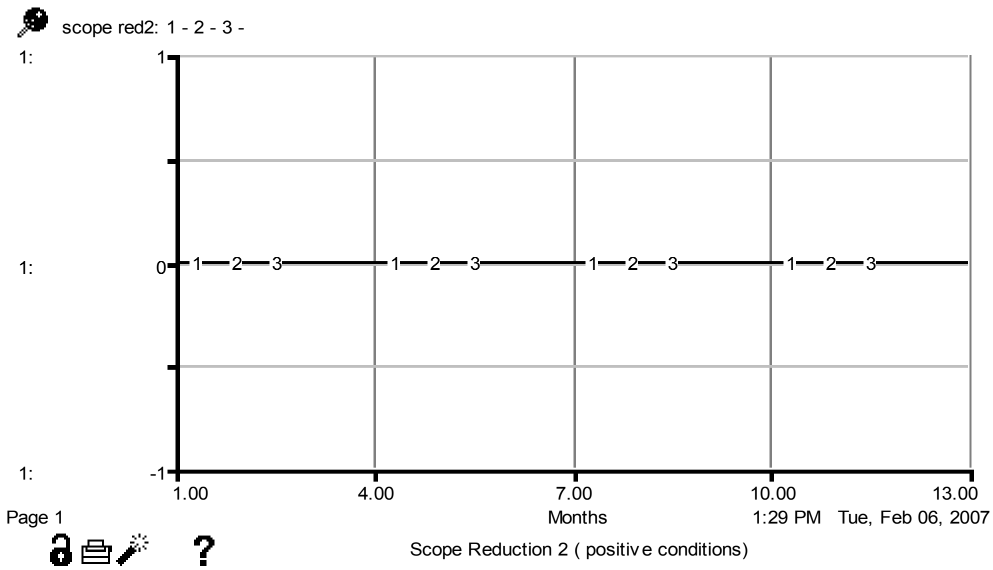


Figure 6-31: Case 1 Level of Scope Reduction 2 (Positive Cond. and Scope Priority Fixed)

Due to the low level of schedule pressure, none of the partners required to reduce scope.

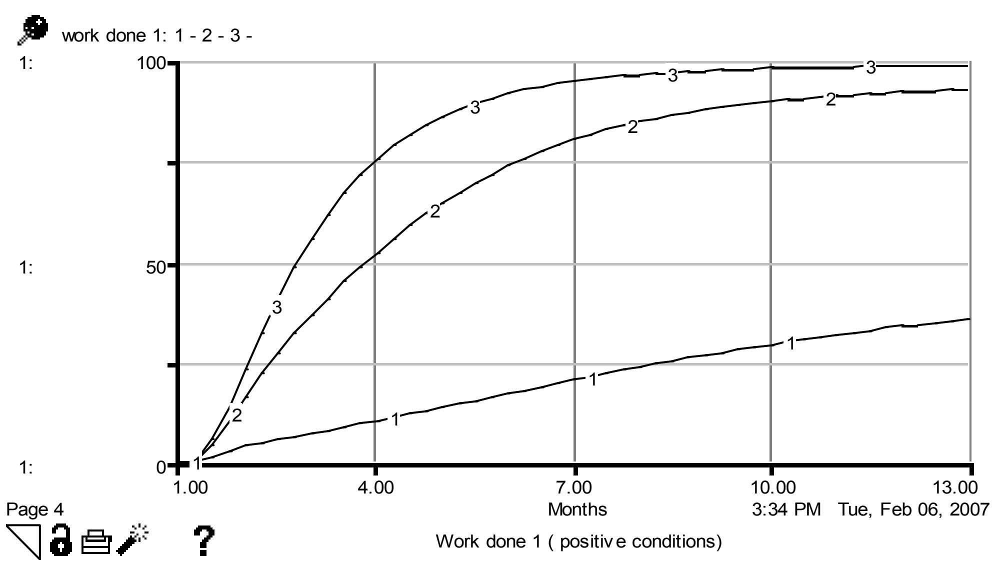


Figure 6-32: Case 1 Level of Work Done 1(Positive Cond. and Scope Priority Fixed)

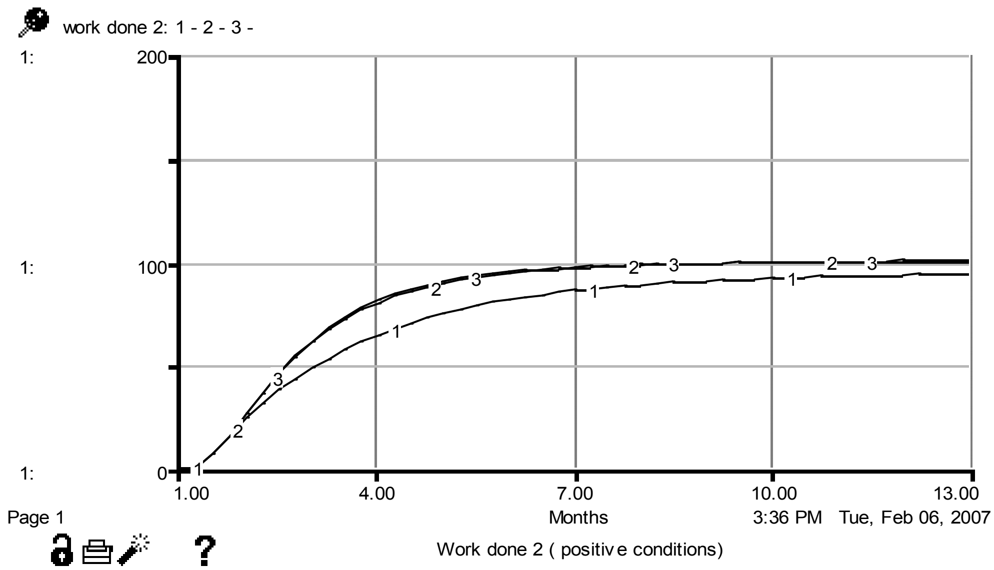


Figure 6-33: Case 1 Level of Work Done 2 (Positive Cond. and Scope Priority Fixed)

For Partner 1 the amount of work completed is affected basically by the level of priority given to the quality goal. For Partner 2, the amount of work completed does not vary significantly with the level of priority given to the quality goal by Partner 1, because the effect of alignment is attenuated by positive conditions, including a lower level of interdependence between partners.

Analysis of Case 1 Model's Behavior under Extreme Positive Conditions and Quality Priority Fixed

Positive conditions (Quality Priority fixed):

Scope Priority 2 =1
Quality Priority1=1
Quality Priority2=1
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=1

Initial Trust in 2=1
Potential communication=1
Fraction of work to be coordinated=0.1,
Fraction of work done by 1 and used by 2=0.1
Fraction of work done by 2 and used by 2=0.1
Scope Priority 1 is set at 0.1, 0.5, 0.9.

As in every case, the level of communication is determined by the level of goal alignment between partners -in this particular case, the level of scope goal alignment.

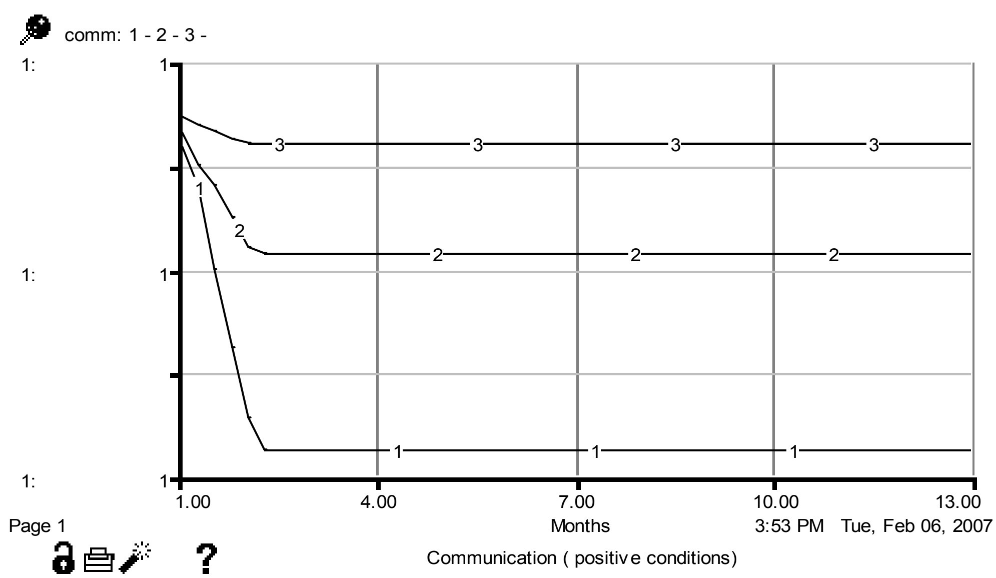


Figure 6-34: Case 1 Level of Communication (Positive Cond. and Quality Priority Fixed)

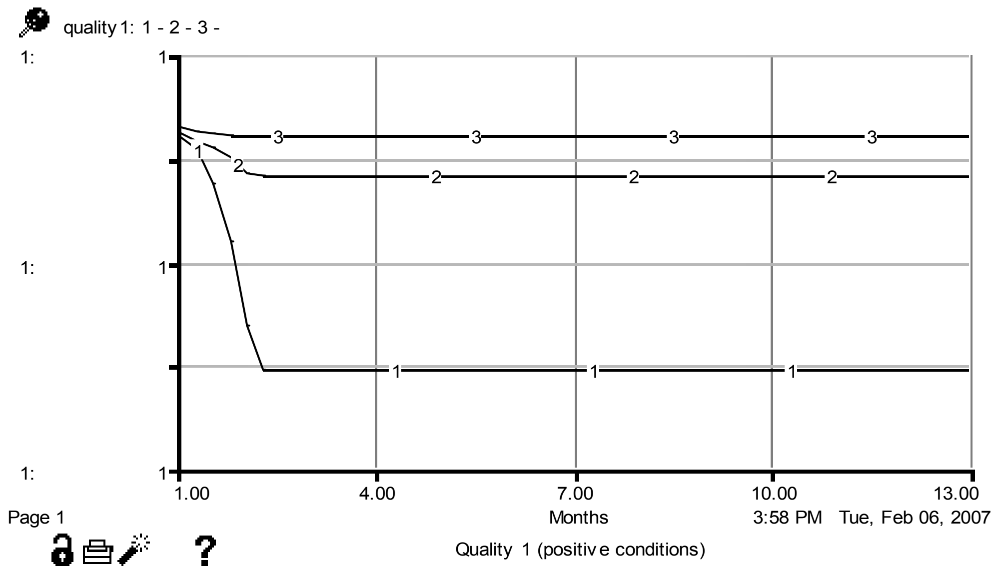


Figure 6-35: Case 1 Level of Quality1 (Positive Cond. and Quality Priority Fixed)

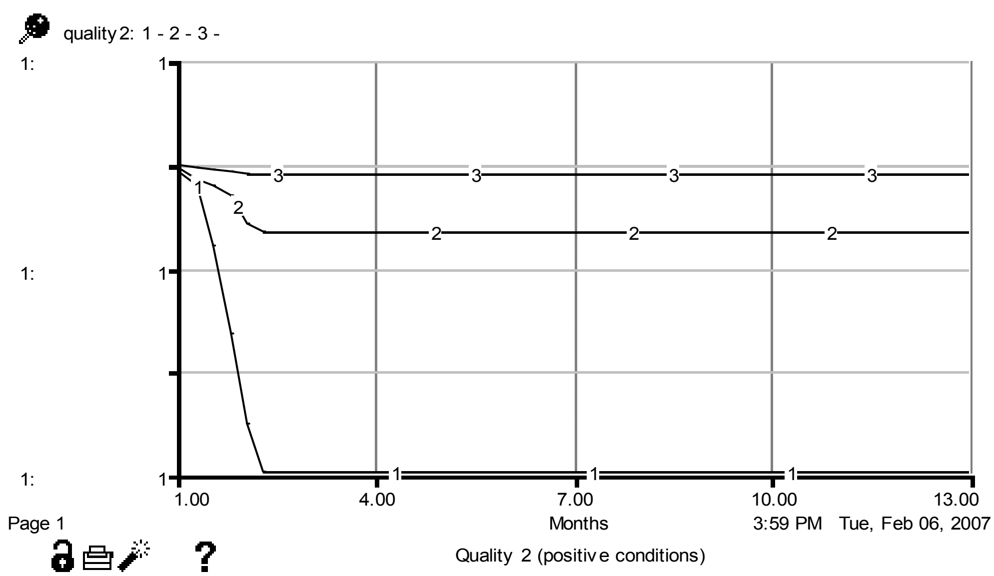


Figure 6-36: Case 1 Level of Quality 2 (Positive Cond. and Quality Priority Fixed)

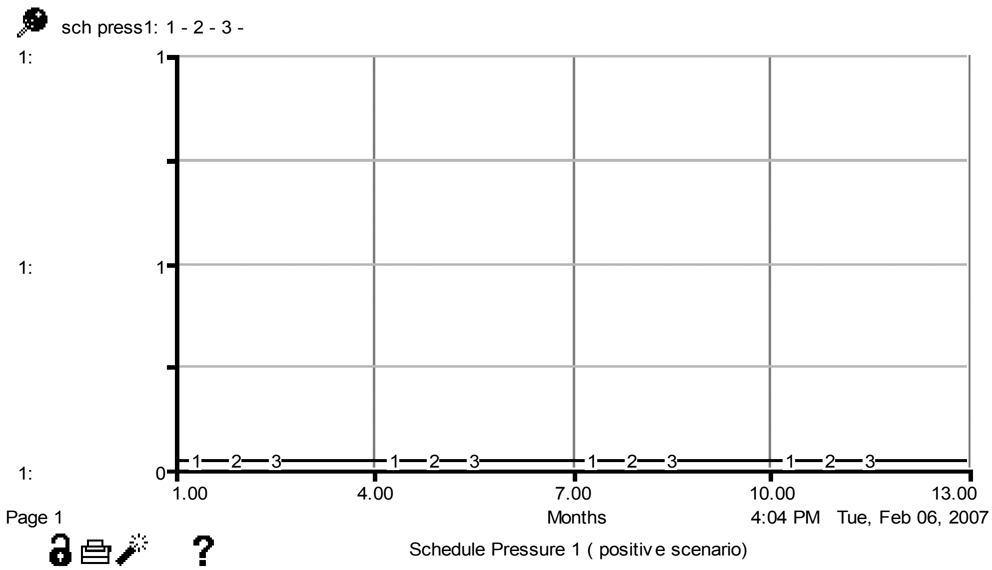


Figure 6-37: Case 1 Level of Schedule Pressure 1(Positive Cond . and Quality Priority Fixed)

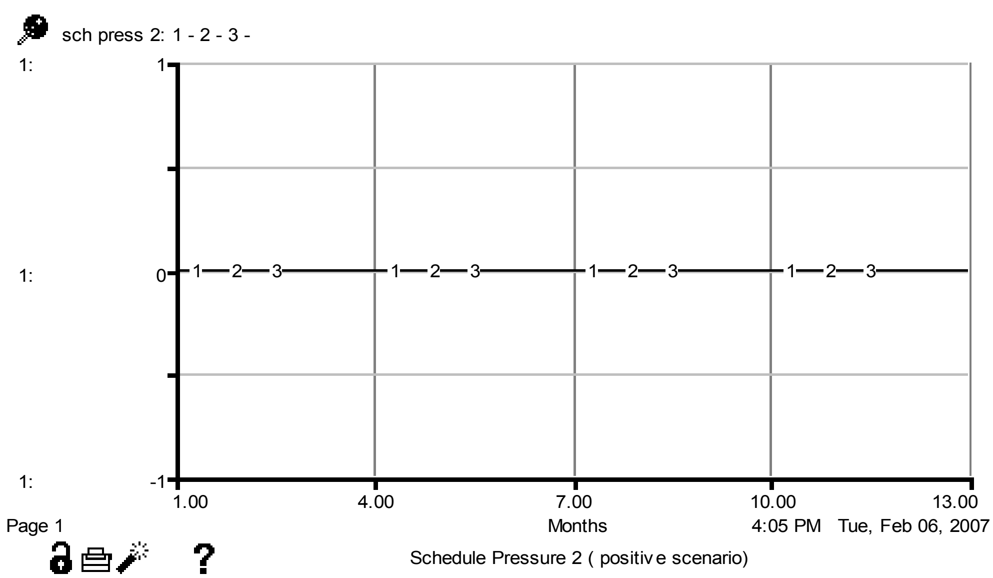


Figure 6-38: Case 1 Level of Schedule Pressure 2 (Positive Cond. and Quality Priority Fixed)

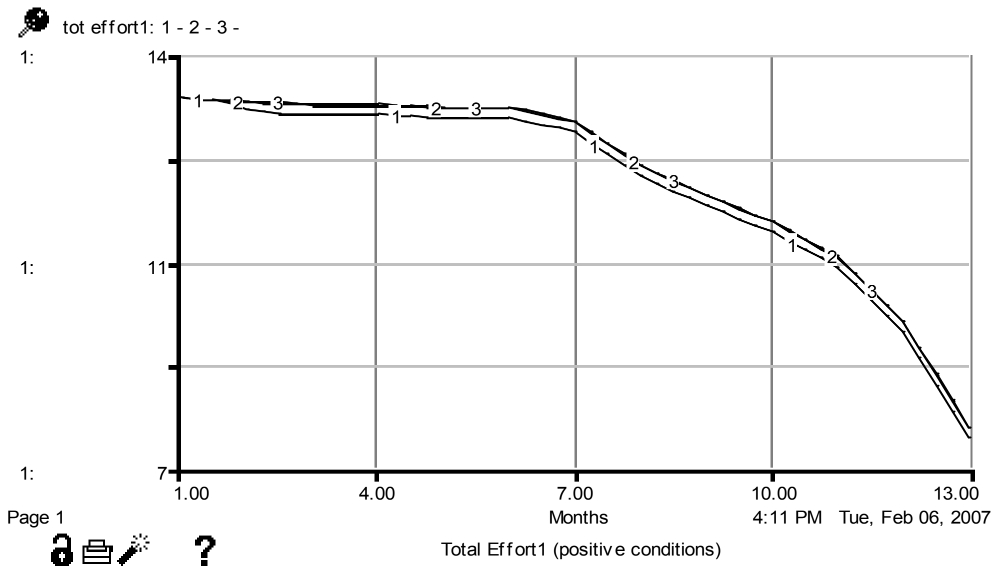


Figure 6-39: Case 1 Level of Total Effort1 (Positive Cond. and Quality Priority Fixed)

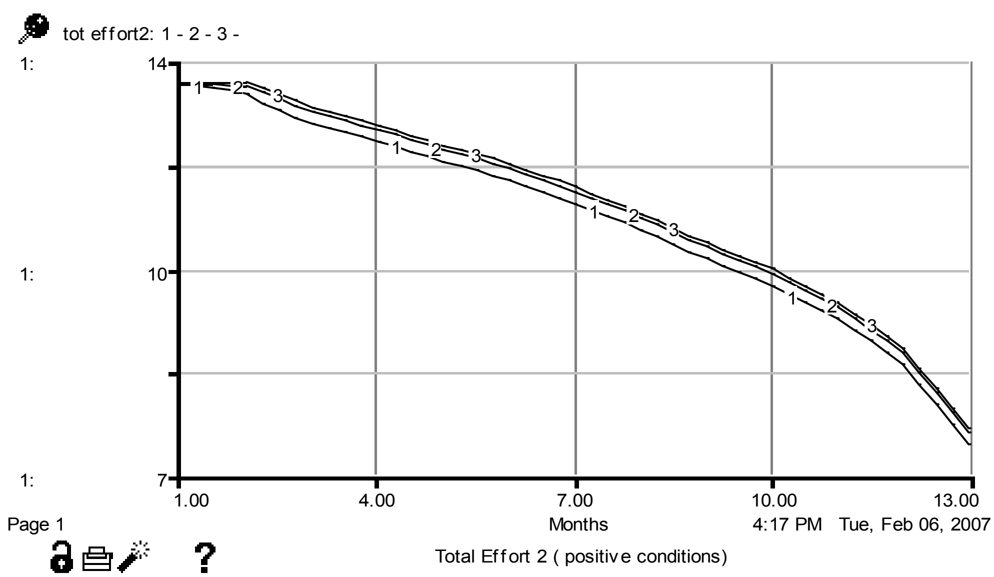


Figure 6-40: Case 1 Level of Total Effort 2 (Positive Cond. and Quality Priority Fixed)

The level of quality, schedule pressure, and scope reduction for both partners are very similar, because the variation in the level of priority assigned to the scope goal by

Partner 1 has a minor impact compared to the impact of variations in the quality priority. Moreover, any impact of variations in the level of scope goal alignment is attenuated by the low level of interdependence between partners.

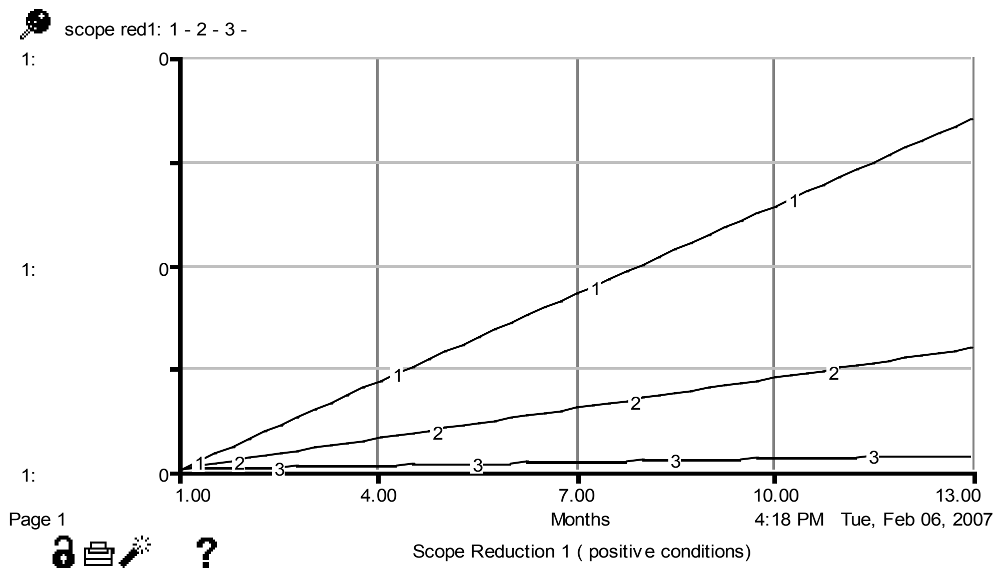


Figure 6-41: Case 1 Level of Scope Reduction 1(Positive Cond. and Quality Priority Fixed)

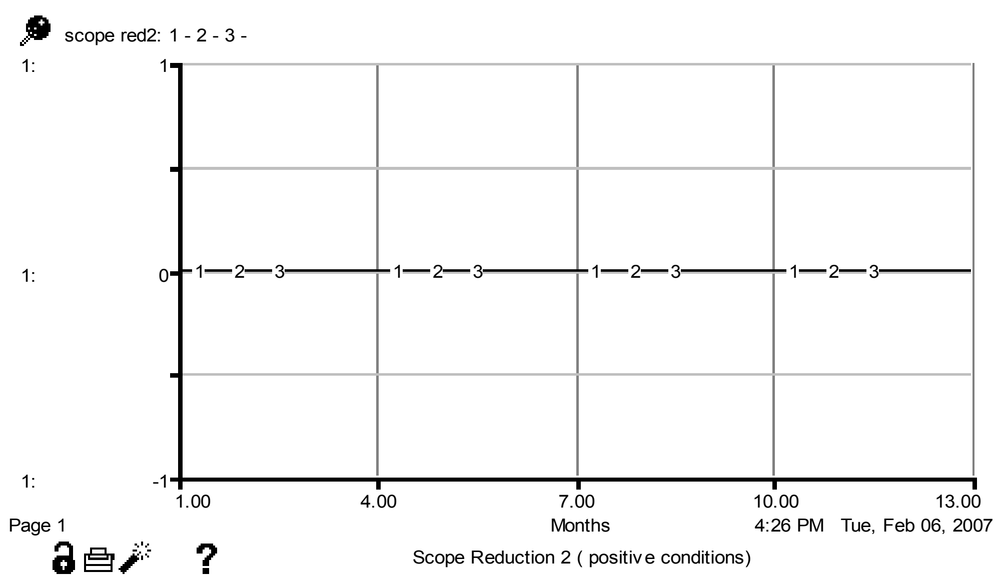


Figure 6-42: Case 1 Level of Scope Reduction 2 (Positive Cond. and Quality Priority Fixed)

The level of priority given to the scope goal by Partner 1 influences the level of scope reduction (see Fig.6-41). On the other hand, the high level of quality, and the low level of rework, schedule slippage and schedule pressure lead to minimal scope reduction in the Partner 2's case.

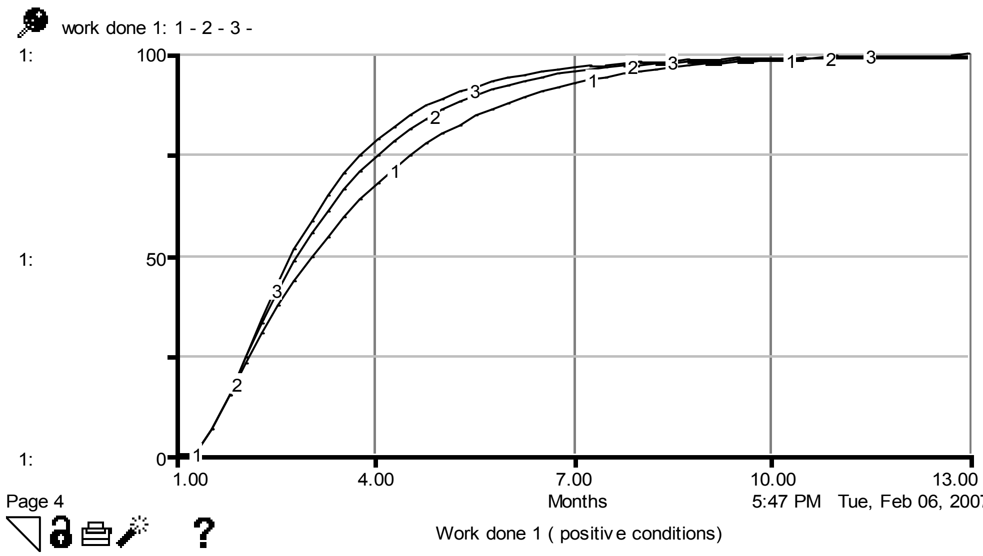


Figure 6-43: Case 1 Level of Work Done 1 (Positive Cond. and Quality Priority Fixed)

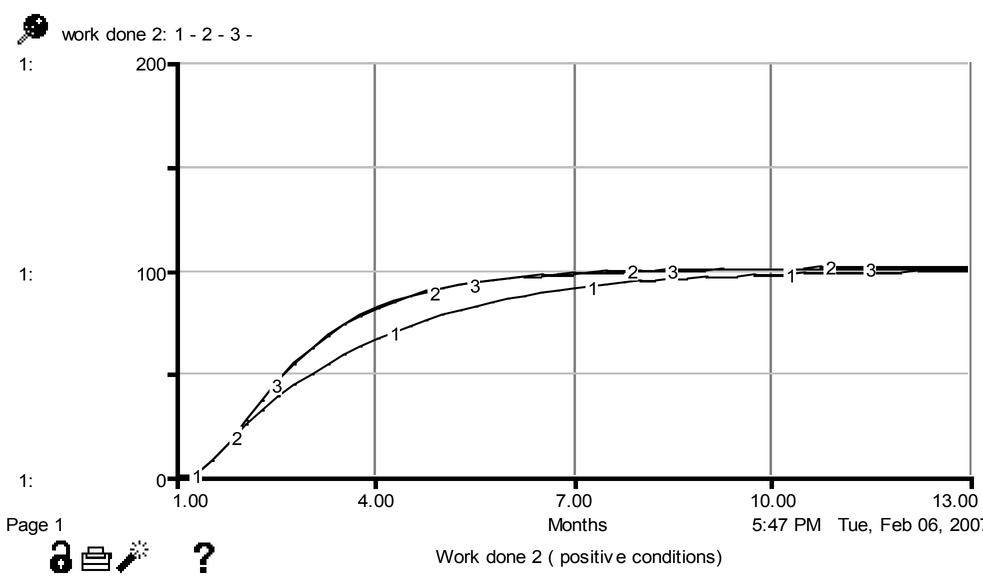


Figure 6-44: Case 1 Level of Work Done 2 (Positive Cond. and Quality Priority Fixed)

The level of work completed by both partners is not affected by the level of scope goal alignment. In addition, the level of scope priority only affects the amount of work performed when there is a significant level of schedule pressure -scope reduction is a mechanism used to alleviate schedule pressure. Because the effect of the level of goal alignment on quality and progress is reduced by the low level of interdependence between partners, schedule pressure is not an issue and then the impact of scope reduction is not significant.

Analysis of Case 1 Model's Behavior under Extreme Negative Conditions and Scope Priority Fixed

Negative conditions (Scope Priority fixed):

Scope priority 2 =0.1
Scope priority1=0.1
Quality Priority2=0.1
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=0.1
Initial Trust in 2=0.1
Potential communication=0.1
Fraction of work to be coordinated=1
Fraction of work done by 1 and used by 2=1
Fraction of work done by 2 and used by 2=1
Quality Priority 1 set at 0.1,0.5, 0.9

Again, the level of communication is determined by the level of goal alignment between partners. In this case, the level of communication is minimal due to the low level of potential communication and initial trust.

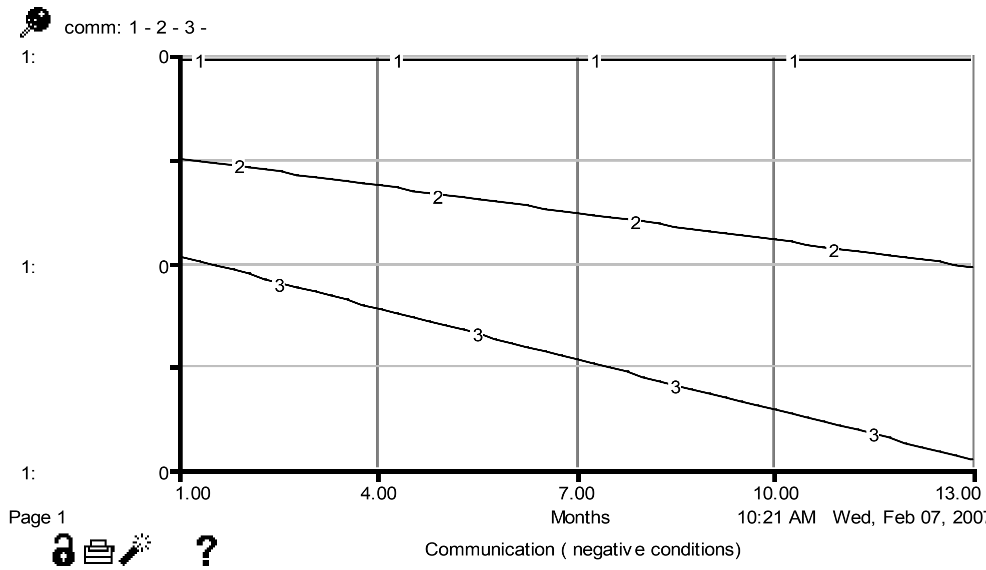


Figure6-45: Case 1 Level of Communication (Negative Cond. and Scope Priority Fixed)

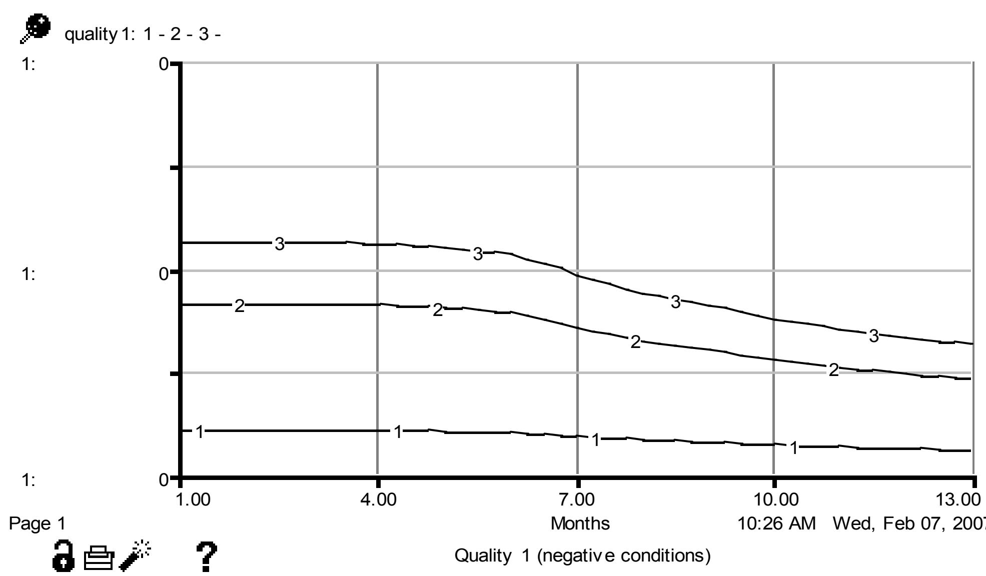


Figure 6-46: Case 1 Level of Quality 1(Negative Cond. and Scope Priority Fixed)

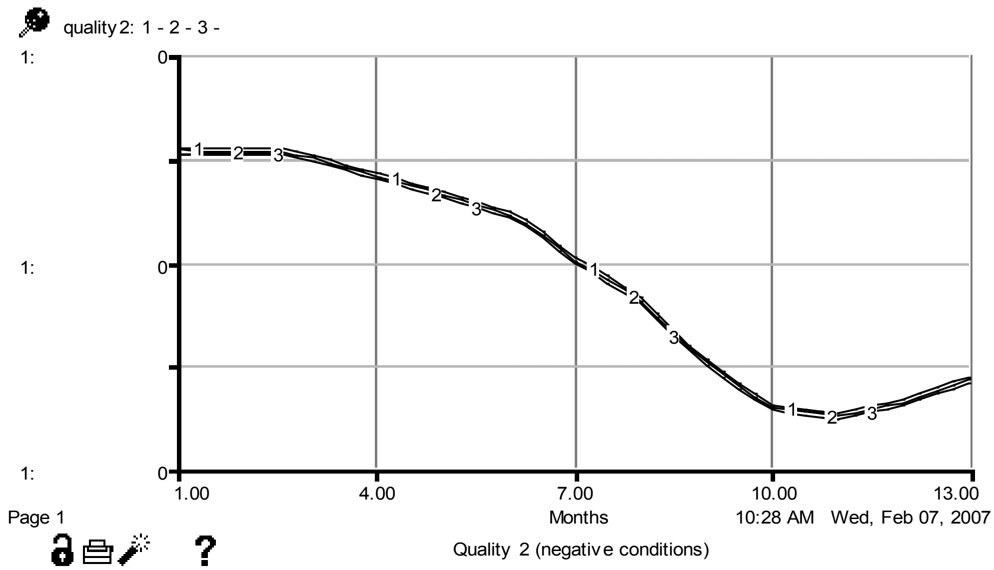


Figure 6-47: Case 1 Level of Quality 2(Negative Cond. and Scope Priority Fixed)

For Partner 1, the level of quality is determined by the level of priority assigned to the quality goal, because that priority is varied. Moreover, quality stays at a very low level along project execution due to the very low level of communication and the high level of interdependence between partners. For Partner 2, the low level of potential communication and the high level of partners' interdependence made the level of quality low for all levels of quality goal alignment.

Because the levels of quality are very low for Partners 1 and 2 at all levels of goal alignment -leading to high levels of rework and schedule slippage- the level of schedule pressure is very high for both partners.

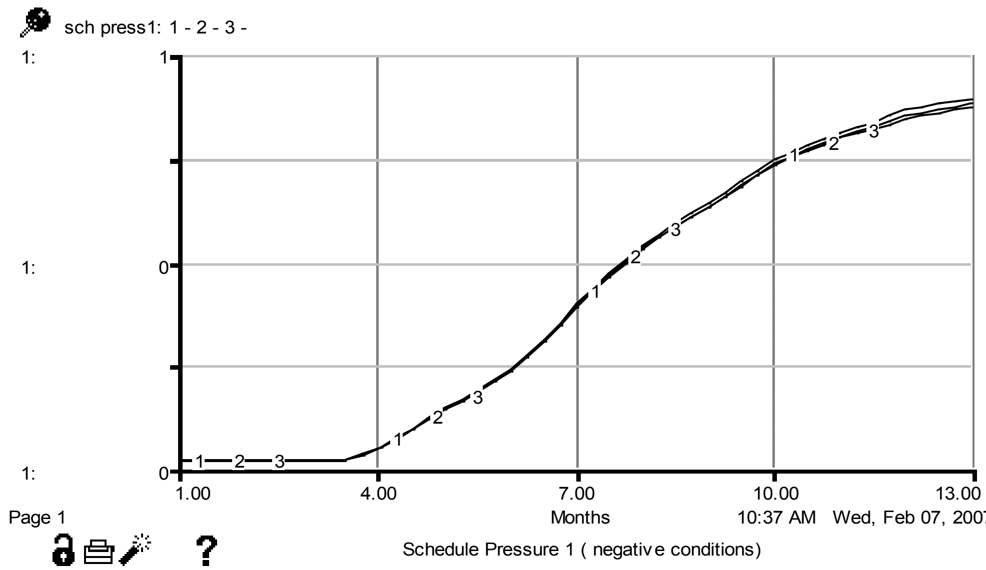


Figure 6-48: Case 1 Level of Schedule Pressure 1(Negative Cond. and Scope Priority Fixed)

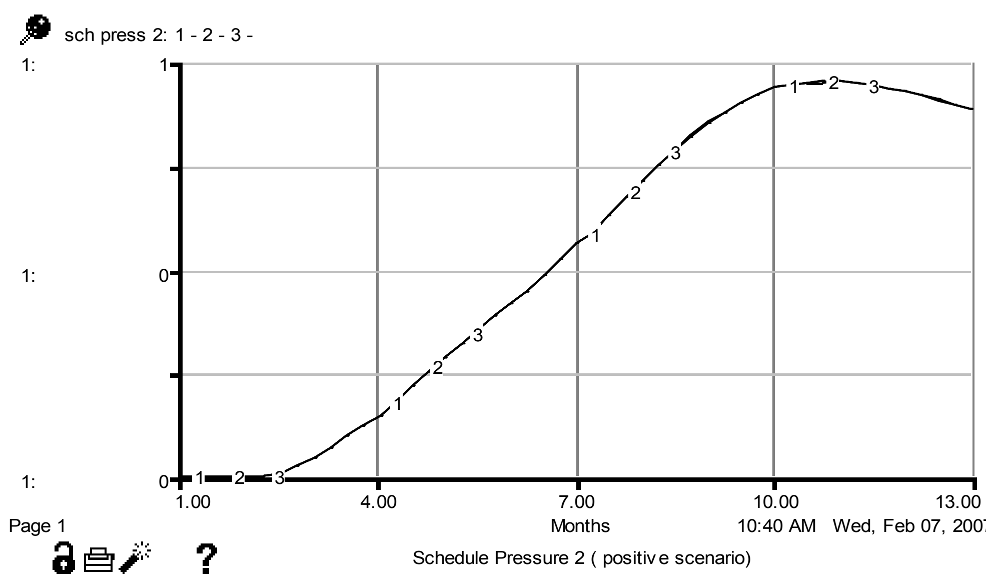


Figure 6-49: Case 1 Level of Schedule Pressure 2 (Negative Cond. and Scope Priority Fixed)

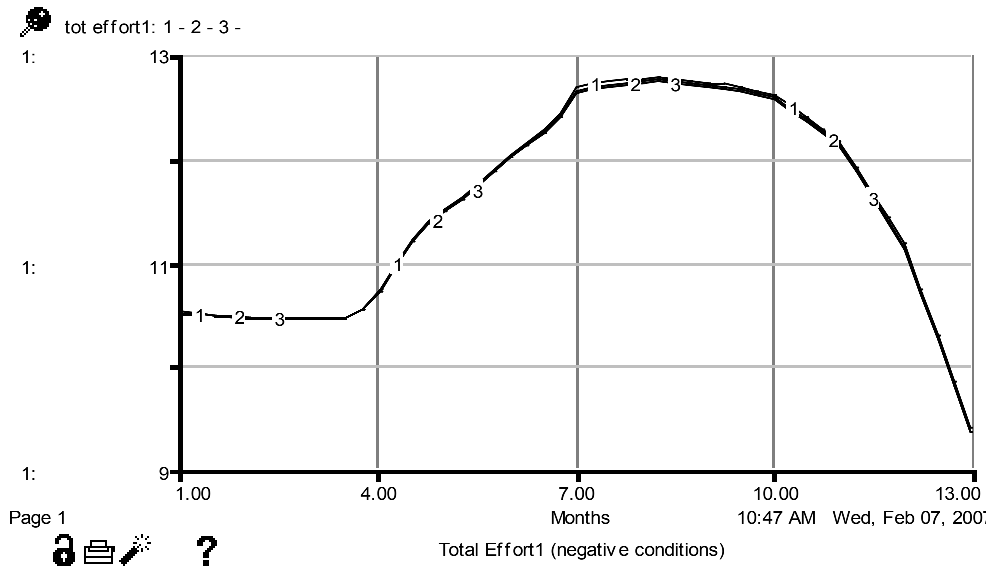


Figure 6-50: Case 1 Level of Total Effort 1(Negative Cond. and Scope Priority Fixed)

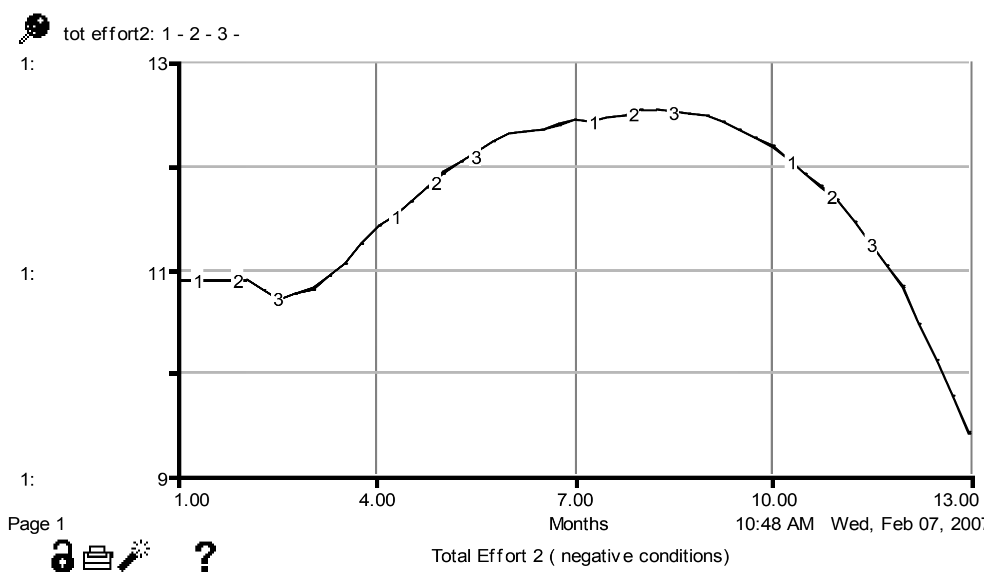


Figure 6-51: Case 1 Level of Total Effort 2 (Negative Cond. and Scope Priority Fixed)

The low level of communication at all levels of goal alignment -influencing the ability to display coordinated effort- the low level of quality -determining the high amount of rework effort required- and the high level of schedule pressure -determining the high amount of additional effort required- lead to a similar high level of total effort deployed by both partners.

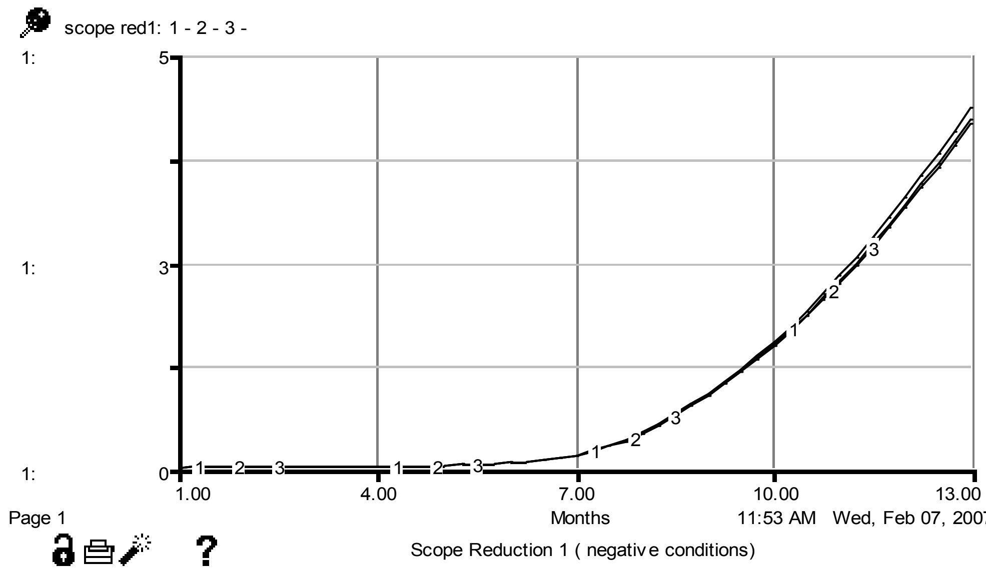


Figure 6-52: Case 1 Level of Scope Reduction 1(Negative Cond. and Scope Priority Fixed)

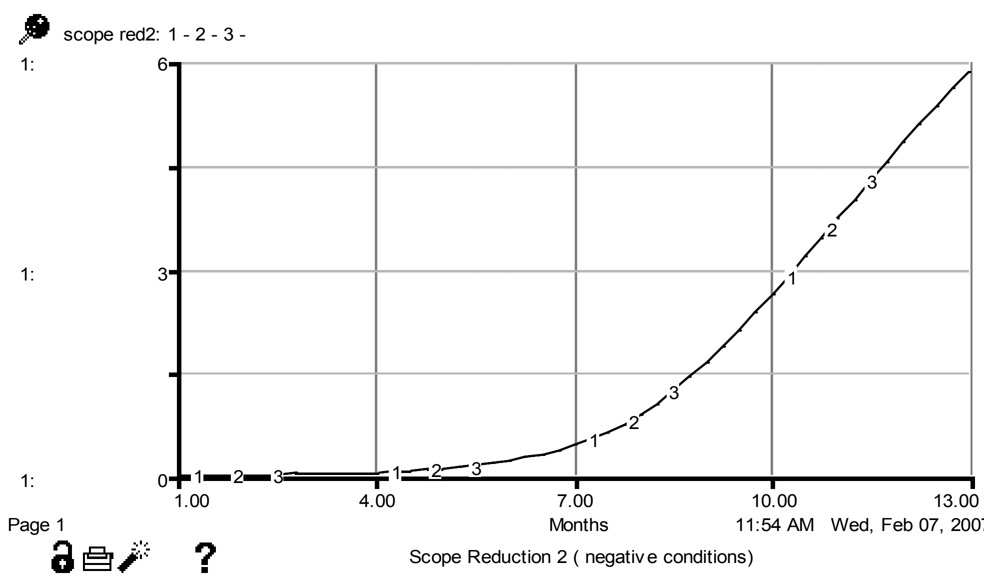


Figure 6-53: Case 1 Level of Scope Reduction 2 (Negative Cond. and Scope Priority Fixed)

Under negative conditions, both partners experience a high level of scope reduction, due to the low level of priority assigned to the scope goal and to the high level of schedule pressure.

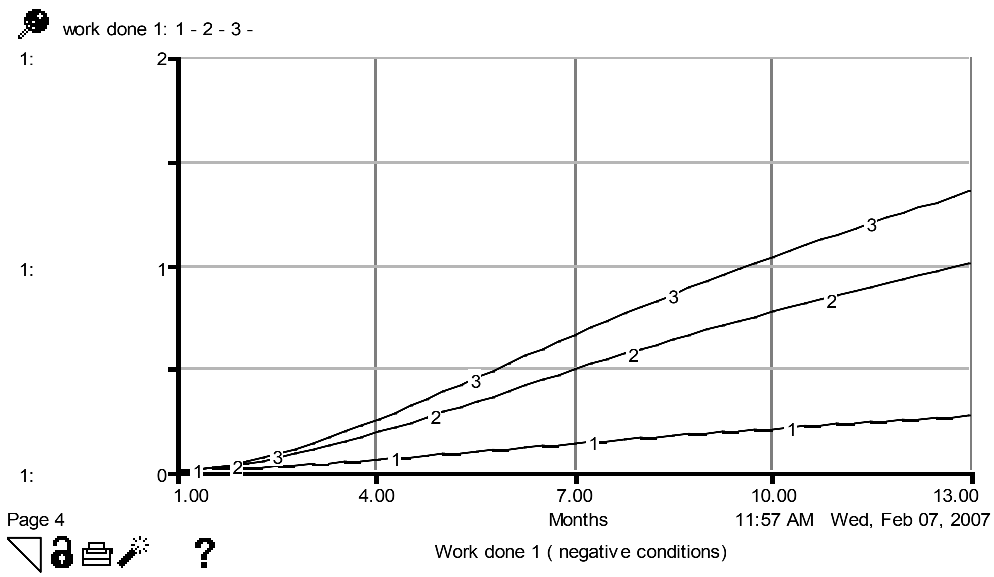


Figure 6-54: Case 1 Level of Work Done 1(Negative Cond. and Scope Priority Fixed)

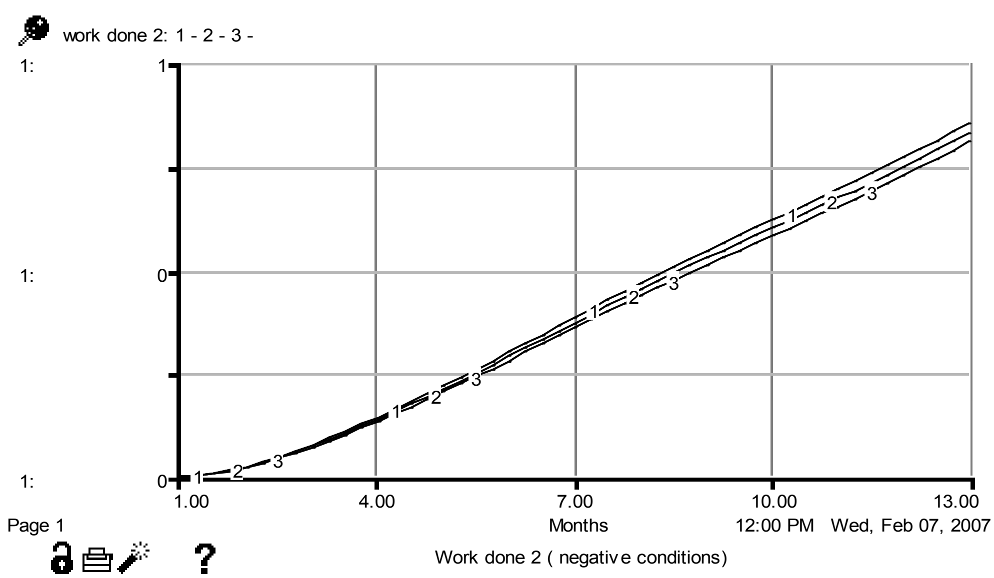


Figure 6-55: Case 1 Level of Work Done 2 (Negative Cond. and Scope Priority Fixed)

Due to the extremely low level of quality, and the inability to deploy a coordinated effort by lack of communication, the amount of work completed is not significant for any of the two partners under extreme negative conditions and varying levels of priority assigned by Partner 1 to the quality goal.

Negative conditions (Quality Priority fixed):

Scope Priority 2 =0.1
Quality Priority1=0.1
Quality Priority2=0.1
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=0.1
Initial Trust in 2=0.1
Potential communication=0.1
Fraction of work to be coordinated=1,
Fraction of work done by 1 and used by 2=1
Fraction of work done by 2 and used by 2=1
Scope Priority 1 is set at 0.1, 0.5, 0.9

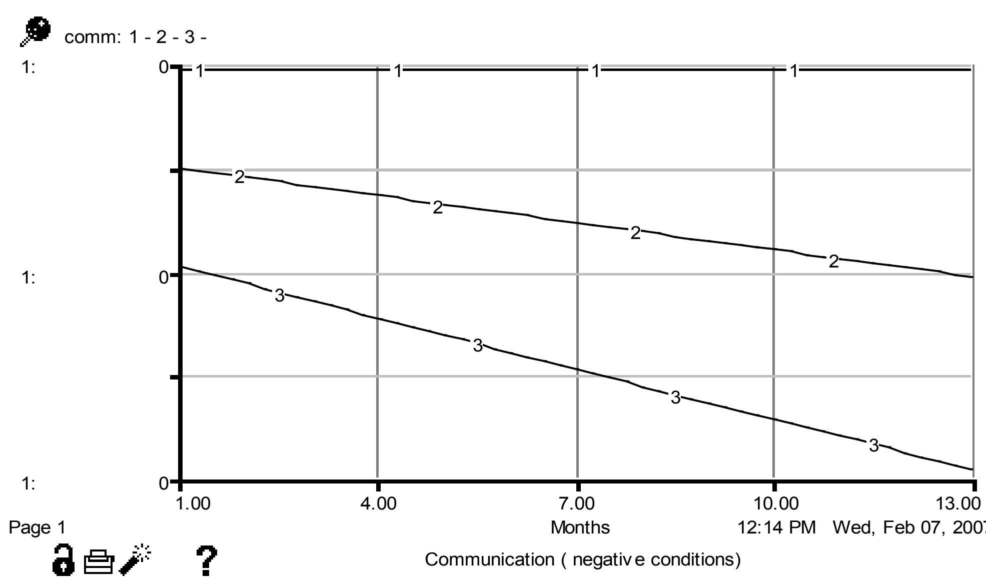


Figure 6-56: Case 1 Level of Communication (Negative Cond. and Quality Priority Fixed)

Despite minor differences in the level of communication due to variation in the level of goal alignment, the low level of potential communication and initial trust lead to a very low level of communication at any level of scope goal alignment for extreme negative conditions.

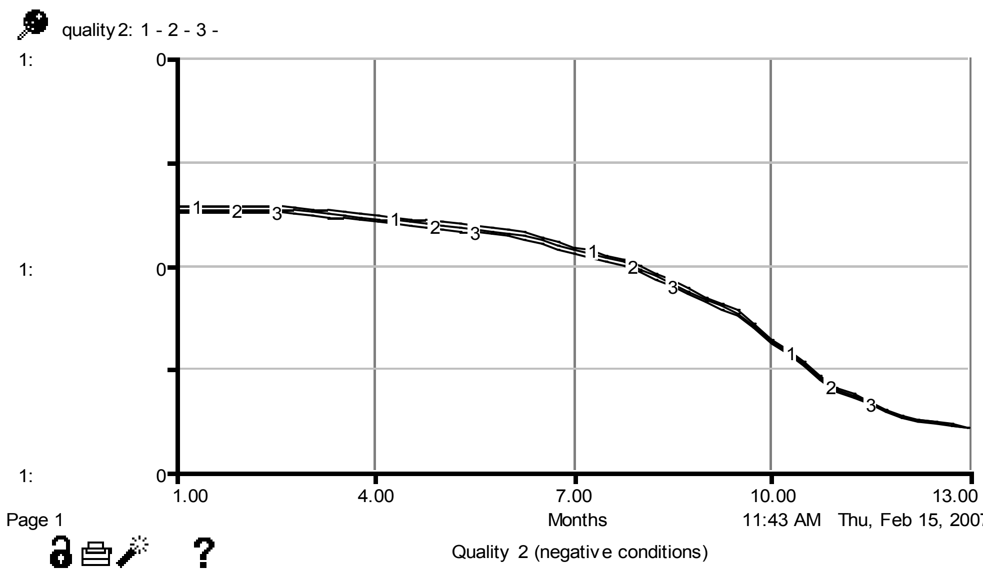


Figure 6-57: Case 1 Level of Quality 2 (Negative Cond. and Quality Priority Fixed)

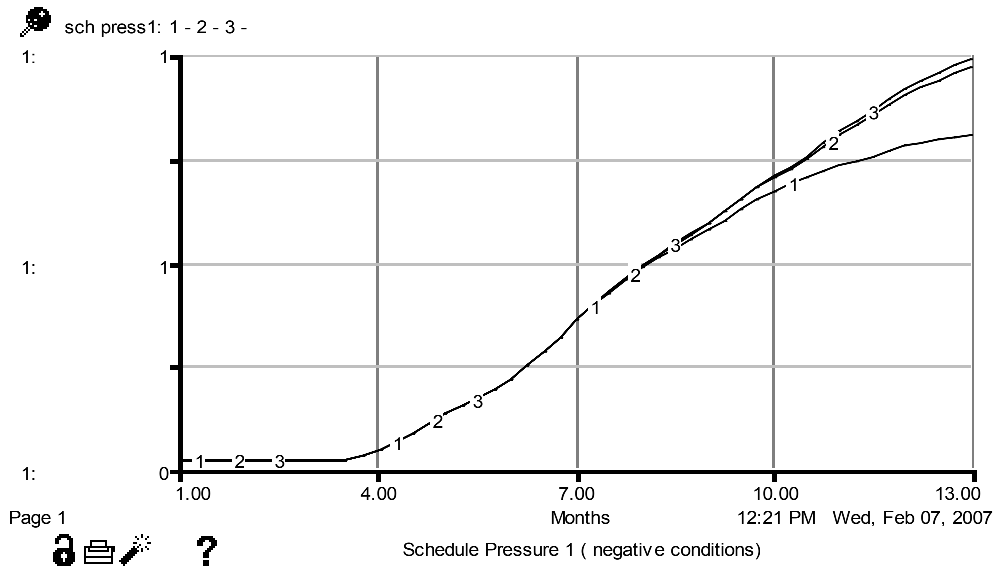


Figure 6-58: Case 1 Level of Schedule Pressure 1(Negative Cond. and Quality Priority Fixed)

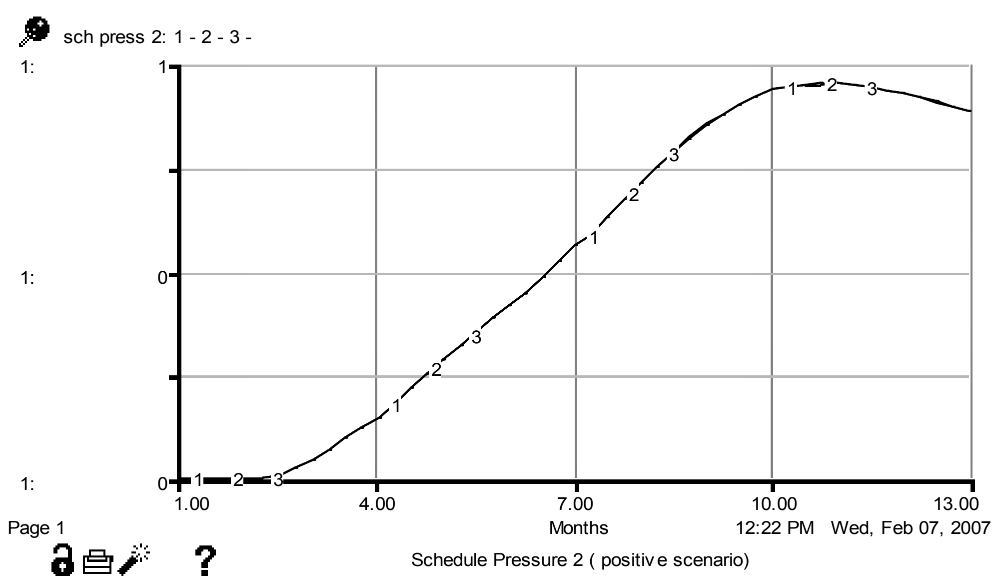


Figure 6-59: Case 1 Level of Schedule Pressure 2 (Negative Cond. and Quality Priority Fixed)

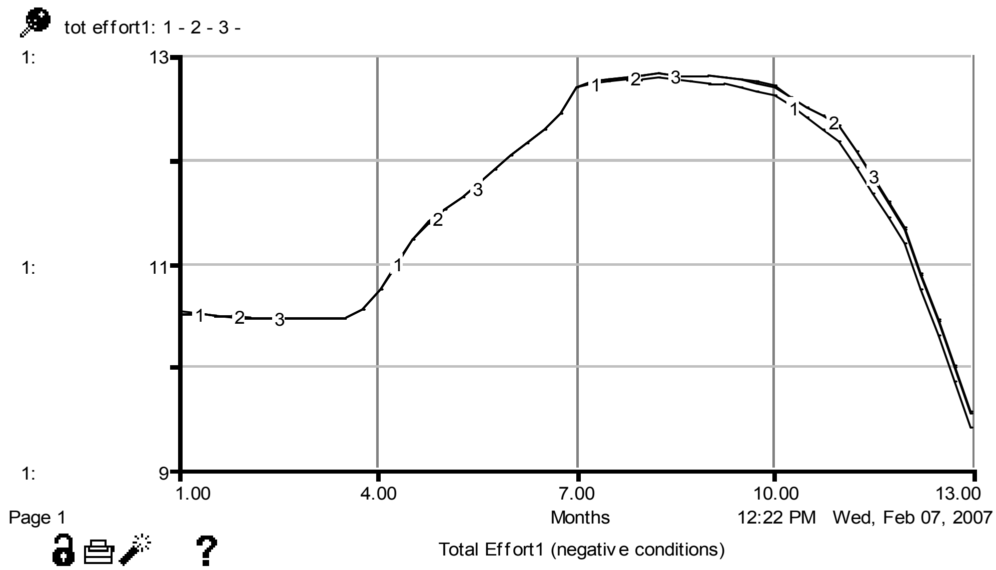


Figure 6-60: Case 1 Level of Total Effort 1(Negative Cond. and Quality Priority Fixed)

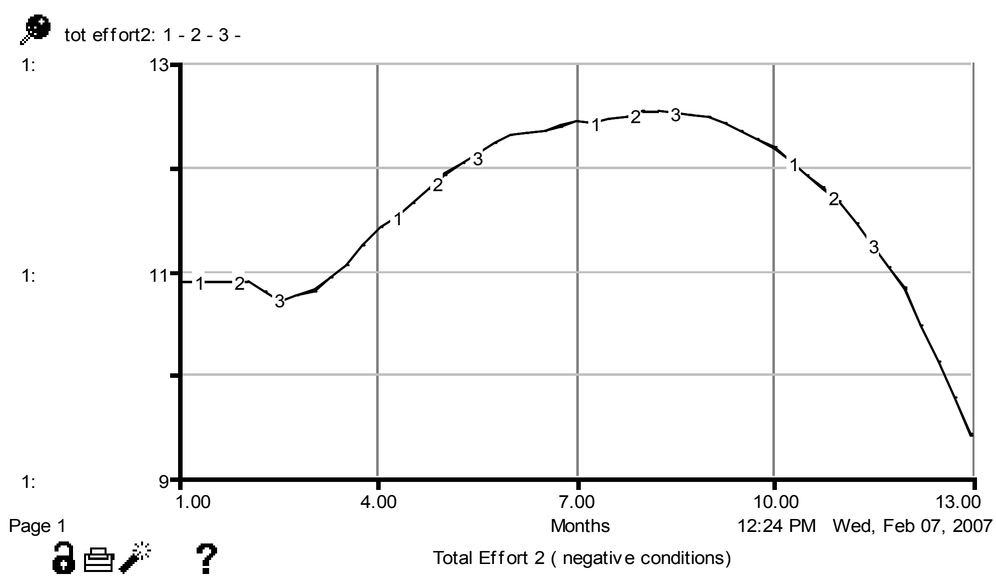


Figure 6-61: Case 1 Level of Total Effort 2 (Negative Cond. and Quality Priority Fixed)

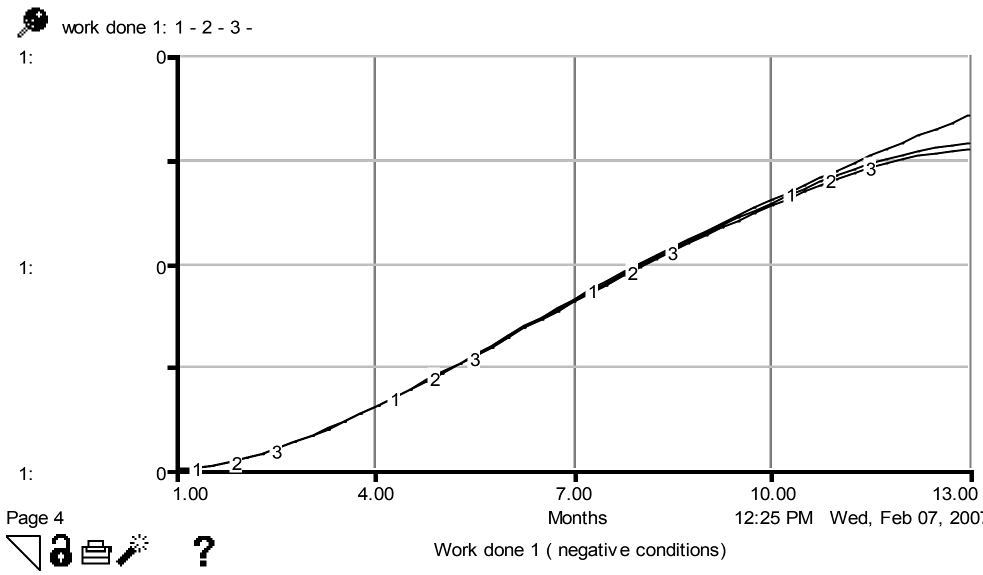


Figure 6-62: Case 1 Level of Work Done 1 (Negative Cond. and Quality Priority Fixed)

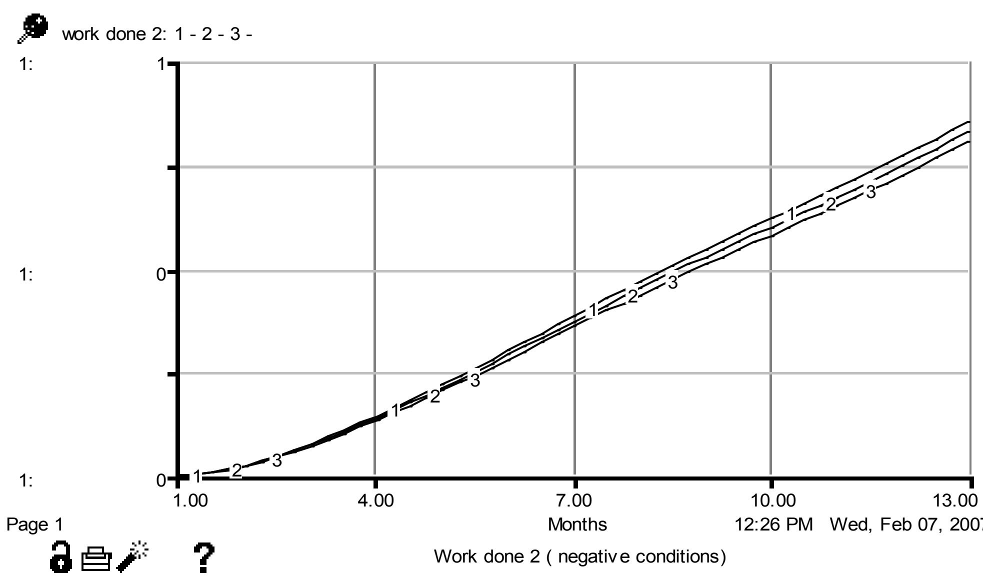


Figure 6-63: Case 1 Level of Work Done 2 (Negative Cond. and Quality Priority Fixed)

As in the case of fixed quality priority for Partner 1, the effect of variations in the level of scope goal alignment is attenuated by the extreme negative conditions, especially the low level of priority given to the quality goal, the low level of initial trust, the low level of potential communications and the high level of interdependence between partners. Hence, the level of quality and work completed provided by the simulation under extreme negative conditions are very low, while the level of schedule pressure and scope reduction are very high. The level of total effort deployed is balanced by the need of additional effort to cope with the schedule slippage, the need of rework, and the inability to deploy coordinated effort due to poor communication between partners.

In general, the case 1 model behaves as expected under average and extreme conditions. As suggested by the case data, the level of goal alignment influences the level of communication between partners, affecting the level of quality displayed, the need for rework and additional effort, the ability to deploy coordinated effort and the level of effort assigned to reviewing other partners' work. These factors affect other project performance indicators, such as total effort deployed -associated to cost objectives- scope reduction, and the amount of work completed.

Exogenous variables moderate the effect of goal alignment, especially the ones associated to the level of interdependence between partners. Finally, under extreme negative conditions, the low level of initial trust and communication between partners attenuates the impact of variations in the level of goal alignment.

6.3.2 Case 2 Model Behavior Analysis

Case 2 Basic Model Behavior

As in the model 1 case, the purpose of the model is to represent the behavior of a multi-organizational project system under different levels of participant organizations' goal alignment. However, in the particular case of model 2, the project work is executed by a contractor and managed by the project team, which is constituted by personnel coming from the two participant organizations. Again, assessing the validity of the model is assessing to what extent the model accomplishes its purpose. Then, it is required to evaluate to what extent the model displays plausible behaviors while performing a sensitivity analysis. Like in the model 1 case, the sensitivity analysis is performed varying the level of goal alignment, and then the effect of that variation on project performance indicators -in this case: work performed and effort deployed- is evaluated.

The model behavior is also affected by exogenous variables that provide inputs to the model-potential quality, potential communication between partners, level at which management understanding of the project, fraction of contractor work to be reviewed by project team, fraction of contractor work that requires project team feedback, and average project team-contractor information transmission duration. As in model 1's case, the sensitivity analysis was performed in two stages. First, the model behavior was simulated under the exogenous variables' average conditions. In this case, most exogenous variables were assumed to be at an intermediate level of their range -in this case, all exogenous variables had a 0-1 range, except the information transmission duration between the contractor and the project team, which was assumed to have a 0-5 range. In the second stage, the exogenous variables were assigned with extreme values, positive and negative. Positive conditions favor the effect of goal alignment on improving project performance. Conversely, negative conditions reinforce the effects of goal alignment that hinder project performance. Those conditions and their effect on how the level of goal alignment affects project performance in the case 2 model are described below.

Analysis of Case 2 Model's Behavior under Average Conditions

As mentioned above, for the average conditions the exogenous variables assume an intermediate value, reflecting normal or regular conditions of the system's exogenous variables.

Quality=0.5 (note that in this case quality is an exogenous variable)
Potential Communication among Partners= 0.5
Management understanding of the project=0.5
Fraction of contractor work to be reviewed by the project team=0.5
Initial level of trust between Partners=0.5
Project team-contractor information transmission duration=3
Fraction of contractor work that requires feedback=0.5
Alignment level is set at 0.1, 0.5, 0.9

Under average levels of the management understanding of the project, initial trust and potential communication between partners, a higher level of goal alignment leads to a higher level of communication between partners, a lower level of management involved and a higher degree of flexibility for decision making granted to the project team members. As a consequence, higher levels of alignment lead to a reduction of the time required for decision making (see Fig. 6-64).

A reduction in the time required for decision making leads to a reduction in the accumulation of problems to be solved, then leaving more time available for contractor's supervision. More time dedicated to contractor supervision favors the project team ability to monitor project progress, and to influence contractor reactions to schedule slippage, increasing the chances for the deployment of additional effort to cope with schedule slippage, which lead to a higher total effort deployed when the level of alignment among partners is higher (see Fig. 6-67).

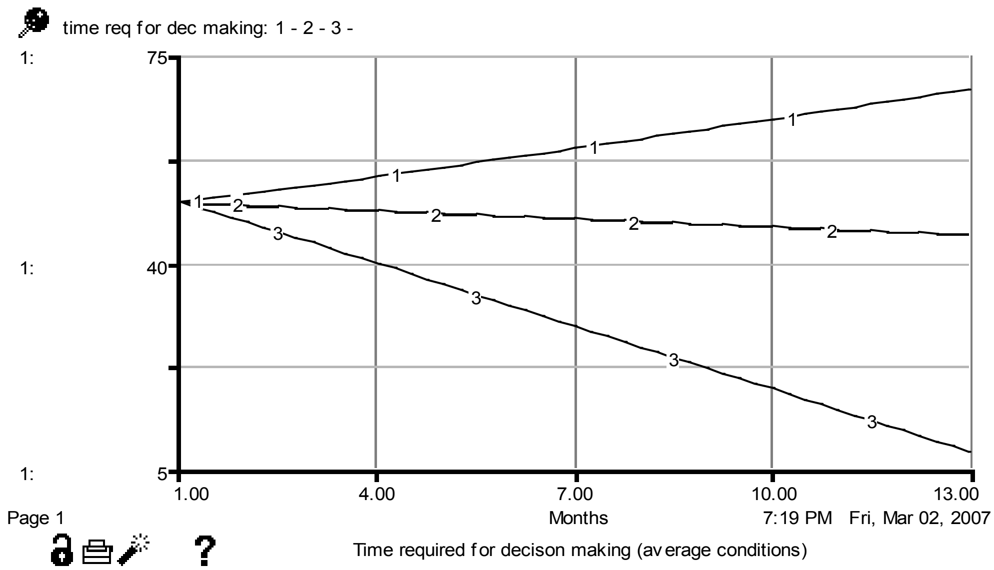


Figure 6-64: Case 2 Time Required for Decision Making (Average Conditions)

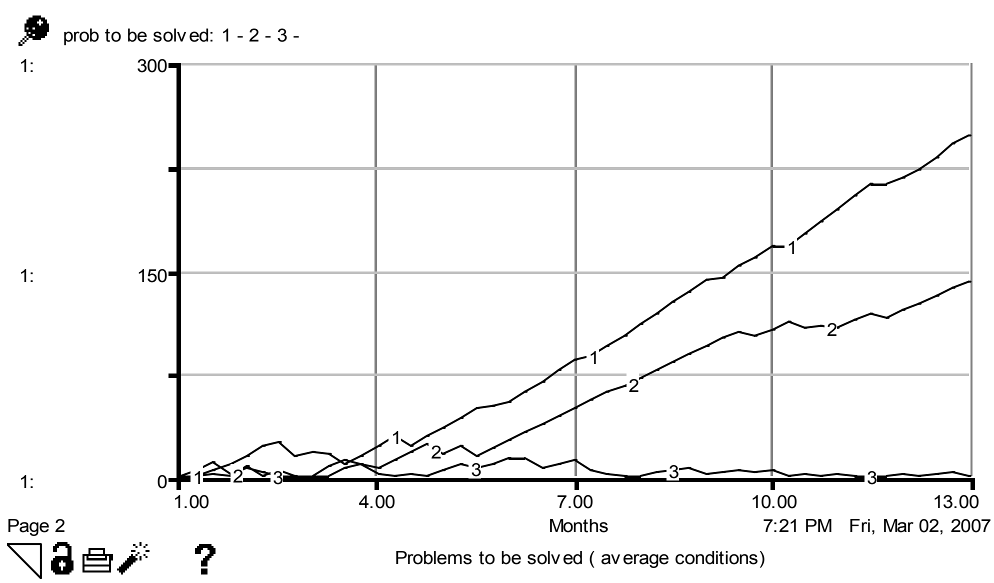


Figure 6-65: Case 2 Level of Problems to be Solved (Average Conditions)

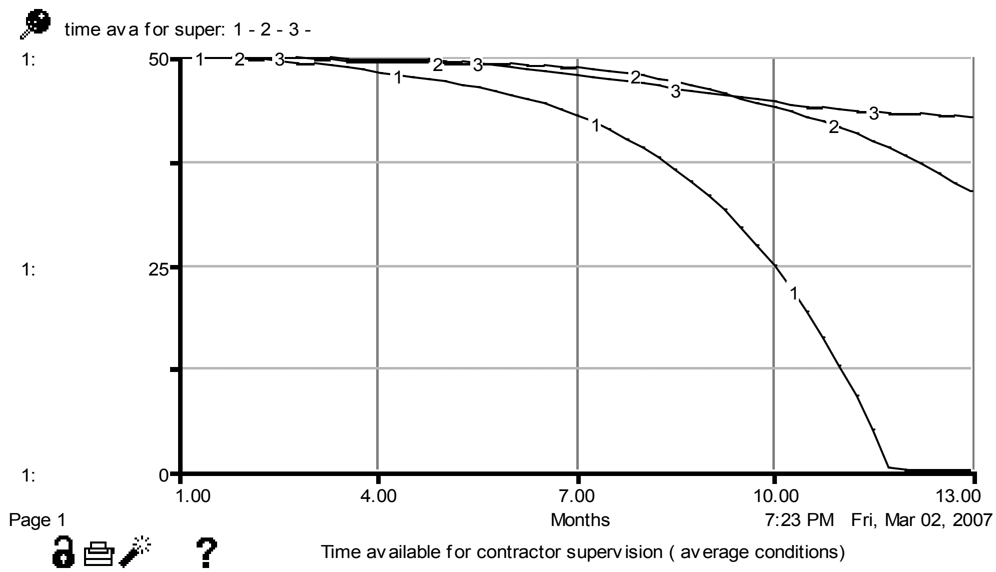


Figure 6-66: Case 2 Time Available for Contractor Supervision (Average Conditions)

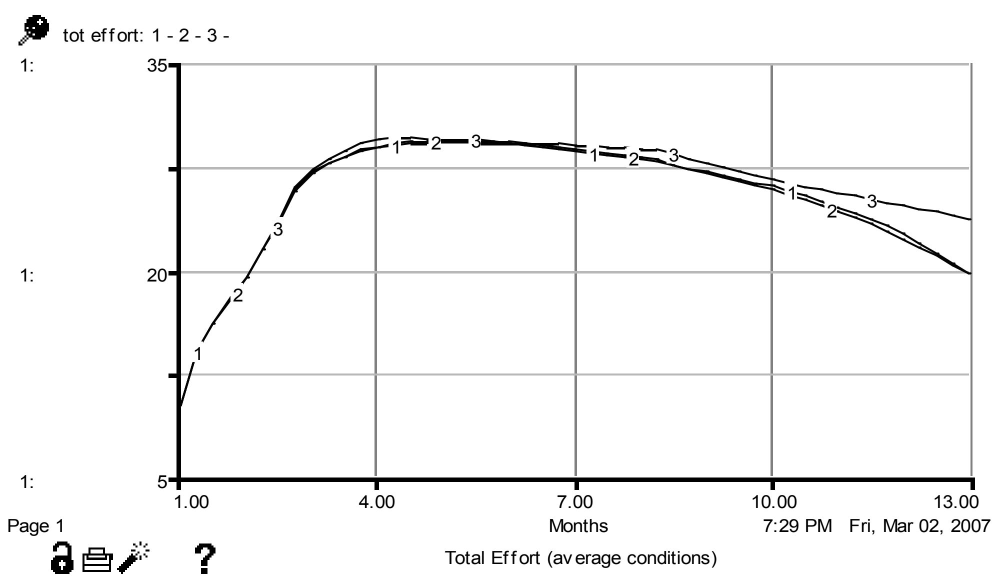


Figure 6-67: Case 2 Total Effort (Average Conditions)

A slightly higher amount of work completed is observed for higher levels of alignment. That difference is reduced by the higher level of effort deployed to cope with schedule slippage.

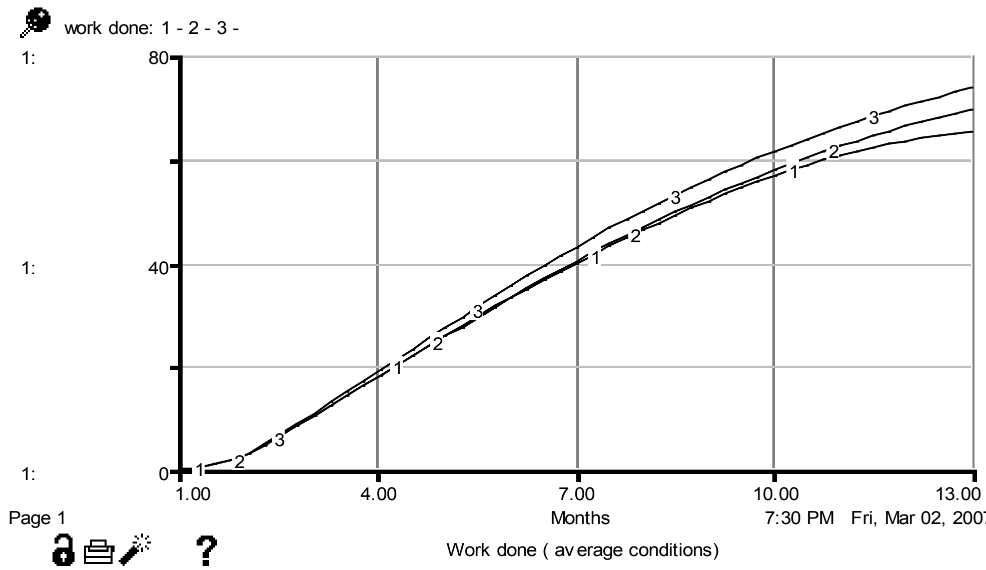


Figure 6-68: Case 2 Work Done (Average Conditions)

Analysis of Case 2 Model's Behavior under Extreme Negative Conditions

For the extreme conditions the exogenous variables assume very high or very low values, reflecting extreme positive or negative conditions of the systems exogenous variables.

Negative conditions:

Quality=0.1
Potential Communication among Partners= 0.1
Management understanding of the project=0.1
Fraction of contractor work to be reviewed by the project team=0.9

Initial level of trust between Partners=0.1
Project team-contractor information transmission duration=5
Fraction of contractor work that requires feedback=0.9
Alignment level is set at 0.1, 0.5, 0.9

Reduced levels of initial trust and potential communication between partners reinforce the impact of low level of alignment between partners on communication. Also, the lower level of management understanding of the project reinforces the impact of the level of goal alignment on raising the level of management involved, and on reducing the degree of flexibility for decision making given to the project team members. Hence, in the case of negative conditions, the time required for decision making increases during project execution at low levels of alignment (see Fig. 6-69).

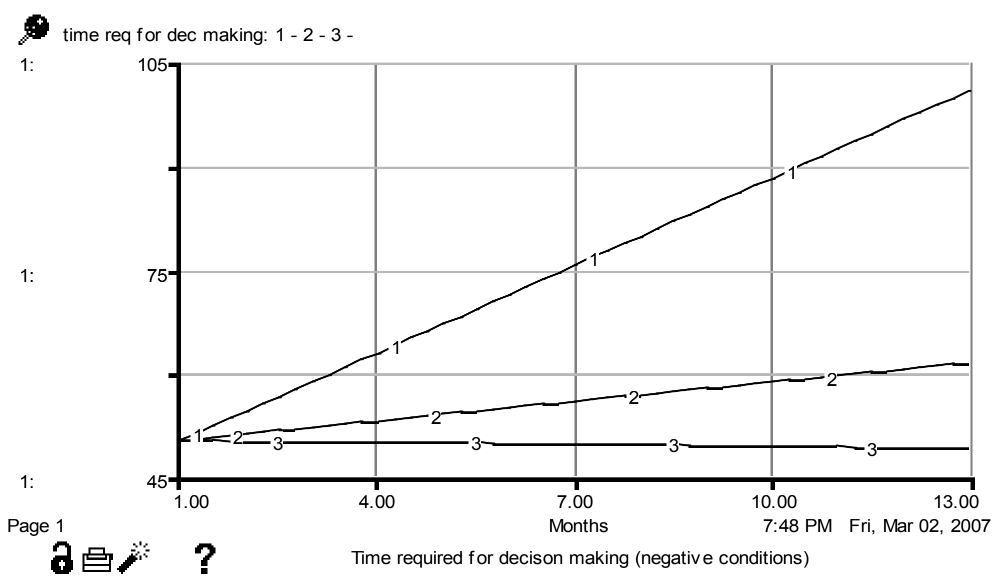


Figure 6-69: Case 2 Time Required for Decision Making (Negative Conditions)

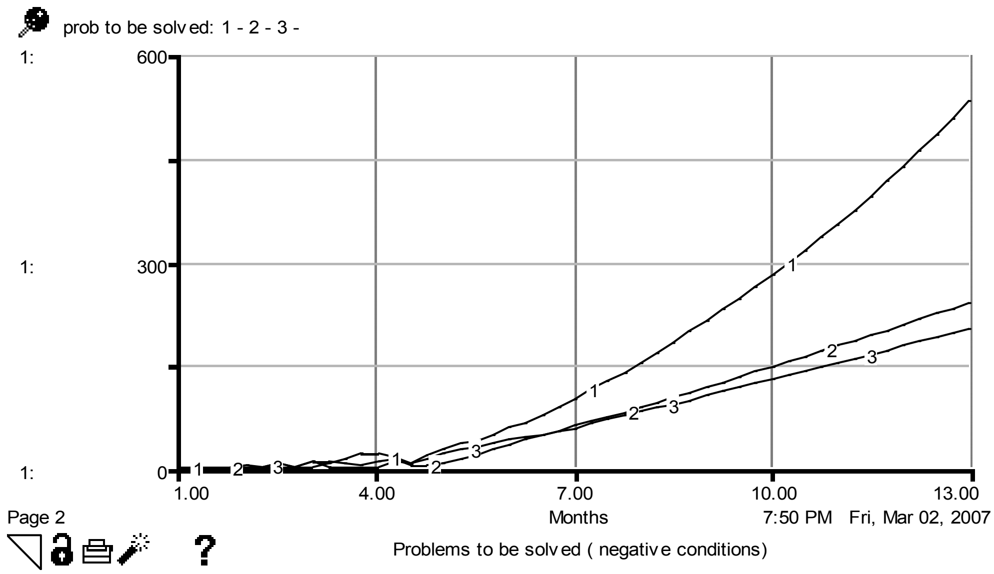


Figure 6-70: Case 2 Level of Problems to be Solved (Negative Conditions)

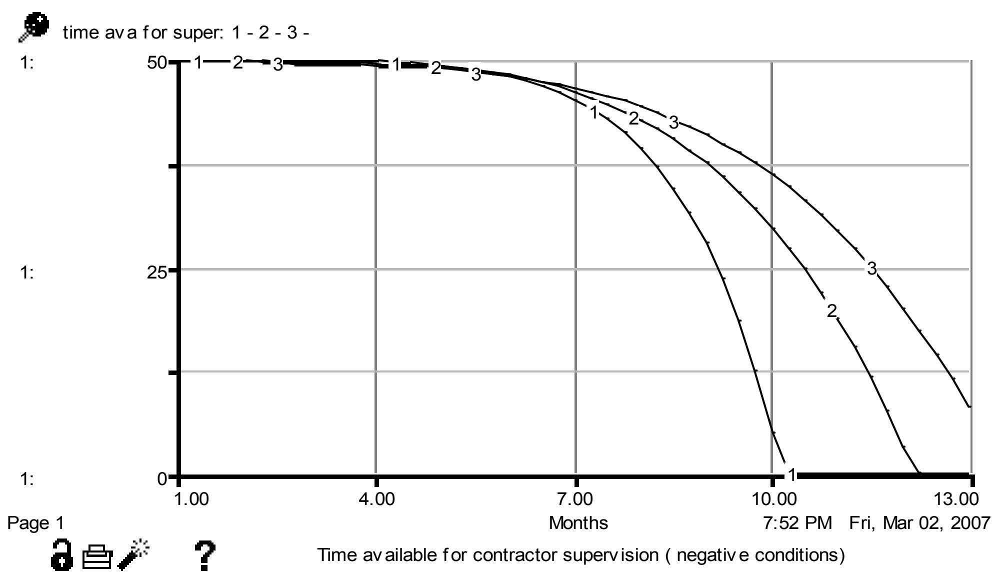


Figure 6-71: Case2 Time Available for Contractor Supervision (Negative Conditions)

Regarding the accumulation of problems to be solved and the time available for contractor supervision, the behavior of the model 2 under negative conditions is similar to the model behavior under average conditions, but in a more extreme way. Lower levels of alignment lead to more time required for problem solving, a lower rate of problem solving, accumulation of problems and less time available for contractor supervision.

The reduced amount of time available for contractor supervision impacts the amount of effort devoted to reviewing contractors' work by the project team, and the amount of additional effort deployed by the contractor to cope with schedule slippage, reducing total effort, progress rate and the amount of work completed.

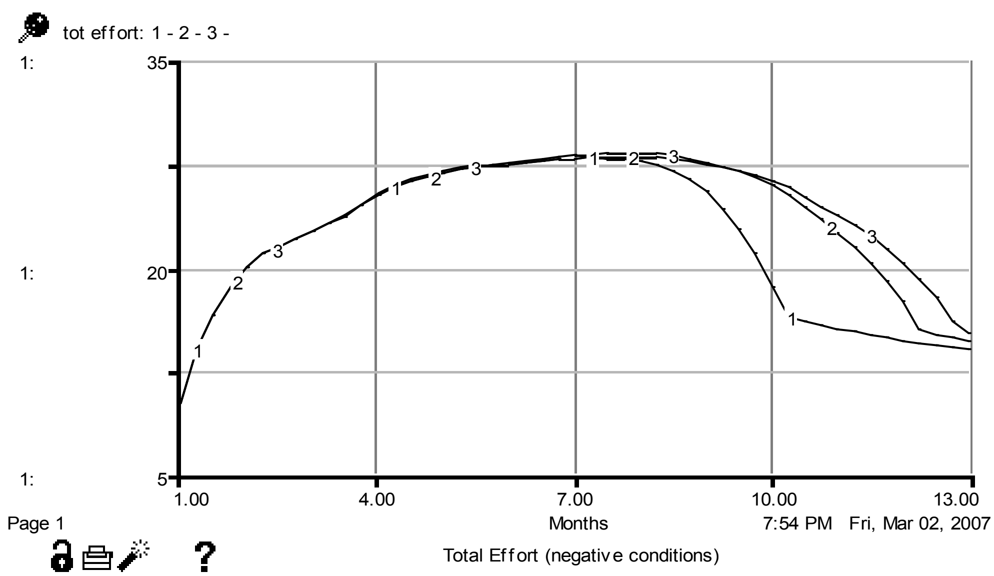


Figure 6-72: Case 2 Total Effort (Negative Conditions)

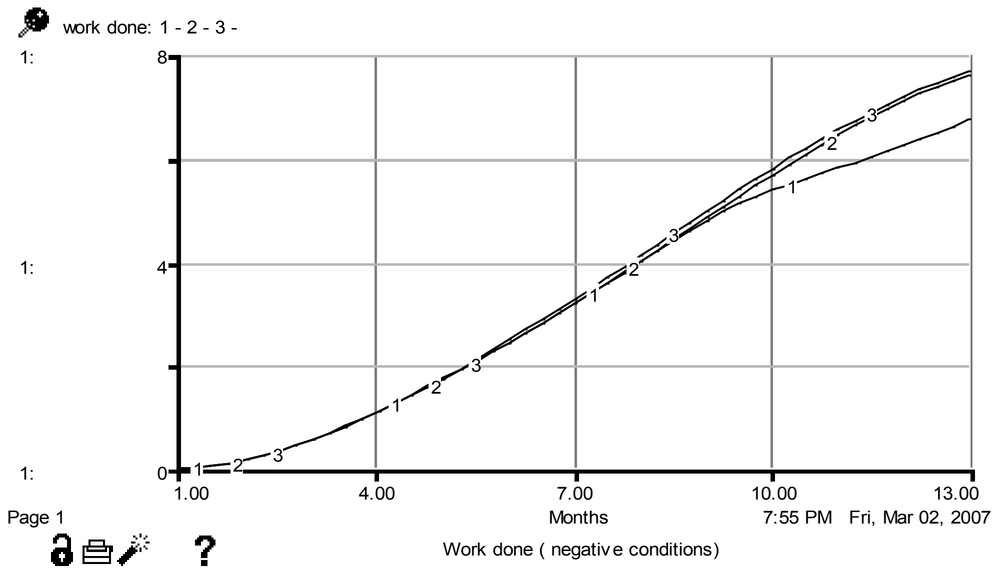


Figure 6-73: Case 2 Work Done (Negative Conditions)

Analysis of Case 2 Model's Behavior under Extreme Positive Conditions

Positive conditions:

Quality= 0.9
Potential Communication among Partners= 0.9
Management understanding of the project=0.9
Fraction of contractor work to be reviewed by the project team=0.1
Initial level of trust between Partners=0.9
Project team-contractor information transmission duration=1
Fraction of contractor work that requires feedback=0.1
Alignment level set at 0.1, 0.5, 0.9

The behavior of model 2 under positive conditions is similar to its behavior under average conditions. However, the effect of variations on the level of goal alignment is moderated by the high level of initial trust and communication between partners, and the high level of management understanding of project issues, which lead to a significant reduction of the time required for decision making by the project team during project execution. Nonetheless, the reduction of the time required for decision making is, as expected, much more considerable when the level of goal alignment is high.

As in the average conditions case, a reduction in the amount of time required for decision making leads to a reduction in the amount of problems to solve and to lower rates of reduction in the amount of time available to the project team for contractor supervision.

Finally, higher levels of management understanding of project issues, initial trust and potential communication lead to a reduced time required for decision making. That, added to a lower level of interdependence between the project team and the contractor - given by minimal fractions of contractor's work needing feedback or reviewing by the project team- leads to a higher rate of progress and to more effort deployed by the contractor to cope with schedule slippage. These two factors generate a reduction of the variation of the amount of work completed when the level of goal alignment is varied.

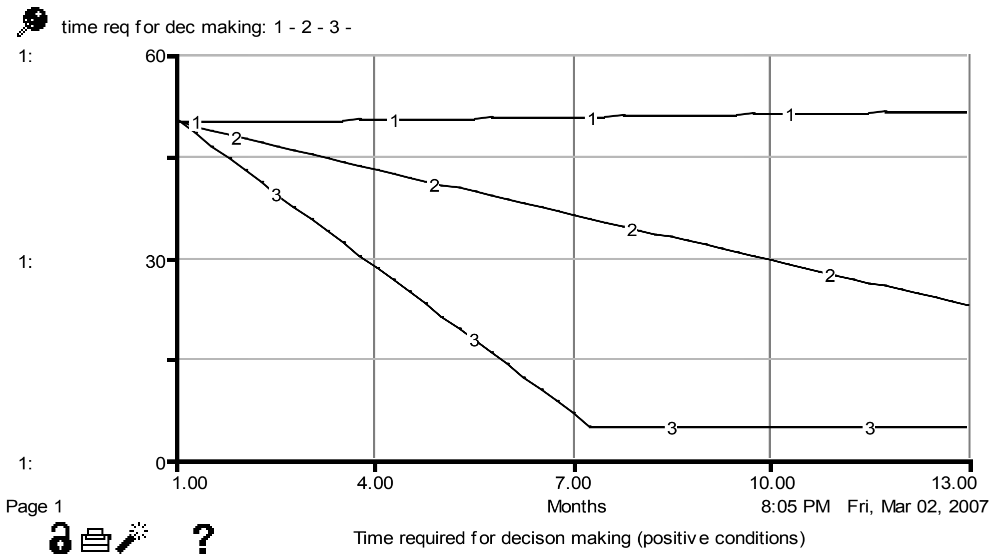


Figure 6-74: Case 2 Time Required for Decision Making (Positive Conditions)

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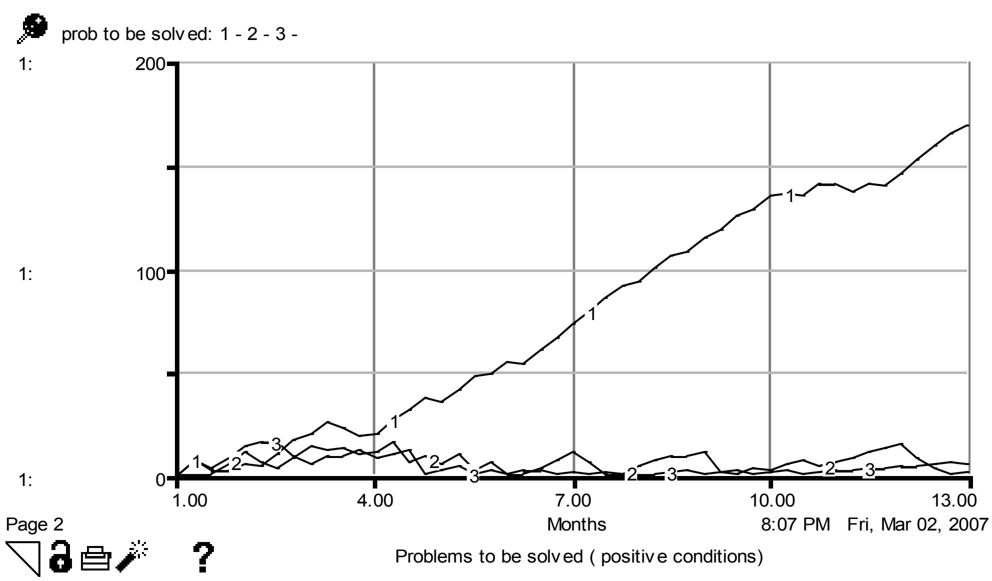

Figure 6-75: Case 2 Level of Problems to be Solved (Positive Conditions)

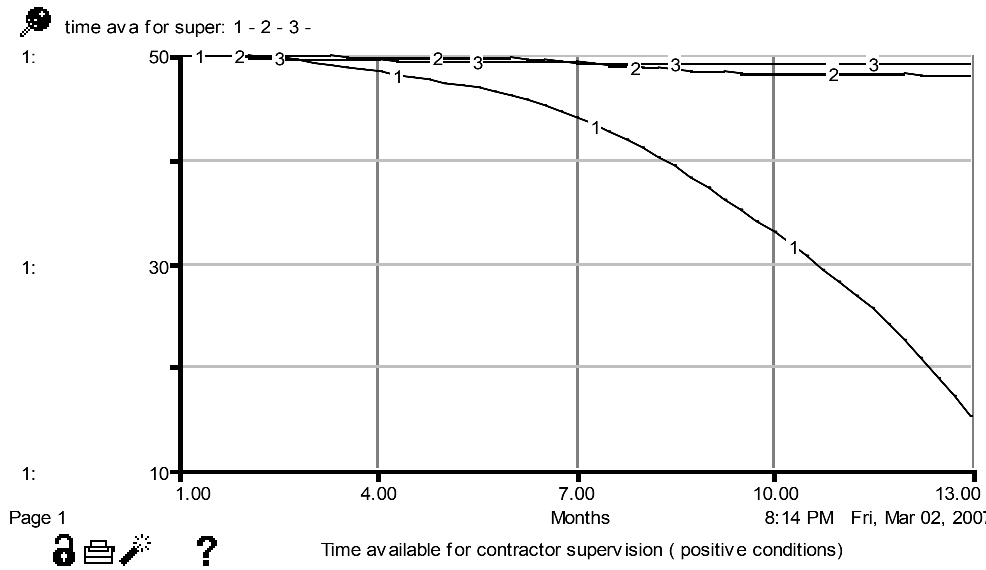

Figure 6-76: Case 2 Time Available for Contractor Supervision (Positive Conditions)

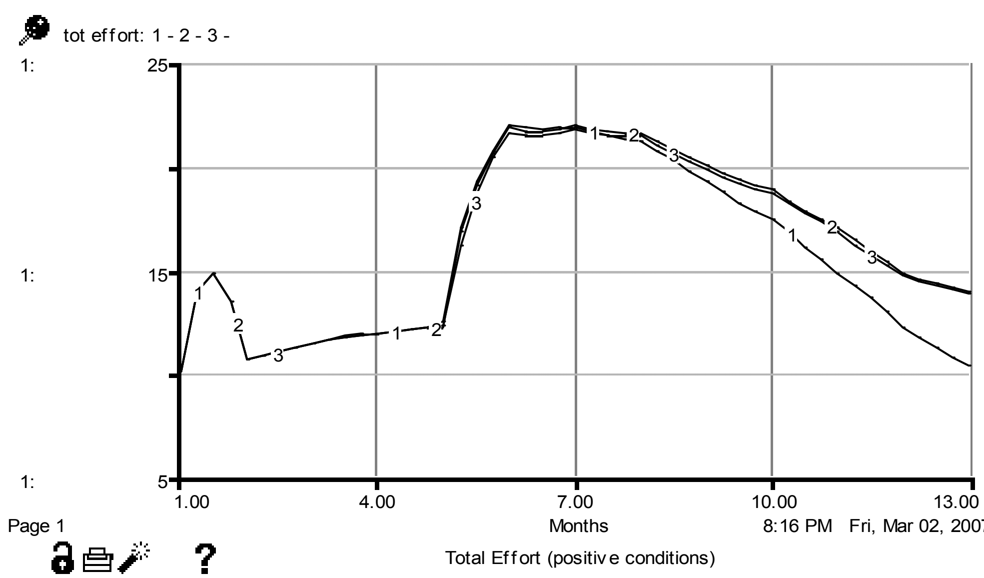

Figure 6-77: Case 2 Total Effort (Positive Conditions)

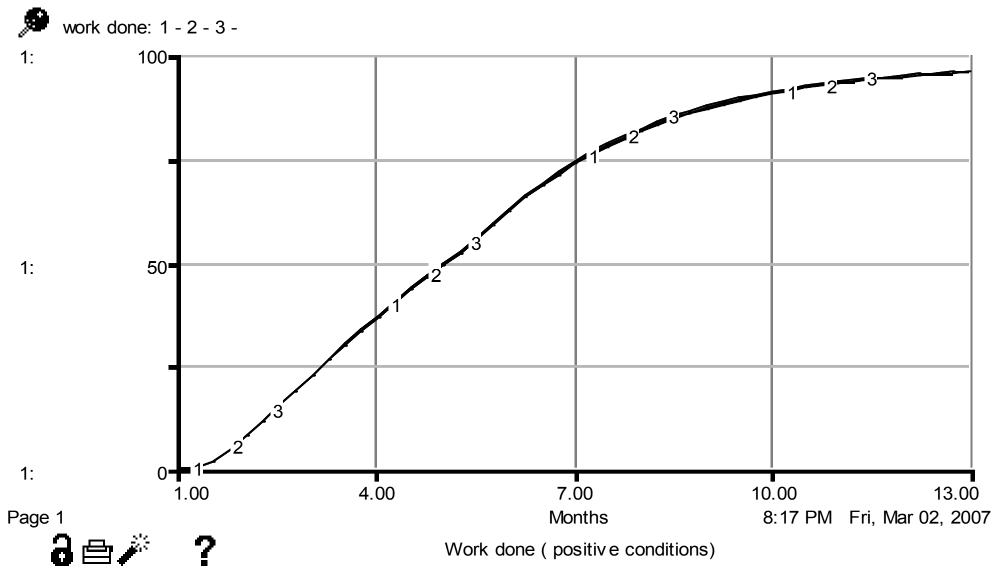

Figure 6-78: Case 2 Work Done (Positive Conditions)

In conclusion, model 2 behaves as expected under average and extreme conditions. As suggested by the case data, the level of goal alignment influences the level of communication between partners, the level of flexibility given to the project team for decision making and the level of management involved in the decision making process.

These factors determine the time required by the project team to make its decisions regarding project issues, and then the amount of problems to be solved accumulated, as well as the time available for the supervision of project contractors. The amount of time available for contractors' supervision affects the amount of time the project team dedicates to reviewing the contractor's work, and the project team's ability to influence the allocation of additional resources when required to cope with schedule problems, then affecting the project progress rate. These factors affect project performance indicators such as total effort deployed and the amount of work completed.

Exogenous variables moderate the effect of goal alignment, especially the ones associated to the level of interdependence between the project team and the contractor. Lastly, under extreme conditions, the very low or high levels of management understanding of project issues, initial trust and potential communication between partners attenuate the impact of variations in the level of goal alignment.

6.3.3 Models' Sensitivity Analysis Considering Exogenous Variables

As mentioned in previous sections, both model dynamics are affected by exogenous variables -exogenous in a sense that their values are determined by dynamics external to the model, but affecting model outputs. These exogenous variables were incorporated in the models in a way consistent with the case data collected. According to the data, exogenous variables interact with variables included in models' dynamics to generate models' dynamics and outputs. Hence, in order to determine if model outputs reflect the actual project system behaviors, it is important to verify if the interaction between exogenous and endogenous variables produce the outputs expected according to the actual project system behavior as described in the case data. To do so, a sensitivity analysis was performed, setting the exogenous parameters at low, intermediate and high levels, and observing as project performance measures variations when the level of goal alignment is varied. If project performance measures vary in a way consistent with what is expected according to the case data, then there could be more confidence on the models' ability to represent the studied multi-organizational project systems' behaviors.

Case 1 Model Sensitivity Analysis

To perform the sensitivity analysis, all model's exogenous variables were set at an intermediate level. Then each exogenous variable, one by one, were considered for variation, while all other were kept at the intermediate level. Hence, each "experiment" or sensitivity analysis run consisted in setting one exogenous variable and the level of alignment at low, intermediate and high levels, while the other exogenous variables were kept at the intermediate level. That was done with the purpose of assessing the effect of the interaction between the level of goal alignment and each exogenous variable on project performance.

In the model 1 case, all the exogenous variables were considered for the sensitivity analysis. These variables and their values at which they were set are listed below.

Scope Priority 2 =0.5
Scope Priority1= 0.5
Quality Priority2=0.5
Initial Quality1=1
Initial Quality2=1
Initial Trust in 1=0.5
Initial Trust in 2=0.5
Potential communication=0.5
Fraction of work to be coordinated=0.5
Fraction of work done by 1 and used by 2=0.5
Fraction of work done by 2 and used by 2=0.5

Also, in the model 1 case, the level of goal alignment is determined by the degree to which project partners assign the same level of priority to the quality and scope goals. Because each of these goals might have a different impact on project dynamics, each goal is considered separately while defining the level of goal alignment. Therefore, each simulation run will consists of setting one exogenous variable at low, intermediate, and high level, with either the level of quality or scope priority was set at low (0.1), intermediate (0.5) and high (0.9) levels

For the sensitivity analysis, initial quality -the level of quality that can be achieved according to the skills and technologies available for tasks execution- was assumed to be at maximum level. Moreover, the fraction of work to be coordinated by partners and the fraction of the work performed by the other partner to be used as an input by each partner were grouped in one variable denominated level of interdependence. The outputs of the simulation runs performed are shown as follows:

Scenario	**High Interdep.**			**Medium Interdep.**			**Low Interdep.**		
Level of Quality Priority1	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done 1	5.22	26.95	28.01	11.78	54.42	61.53	21.67	80.10	89.20
Work done 2	21.37	30.51	23.81	44.50	57.63	51.82	70.21	80.18	76.98
Quality1 (average)	0.08	0.38	0.48	0.11	0.53	0.70	0.14	0.63	0.85
Quality2 (average)	0.33	0.37	0.33	0.49	0.51	0.49	0.61	0.62	0.61
Total effort 1	168.93	162.56	158.80	166.56	150.93	145.42	162.66	142.83	139.95
Total effort 2	154.59	153.64	153.79	145.86	143.93	144.12	134.32	132.09	131.87
Scope reduction1	0.37	0.17	0.16	0.29	0.06	0.04	0.22	0.01	0.01
Scope reduction2	0.46	0.36	0.43	0.26	0.19	0.23	0.10	0.05	0.07

Table 6-7: Model 1 Level of Interdependence Simulation Output (Scope Priority Fixed)

Scenario	High Interdep.			Medium Interdep.			Low Interdep.		
Level of Scope Priority1	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done 1	20.75	26.95	20.74	47.23	54.42	47.25	75.15	80.1	75.16
Work done 2	23.04	30.51	23.03	49.57	57.63	49.56	75.5	80.18	75.5
Quality1 (average)	0.34	0.38	0.34	0.50	0.53	0.50	0.62	0.63	0.62
Quality2 (average)	0.33	0.37	0.33	0.49	0.51	0.49	0.61	0.62	0.61
Total effort 1	161.99	162.56	162.43	150.54	150.93	150.58	140.75	142.83	140.75
Total effort 2	154.02	153.64	154.02	144.70	143.93	144.70	132.57	132.09	132.57
Scope reduction1	1.90	0.17	0.02	0.31	0.06	0.01	0.05	0.01	0
Scope reduction2	0.44	0.36	0.44	0.24	0.19	0.24	0.08	0.05	0.08

Table 6-8: Model 1 Level of Interdependence Simulation Output (Quality Priority Fixed)

When varying the level of interdependence between partners, the effect of the level of goal alignment for both the quality and scope priorities add to the level of interdependence effect. Higher interdependence between partners means that they use more partners' work as input for their tasks, and need to share more information and coordinate efforts. Because the level of goal alignment affects the level of trust and communication between partners, higher levels of interdependence reinforce the effects of low levels of goal alignment on project performance. In the simulation outputs a decline can be observed in project performance indicators when the level of interdependence increases, as expected.

Scenario	High Pot. Comm			Med. Pot. Comm.			Low Pot. Comm.		
Level of Quality Priority1	0.1	0.5	0.9	0.1	0.5	0.9	0.1	0.5	0.9
Work done 1	12.03	57.97	63.06	11.78	54.42	61.53	10.57	44.49	54.52
Work done 2	45.15	62.64	55.63	44.5	57.63	51.82	41.95	47.88	45.69
Quality1 (average)	0.13	0.61	0.80	0.11	0.53	0.70	0.08	0.38	0.53
Quality2 (average)	0.55	0.59	0.55	0.49	0.51	0.49	0.38	0.39	0.39
Total effort 1	174.40	156.91	152.85	166.56	150.93	145.42	152.75	138.47	133.76
Total effort 2	153.34	150.52	150.68	145.86	143.93	144.12	134.59	133.61	133.88
Scope reduction1	0.29	0.05	0.04	0.29	0.06	0.04	0.30	0.10	0.06
Scope reduction2	0.25	0.16	0.21	0.26	0.19	0.23	0.28	0.26	0.27

Table 6-9: Model 1 Level of Potential Communication Simulation Output (Scope Priority Fixed)

Scenario	High Pot. Comm			Med. Pot. Comm.			Low Pot. Comm.		
Level of Scope Priority1	0.1	0.5	0.9	0.1	0.5	0.9	0.1	0.5	0.9
Work done 1	48.50	57.97	48.52	47.23	54.42	47.25	41.63	44.49	41.65
Work done 2	52.52	62.64	52.51	49.57	57.63	49.56	44.53	47.88	44.52
Quality1 (average)	0.58	0.61	0.58	0.50	0.53	0.50	0.38	0.38	0.38
Quality2 (average)	0.55	0.59	0.55	0.49	0.51	0.49	0.39	0.39	0.39
Total effort 1	157.94	156.91	158.00	150.54	150.93	150.58	138.57	138.47	138.65
Total effort 2	151.52	150.52	151.52	144.70	143.93	144.70	134.14	133.61	134.14
Scope reduction1	0.28	0.05	0.01	0.31	0.06	0.01	0.46	0.10	0.01
Scope reduction2	0.22	0.16	0.22	0.24	0.19	0.24	0.27	0.26	0.27

Table 6-10: Model 1 Level of Potential Communication Simulation Output (Quality Priority Fixed)

Scenario	High Initial Trust			Med. Initial Trust			Low Initial Trust		
Level of Quality Priority 1	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done 1	22.50	75.74	84.63	11.78	54.42	61.5	5.7	23.28	29.78
Work done 2	63.67	78.47	74.42	44.50	57.63	51.82	24.43	26.78	25.42
Quality1 (average)	0.13	0.60	0.79	0.11	0.53	0.70	0.09	0.38	0.52
Quality2 (average)	0.55	0.58	0.56	0.49	0.51	0.49	0.39	0.40	0.39
Total effort 1	168.97	148.87	147.06	166.56	150.93	145.42	157.65	153.37	147.61
Total effort 2	143.01	138.52	139.32	145.86	143.93	144.12	143.10	144.04	142.83
Scope reduction1	0.20	0.01	0.01	0.29	0.06	0.04	0.36	0.21	0.16
Scope reduction2	0.12	0.05	0.07	0.26	0.19	0.23	0.43	0.40	0.42

Table 6-11: Model 1 Level of Initial Trust Simulation Output (Scope Priority Fixed)

Scenario	High Initial Trust			Med. Initial Trust			Low Initial Trust		
Level of Scope Priority 1	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done 1	70.65	75.74	70.67	47.23	54.42	47.25	22.25	23.28	22.21
Work done 2	72.01	78.47	72.01	49.57	57.63	49.56	25.10	26.78	25.10
Quality1 (average)	0.58	0.60	0.58	0.50	0.53	0.50	0.37	0.38	0.37
Quality2 (average)	0.56	0.58	0.56	0.49	0.51	0.49	0.39	0.40	0.39
Total effort 1	148.97	149.37	149.77	150.54	150.93	150.58	150.83	153.37	151.30
Total effort 2	140.41	139.02	141.21	144.70	143.93	144.70	142.93	144.04	142.93
Scope reduction1	0.06	0.01	0.00	0.31	0.06	0.01	1.88	0.21	0.02
Scope reduction2	0.09	0.05	0.09	0.24	0.19	0.24	0.42	0.40	0.42

Table 6-12: Model 1 Level of Initial Trust Simulation Output (Quality Priority Fixed)

The same is true for the initial trust and level of communication variables. According to the case data, trust and communication between partners reinforce one to the other. Higher levels of trust lead partners to be more open and willing to communicate their intentions and objectives to the other partners, and the knowledge of these intentions and objectives reinforces trust. Hence, it can be expected that higher levels of initial trust contribute to developing a higher level of communication. Therefore, the combination of higher initial levels of trust with higher level of alignment would result in better indicators of project performance, because it would lead to higher quality, higher coordination in effort deployment, more work completed, less schedule pressure and then higher quality. On the other hand, high potential communication -in the form of co-location, technological infrastructure, and communication policies- also favors the development of a high level of communication between partners. A decline in project performance measures can be observed in the simulation outputs when the levels of potential communication and initial trust decline, reinforcing the effect of a reduction in the level of goal alignment -for both scope and quality priorities. That decline is in concordance with the expected model behavior. A table summarizing the relative significance of the effects of the different exogenous variables studied on case 1 model's performance parameters is presented below.

Exogenous Factor	Level of Interdependence	Potential Communication	Initial Trust
Work done 1	High	Intermediate	High
Work done 2	High	Intermediate	High
Quality1 (average)	High	Intermediate	High
Quality2 (average)	High	Intermediate	High
Total effort 1	Intermediate	Low	Low
Total effort 2	Intermediate	Low	Low
Scope reduction1	High	Intermediate	Intermediate
Scope reduction2	High	Intermediate	Intermediate

Table 6-13: Relative Effect of Exogenous Variables on Case 1 Model Behavior.

Case Model 2 Sensitivity Analysis

The sensitivity analysis for model 2 was performed in a similar way as in the model 1 case. The exogenous variables considered for the sensitivity analysis and the value they were set at are listed below:

Quality= 0.5
Potential Communication among Partners= 0.5
Management understanding of the project=0.5
Fraction of contractor work to be reviewed by the project team=0.5
Initial level of trust between Partners=0.5
Project team-contractor information transmission duration=3
Fraction of contractor work that requires feedback=0.5

In the model 2 case, the level of alignment is not determined by a specific level of agreement on specific goals, but in a general way, which can be applied to any project goal. The levels at which the alignment variable was set for the sensitivity analysis are presented below:

Alignment levels=0.1, 0.5, 0.9

As in the model 1 case, the fraction of contractor's work to be reviewed by the project team, and the fraction of contractor's work that requires feedback from the project team are grouped in one variable denominated level of contractor dependence on project team. The model 2's sensitivity simulation runs are presented below:

Scenario	High Contractor Dependence on Project Team			Medium Contractor Dependence on Project Team			Low Contractor Dependence on Project Team		
Level of Goal Alignment	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done	30.22	41.43	66.01	65.15	67.18	73.65	77.35	78	78.18
Total effort	241.98	281.18	318.13	296.51	310.82	328.62	322.33	325.21	330.14

Table 6-14: Model 2 Level of Contractor Dependence on Project Team Simulation Output

In the model 2 case, a high level of contractor dependence on project team is generated by a work design that requires the contractor to request a lot of feedback from the project team -and then having to wait for the project team's decision making process. The high level of dependence is also generated by specifying that a high fraction of contractor work has to be reviewed and approved by the project team. A high level of contractor dependence on project team requires a project team being capable of providing swift feedback and expedited reviews in order to avoid affecting project performance. Moreover, according to the case data, the level of goal alignment among partners affects the time required by the project team to make decisions and provide indications to the contractor. Hence, a high contractor dependence on the project team would reinforce the effect of variations in the level of project team goal alignment on project performance measures. That reinforcement effect can be observed in the Table 6-14, where the higher level of contractors' dependence on the project team led to a stronger effect of the level of project team goal alignment on project performance indicators.

Scenario	High Level of Mgmt. Understanding of Project Issues			Medium Level of Mgmt. Understanding of Project Issues			Low Level of Mgmt. Understanding of Project Issues		
Level of Goal Alignment	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done	66.02	70.72	74.56	65.58	69.34	73.7	61.37	68.29	70.66
Total effort	315.97	327.90	330.85	307.32	326.24	330.58	288.01	320.69	316.65

Table 6-15: Model 2 Level of Mgmt. Understanding of Project Issues Simulation Output

According to the case data, a high level of understanding of project issues by the management of the organizations participating in the project would contribute to reduce the time required for project team decision making, because the decision making time for senior managers would be also reduced when consulted by the project team about project issues. That behavior is observed in the simulation output depicted in the Table 6-15.

Scenario	High Level of Initial Trust			Med. Level of Initial Trust			Low Level of Initial Trust		
Level of Goal Alignment	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done	66.81	70.21	73.77	68.48	68.65	73.7	66.64	67.65	73.56
Total effort	310.63	322.06	330.59	299.20	318.00	330.58	305.67	320.37	330.51

Table 6-16: Model 2 Level Initial Trust Simulation Output

Scenario	High Level of Potential Communication			Medium Level of Potential Communication			Low Level of Potential Communication		
Level of Goal Alignment	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**	**0.1**	**0.5**	**0.9**
Work done	68.25	71.19	74.58	67.84	69.38	73.7	66.1	68.2	70.27
Total effort	313.54	327.93	330.85	308.78	319.79	330.58	292.06	306.74	326.03

Table 6-17: Model 2 Level Potential Communication Simulation Output

Finally, the initial level of trust among partners, and the level of potential communication would affect the development of communications between partners during the project execution. The level of communication among partners affects the time required for project team decision making, because many decisions might require the participation of all organizations participating in the project. Therefore, lower levels of initial trust and potential communication could reinforce the effect of a low level of alignment on trust and communication on project team decision making and project performance. However, because these two exogenous variables affect project performance through the level of communication between partners and the time required for project team decision making, the effect of each variable operating alone is less significant than the effect of the other exogenous variables considered for the sensitivity analysis (see Table 6-17). A table summarizing the relative effect of the studied exogenous variables on case 2 model's performance parameters is presented below.

Exogenous Factor	Level of Project Team-Contractor Dependence	Level of Mgmt. Understanding of Project Issues	Initial Trust	Potential Communication
Work done	High	Intermediate	Low	Low
Total effort	Low	Intermediate	Low	Low

Table 6-18: Relative Effect of Exogenous Variables on Case 2 Model Behavior

6.4 Summary

The models' structures validation by the participants in the projects provides confidence that the model structures resemble the project dynamics induced by the level of goal alignment in the cases studied. The validation of the model structures by individuals with experience in multiple multi-organizational projects suggest that the basic model structures could be applicable to simulate, with the required adaptations to particular contexts, the dynamics induced by the level of goal alignment in other multi-organizational projects. Finally, the comparative analysis of the model structures with findings in previous related research provides evidence that scholars have observed dynamics and relationships in projects and collaborative efforts to some degree similar to the ones associated with the model structures. On the other hand, discrepancies observed were analyzed and their impact on the model validity assessed.

In general, the models' simulations outputs show that the models behave in a way consistent with the behaviors described in the case data. However, it should be recalled that the consistency between model behaviors and the behaviors reported in the case data should be interpreted only as a sign of the models ability to fulfill their purpose, which is to represent the behaviors of the multi-organizational project systems studied. Because the modeling process lacked of quantitative data, there is a lot of uncertainty about the magnitudes of the variables involved, as well as about the shape of the relationships between them. Qualitative data only allows defining the structure of the models and the directions of the relationships. Hence, the modeling process and the resulting system dynamics models should be considered only as a way to present the case study results in a structured way, describing how the level of goal alignment affected performance in the multi-organizational projects studied. Because the models have not been validated for all possible contexts, they should not be used to explore possible multi-organizational project systems' behaviors under circumstances different from the ones described in the case data without studying each project's specific environment. For the same reasons, the models should be used with caution to analyze possible effects of the implementation of management policies on projects' dynamics and performance.

CHAPTER 7: CONCLUSIONS, IMPLICATIONS FOR PRACTITIONERS AND FURTHER RESEARCH

7.1 Recapitulation

As the number of multi-organizational collaborative ventures has been growing during the last several decades in the form of alliances, partnerships, consortia and business networks, they have been the focus of extensive research. However, the particular case of multi-organizational projects presents specific challenges to management because, to be successful, they require collaboration of disparate organizations with their own objectives regarding the project, and probably different strategic goals and priorities. Hence, this dissertation has focused on examining the project dynamics induced by the level of alignment toward project goals among the organizations participating in multi-organizational projects, and how these dynamics might affect project performance.

To accomplish this purpose, this dissertation benefited from previous research on the areas of goal alignment, multi-organizational collaboration, and project management to elaborate a set of propositions that attempted to explain how the level of goal alignment affects multi-organizational project dynamics and performance. These propositions were assessed through a case study inquiry, including two cases and a cross-case data analysis. The findings of that inquiry were expressed in system dynamics models simulating the dynamics generated in a multi-organizational project by the level of goal alignment among the participating organizations. These models are intended to help to understand how these dynamics develop and affect project performance. Participants in the studied multi-organizational projects, individuals with experience in multi-organizational projects and previous research in related areas were used to assess the validity and potential generizability of the models. Finally, average conditions tests, extreme conditions tests and sensitivity analysis were applied to the models to assess to what extent their behavior resembles the expected behavior according to the case data.

The findings of this research effort, the implication of these findings for researchers and practitioners, avenues for further research, and potential limitations of the study are discussed below.

7.2 Major Findings, Discussion and Contributions to the Inter-Organizational Collaboration and Project Management Theory

The major findings of this study are discussed below, with emphasis on an analysis of the findings in the context of the existing literature and the contribution to the inter-organizational collaboration and project management theory.

1. Changes in the business environment of the participating organizations in a multi-organizational project might induce changes in the level of goal alignment.
2. In the cases studied, the low level of goal alignment during the project life cycle did not lead the participating organizations to reduce the level of effort allocated to project execution. This finding contrasts with the initial study proposition derived from the alliances dynamics literature, which

suggest that when organizations involved in alliances perceived that their objectives for the alliance have not been achieved, the organizations constrain the resources allocated to the alliance (Ring and Van den Ven, 1994; Doz, 1996; Arino and de la Torre, 1998). A possible explanation of this divergence of findings is that, in both cases studied, legal contracts had to be honored and the partners operated in the same markets. Failing to fulfill the contract terms might cause the organization responsible to have problems while attempting to do business in the future within the markets in which that organization operates.

3. In both cases studied, a pattern was identified concerning the mechanism through which the level of goal alignment affected project performance. In both cases, that mechanism was the variation of the level of communication and trust among partners. Also, in both cases the level of communication and trust reinforced one another. In the multi-organizational collaboration literature, the models developed by Black et al. (2002) and Luna (2004) discussed in the literature review section described the relationship between trust and knowledge about partners intentions. In these models, trust was characterized as an average of a calculative component -based on a prior perception of partner's trustworthiness and the risks associated with trusting the partner- and a knowledge component -based on a perception of trustworthiness developed through the collaborative interaction. That model is supported by the findings of this study. The case data shows that there is a

calculative component, named in this study as “initial trust” determined by prior experiences with the partners, including experiences -or lack of them- lived during the project negotiation phase. However, the second knowledge component in the cases studied is related to the perception by the trustier partner -or partner who trusts other partners- that its goals are considered by the trustee partners -or partners who are trusted by the trustier. Luna and Black models did not consider the goal alignment factor in their models. On the same token, they did not consider the effect of trust on communication and then on knowledge about partners observed in the cases studied in this research.

4. The trust–communication mechanism operated in different ways in the cases studied because in one case the project team executed the project tasks, and in the other the project team only managed the project, which was executed by a contractor.

5. In the first case, the low level of trust led to a low level of communication between partners. The perception that the partners did not share the same quality and scope goals led to a low level of trust concerning partners' intentions for the project and to a high level of animosity between partners. That animosity can be characterized as a relationship conflict, because it involves perception of other people, including their motives and actions, leading to interpersonal tension (Simons and Peterson, 2000). Relationship conflict has been found in previous research positively related to low levels of communication in teams' contexts (Pelled, 1996).

Hence, the trust-communication relationship observed in the cases studied corresponds in a significant degree to what has been described in the literature.

6. The low level of communication affected the quality of the tasks that had to be coordinated between partners -in particular system integration problems- as well as the deployment of resources as required to complete the products needed by the other partners as inputs for their tasks. Quality and effort coordination problems led to delays in tasks execution, project slippage and schedule pressure. Some options proposed or used by partners to cope with the schedule pressure created the perception in other partners that their goals for the project were not considered In the first case studied, one partner perceived that its quality and scope goals were not considered and somewhat traded off in favor of schedule and cost goals. That led to further reduction in the level of trust and communication in a reinforcing cycle that deteriorated even further project performance. Black et al. (2002) described a similar feedback loop in which the level of trust led to the level of willingness to engage in the collaborative effort. The experiences of working together -including the achievement of outcomes perceived as positive or negative- led to a new level of trust and willingness to collaborate. However, as mentioned above, the Black et al. model does not consider the effect of trust on communication, and then on the knowledge accumulated about partners' intentions and constraints for the project.

7. In the second case, the trust-communication mechanism operated in a way that interfered with the project team's ability to manage the project. Low levels of trust and communication limited the project team's problem solving capabilities leading to delays in the decision making processes. Because the problem solving activities had to involve all partners -in particular when the issues could affect project schedule or cost, or the facilities' performance and operability- low levels of communication enlarged the time required for decision making. Thomsen et al. (2005) proposed, for the case of a single organization, that moderate levels of goal incongruence among the participants in a project would improve project performance, because it could bring more alternative courses of action while facing project problems (Weck, 1979). On the other hand, high levels of goal incongruence could lead to time consuming arguments in detriment of project performance (March and Simon, 1993). Then, Thomsen et al. suggested a U shaped relationship between goal incongruence and project cost and duration. The behavior predicted by Thomsen et al. for high goal incongruence situations was observed in the case 2 data collected. The low level of goal alignment -or high level of goal incongruence- led to "finger pointing and haggling over contract terms" between partners, which delayed the making of decisions about project issues and then project schedule. In addition, the low level of goal alignment induced a low level of trust and then a low level of communication. The positive relationship between trust and

communication in teams has been documented in the literature (Butler, 1999; Dyer and Chu, 2003). In case 2, the low level of trust led to very "guarded and cautious communications". Partners established communications mostly to argue about the conflicts generated by the low level of goal alignment, and not to find workable solutions to the issues, delaying the decision making process.

8. The difficulties observed in project team problem solving and decision making in case 2 led to the elevation of the conflict to higher levels of management. Because the project goals the project team members received from their organizations contradicted in some cases the goals received by the project team members belonging to other partners' organizations, they needed to consult their senior management to see to what extent they might compromise on those goals to reach agreements on solutions to project issues. A related problem described in case 2 data was that the low level of goal alignment led to an strict and literal interpretation of the project contract, because partners wanted to preserve their interests from changing project goals through the strict adherence to the contract terms, making possible compromises much harder to achieve, then leading to more delays in the decision making process.

9. The delays in the decision making process limited the rate at which the project team was able to solve problems, leading to schedule delays and to the accumulation of problems to solve. Simon (1997) proposed that human actors have cognitive limitations to process information, and assign

priorities to information processing tasks according to their own goals. In the case studied the accumulation of problems to be solved created a "bottleneck" which led each partner to try to solve the most important problems according to their priorities, hindering the team effort to be proactive in anticipating incoming problems and in contributing with the contractor with strategies to approach them before they affect project performance. The inability to anticipate and solve problems at their early stages of development contributed with the accumulation of more problems to solve, in a reinforcing cycle that accelerates the deterioration of project performance measures.

10. Yin (2003) suggests that while performing a case study the researcher should guide her inquiry by the assessment of the case study propositions, and collect only the information required to that assessment, which should lead to the answer of the research question. However, during the interview and in the questionnaires' responses some issues were discussed that, although they do not directly contribute to the assessment of the study propositions, they might interact with the factors directly involved in the effect of the level of goal alignment on project performance, to somehow moderate that effect. These factors are: the geographic location of the project members -lack of face to face contact might hinder the communication efforts and the development of trust- the level of task interdependence -lower levels of interdependence and coordination might make the level of communication less relevant- the level of project team

members experience in multi-organizational projects, the level of definition of project requirements -the higher the ambiguity in requirements definition, the higher the likelihood of misinterpretation or introduction of changes by an interested partner- and the level of detail in project planning -including the degree to which that plan is known by all participants, which would reduce the ambiguity about when sub-products are required.

11. As a conclusion, the study findings discussed above lead to the following explanatory statements and assumptions, which constitute a theory concerning how the level of goal alignment affect multi-organizational projects performance:

    - The level of goal alignment among partners in a multi-organizational project affects the level of agreement on design, problem solving and decision making criteria and partners' perception that their goals are being considered while performing required goals trade-offs.
    - The degree to which partners perceive that their goals are being considered lead to a degree of relationship conflicts between project team members belonging to different partners.
    - The level of agreement on design, problem solving and decision making criteria lead to a level of flexibility and autonomy for decision making available to the project team, and to a certain level

of trust among partners. The level of relationship conflict also lead to a certain level of trust among partners.

- The level of trust leads to a level of communication. The level of communication also affects the level of trust. Past experiences and perceptions of the level of risk involved in the relationship lead to the initial level of trust among partners.
- Concerning project execution, the level of trust and communication affects the exchange of information required to perform interdependent tasks, to deploy effort that requires coordination between partners, and the amount of effort allocated to review other partners' work thereby affecting quality, progress rate and work completed. Slippage in the achievement of project goals concerning these performance measures might exacerbate goals conflict, leading to less trust and communication, in a reinforcing feedback cycle.
- Concerning project management, the level of trust and communication between partners, as well as the level of flexibility and autonomy for decision making available to the project team, affect the time required for decision making. The rate of decision making affects the accumulation of problems to be solved and thereby the amount of time available to manage the project in a proactive way, which influences the rate of progress and the

amount of work completed, affecting again the level of problems to be solved, in a reinforcing feedback cycle.

- The effects described in these statements are moderated by the following factors: the level of tasks interdependence and coordinated effort t-in the case of project execution- and the level of autonomy of the execution party -in the case of project management- the initial level of trust, the partners' potential quality and communication level

The potential validity of these statements is constrained by the degree to which the following assumptions hold true:

- Each organization involved in a multi-organizational project brings its own goals to the project, which might differ from the other partners' goals.
- The multi-organizational project is executed in an environment of stable organizations. No major technological or organizational changes occurs during the project life cycle in the participating organizations
- The organizational contexts do not impose resources constraints on the project out of the normal resources limitations faced by the participating organizations. Each participating organization is assumed able to supply the required resources to the project.
- The project manager's leadership skills, the project team members' teamwork skills level, and the power asymmetry between partners

have no effect on the project dynamics described in the statements. The influence of these factors should be matter of future research.

This research contributes to start filling a gap in the project management and inter-organizational collaboration fields. To the best of my knowledge, there is not another study attempting to describe how the level of goal alignment among the participants affects multi-organizational projects performance. Most of the studies available focus on investigating the factors that might affect multi-organizational collaboration formation and performance, but not on how those factors interact to produce the observed effects. Only the Black et al. (2002) and Luna (2004) models describe the dynamics of trust and collaboration, but these models do not consider the effect of the level of goal alignment among the participants in the collaborative effort. The virtual team alliance (VTA) model introduced by Thomsen et al. (2005) attempts to predict to what degree the level of goal incongruence among the participants in a project influences certain project performance measures like cost and time to completion. This model is a stochastic one; built on micro-canonical behaviors based on the information processing approach to the organization. The model also incorporates several moderating variables. However, the VTA model does not describe how the level of goal incongruence affects the dynamics developed between the elements of the project system, including resources, goals, processes, constraints and management policies.

Hence, the main general contribution of this study is the development of a preliminary theory about **how** the level of goal alignment affects the multi-organizational project system dynamics and performance. Future researchers could build on this preliminary theory to analyze particular cases of multi-organizational projects, refining it according to the specific project environment, and incorporating new direct or moderating effects according to new data available.

Other particular theoretical contributions of this study are discussed as follows:

1. The study findings suggest that the level of goal alignment among participants in a multi-organizational project affects project dynamics at both project management and project execution levels. At the project management level, the level of goal alignment seems to affect the project team ability to make the required decisions promptly to get the project back on track when facing problems. Also, the level of goal alignment seems to affect the project team ability to monitor project progress and anticipate incoming issues which might affect performance. At the project execution level, the study findings indicate that the level of goal alignment affects the project team's ability to exchange the information required to execute interdependent tasks, and also the ability to coordinate the use of resources to deliver the required sub-products on time, affecting the quality, effort and progress structures of the project dynamics system, and then project performance.
2. Study findings suggest that the effects described above are generated through the variation of the level of trust and communication between partners. Also, the study provides evidence of the dynamic relationship between trust, the perception of the incorporation of partners' goals for the project and the level of communication among partners in the cases studied. These contributions add to past research on inter-organizational collaboration by including the reinforcing dynamics between the level of trust and communication, and their effect on the

perception of other partners' intentions and constraints for the project. The importance of the initial level of trust between the project team members was also identified. The initial level of trust can contribute to start a "virtuous" feedback loop of high trust leading to a high level of communication and then to a higher level of trust.

3. This study presents two system dynamics models based on previous project management system dynamics applications, and on the case data collected. The first model attempts to represent the dynamics developed at the project execution level by the level of goal alignment among partners in the studied multi-organizational project (case 1). The second model (case 2) attempts to represent the dynamics developed at the project management level by the level of goal alignment among partners in the case 2 multi-organizational project. Despite the fact that these models are based only in qualitative data, that they represents the dynamics in particular cases and that they only include two organizations; the models can be useful as a tool to explain the possible impact of goal alignment on multi-organizational projects performance. Also, future researchers could build on these models to develop their own system dynamics applications for other multi-organizational projects under similar or different circumstances and contexts.

The contributions described above are theoretical or research contributions. As follows the practical implications of the findings of this study are discussed.

7.3 Implications of the Study Findings for Project Management Practitioners

The findings of the present research have the following implications for the senior management of the organizations, as well as for project managers and other personnel involved in a multi-organizational project. These implications are based on the analysis of the data collected for the particular cases studied, and on its comparison with previous research. Hence, they should not be interpreted as prescriptions for all multi-organizational projects, but just as points to be considered while managing that kind of projects. The implications should be rather used as suggestions which applicability is contingent to the specific project circumstances.

1. Because, according to the study findings, a low level of goal alignment might significantly affect multi-organizational projects dynamics and performance, senior management of the organizations involved should be aware of possible changes in the business environment that could induce variations in the level of goal alignment among the project partners. In the case of detected misalignment, project goals should be renegotiated in order improve the level of goal alignment. Senior management should clearly state the renegotiated project goals for the project team.
2. Senior management should analyze possible goal conflicts -or potential low level of goal alignment- while selecting partners for the accomplishment of a multi-organizational project. Situations like the one described in case 1, in which a partner was also the final user of the product developed, should be considered candidates for further analysis. In that analysis the risks of low level of goal alignment and its consequences should determined, as well as

possible courses of action, including the replacement of partners, or specific mitigating actions to reduce the goal conflict impact (see points 5 and 6 below).

3. Senior management of the organizations participating in a multi-organizational project should be aware of project issues with a certain level of detail, in order to provide swift support to the project management team when they elevate problems related to goal conflicts between partners. On the other hand, when the strategic objectives of the organization are not compromised, senior management should provide the project team with guidelines and certain latitude to negotiate with other partners' representatives when goals conflicts are present, in order to quickly find workable solutions, without submitting the conflict to senior management consideration. These suggestions might contribute to increase the efficiency of the project team decision making process, avoiding the accumulation of problems, preventing possible schedule slippages and giving more time to the project team for effective project monitoring.
4. The study findings suggest the importance of the level of trust and communications between partners in multi-organizational project performance, and how the level of goal alignment might affect project performance through the reduction of those levels. In addition, the study findings also highlight the importance of the level of initial trust between partners, which could start a virtuous cycle of trust formations and high level of communication. The case data reflects that the initial trust can be enhanced

by involving the project team in the project negotiations phase, where project team members can learn about other partners' intentions, resources and constraints for the project. Moreover, some face-to face contact and team building interventions could be helpful to improve the initial level of trust, especially in the case that project team members have not worked together before, or when they will not be located in the same physical facilities (virtual teams).

5. The study findings also suggest that the most important mechanism through which the level of goal alignment affected project performance in the cases studied was the low level of communication between partners. Hence, project managers should consider specific measures to enhance the level of communication between the project team members belonging to the different organizations participating in the project, in order to facilitate the information exchange required by the interdependent tasks and the coordination of the resource deployment as required to perform collaborative tasks. O' Sullivan (2003) described in his case study the strategies deployed by the leading organization of an aerospace product development project, which worked with 20 suppliers, located in different geographical sites. To overcome possible communication difficulties and accomplish the project objectives, the leading organization deployed two strategies. The first strategy was a profound standardization of the work patterns, including how, where and when the work should be performed. To achieve that standardization, the leading organization made use of three tools. First, the implementation of a digital

model based in a specific design software application, which had to be employed by all suppliers. Second, direct communications were standardized through a 'coordinating memo" template, to make sure that all the information required was conveyed. Third, a master schedule was devised and implemented, matching and integrating all suppliers' individual schedules, to ensure the proper work synchronization. These strategies are to a large extent similar to the ones proposed by the case 1's interviewees. They suggested that project requirements had to be defined with minimum ambiguity before the project starts, as well as common work standards. Case 1 interviewees also suggested the necessity of having a project plan, accepted by all team members, which clearly specifies when the required sub-products for integration should be released, to reduce the possible ambiguity of the "meaning of quick". Hence, the strategy implemented by the leading organization, as described in the O'Sullivan case, seems to be very plausible for consideration to reduce the ambiguity in multi-organizational projects' communications and coordination.

6. The second strategy implemented by the leading organization in the O'Sullivan case was a modularization of the design, which reduced the amount of interfaces and interdependence between the suppliers, and defined standards for the performance of each subsystem. The objective of this strategy was to reduce the required level of communication for task execution, making the project less susceptible to communications problems. Because the level of communication was identified in the studied case data as the most

important mechanism through which the level of goal alignment affects multi-organizational project performance, a strategy that reduces the potential impact of a low level of communication on project performance would reduce the project exposure to the risk of variations in the level of goal alignment among partners.

7.4 Study Limitations and Further Research

The present study has several limitations, rooted in the research methodology used and in the data available. These limitations are discussed below.

1. The case study research methodology, while useful to answer "how" research questions; imposes limitations for the generizability of the studies' findings. In the research methodology chapter, that limitation was discussed. Like experiments, case studies are generalizable to theoretical propositions, and not to populations. A case study does not represent a sample, and in doing a case study, the goal is to expand and generalize theories and not to enumerate frequencies (Yin, 2003). Hence, the only way to assess to what extent the theory developed in this study about how the level of goal alignment affect multi-organizational project performance is valid for other cases is to perform a similar study on those cases. As more replications are performed, more data would be collected and more confidence could be allocated to the resultant theoretical propositions.
2. Due to confidentially issues discussed in the research methodology section, only interviews data was collected. Written documentation was not available, so the triangulation strategy proposed could not be implemented. Hence, quantitative

data was not available. Lack of quantitative data prevented the numeric definition of the relationships between the variables in the system dynamics models, and then the comparison of the models simulation outputs with real project performance values. The use of data collected during the interviews without being triangulated with other data sources might have introduced biases because interviews data was based only on interviewees' recollection of past events - however, one of the projects studied is still on progress. Moreover, those recollections diverged somewhat according the interviewee role in the project. Project managers had the tendency to see the past projects in a more positive way then other project team members, in particular what concerns to team processes. That bias has been reported in other studies (Larson and LaFasto, 1989; McComb et al., 1999). Finally, in case 2 only members belonging to a partner organization and to the EPC contractor were available for interviewing, then other partners' views were not incorporated in the analysis. These limitations might have had an impact on the validity of some of the findings of the study. On other hand, the fact that the majority of the interviewees, the majority of the panel of individuals with experience in multi-organizational projects, and the comparison to past related research validated the models structures provides a certain level confidence in them.

3. Another limitation is that both project presented a relative low level of goal alignment, instead of a high level of alignment. That might have introduced a "negative bias" in the research. Further research should attempt to study the effects of a high level of alignment on project dynamics and performance.

4. Because the system dynamics models developed in this study are based only in qualitative data, caution should be displayed if these models are going to be used to analyze the effects of project management policies implementation. The models should be adapted for each particular case, and specific parameters for each case should be estimated as well. The models developed in this dissertation are intended only to be a repository of case' findings and a way to represent possible behaviors of the project systems studied.

Future research might be able to overcome this study's limitations, then refining and enriching the theoretical propositions elaborated. As follows, some avenues for these future research efforts are suggested.

1. A research design which would contribute to validate and enhance the theoretical propositions developed in this study is a longitudinal study of multi-organizational project, in which the researcher could have access to all the project data as reported by all partners, including communications, meeting minutes, project reports etc. The researcher should be able to conduct interviews with a certain frequency with individuals at all level of the project organization, belonging to all the organizations involved, probably applying instruments to measure variables such as the level of trust and communication. The conduction of the study while the project is in progress would allow the researcher not to rely on interviewees' recollection of past events -or the recollection of the interviewees' perceptions of these events- but on "fresh" perceptions contrasted with written data. The availability of project numeric data would permit to determine with more precision models' parameters, and to perform simulations

which outputs could be compared with the project historic data. That would allow the researcher to assess to what extent the model developed is able to reproduce real projects behaviors (model calibration).

2. Another avenue for research is the analysis of possible factors the might moderate the effect of the level of goal alignment on project dynamics, such as the role of project manager personality, skills, and leadership style; the organizational cultures of the participating organizations, the project team members level of teamwork skills, the comparative partners' sizes and capabilities, the salience of power asymmetries between partners, and the effects of facilitation in the resolution of conflicts generated by low levels of goal alignment..
3. Relaxing some of the basic models assumptions could also provide research topics. One models assumption establishes that no major technological or organizational changes occur outside the project during the simulation period that might affect project team performance. Particular attention should be directed to the possible effects of the implementation of management policies such as risk/rewards systems, used very frequently in project alliances (Green and Keogh, 2000). Another assumption which relaxation could be investigated is the lack of limits to the amount of skilled resources available to the project partners, so the case in which other projects in partners' portfolios might compete for resources with the project studied could be analyzed.

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8.0 APPENDIXES

APPENDIX A: INTERVIEW PROTOCOL

INTERVIEW PROTOCOL

The interviewees' rights as subjects of this study should be disclosed, including the right of withdraw from the study at will, as well as the right to not to answer questions. The signature of the informed consent form should be required.

The purpose of this research is to investigate how the level of goal alignment might affect multi-organizational projects performance. **For our case, goal alignment is defined as the degree to which participant organizations in a multi-organizational project agree in the level of priority of the cost, schedule, scope, and quality goals. Also, project performance is defined as the degree to which the project objectives concerning cost, schedule, quality and scope were achieved.**

It is important to keep in mind that all the questions are referred to the particular project subject of this study (in your case xxxx). Your answer should reflect only your experiences in that project.

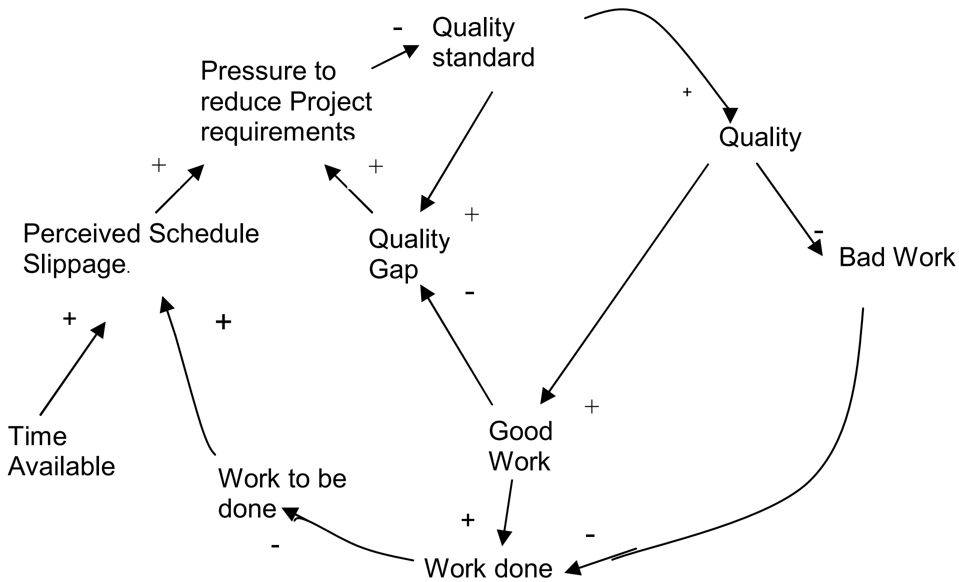
Questions:

1- Describe the project, its goals, and the partnership structure
2- Describe your role in the project, for how long you were involved?
3- How would you characterize the level of goal alignment among partners during the project, were there variations of that level?
4- Were there variations in the level of goal alignment among Partners regarding project cost priority? How did they affect project performance?
5- The same question for the time, quality and scope priorities
6- How was the level of trust between Partners? Did that level of trust affect project performance? If yes, how?
7- How was that trust generated or destroyed?
8- To what extent the satisfaction of the expectations that each participating organization brought to the project affected the level and quality of resources deployed by these Partners on the project?

9- The following picture is a project cause effect structure associated to the quality variable. Please assess to what extent this cause-effect structure is valid for the project studied. How could the level of goal alignment concerning cost, schedule, quality, and scope affect that cause- effect structure? **Note: the cause effect structures should be sent in advance (at least a week before the interview) to the interviewees, so they can be familiarized with them. The researcher should be available to the interviewees for any clarification required concerning the cause effect structures.**

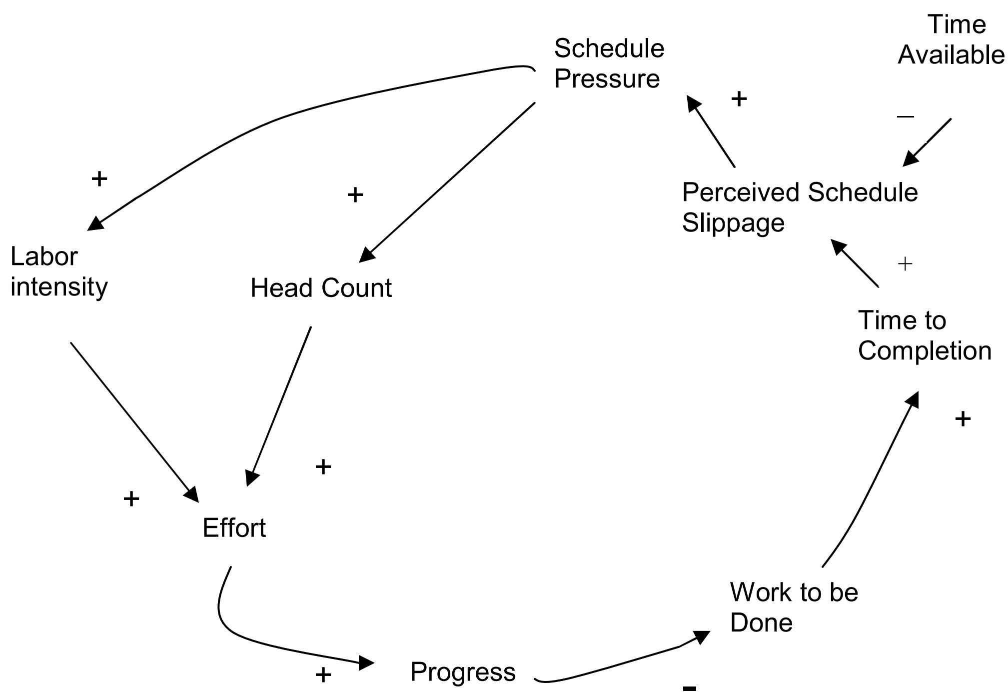
10- The question no. 9 will be repeated for the labor, scope, schedule and basework feedback structures.

The Quality Structure



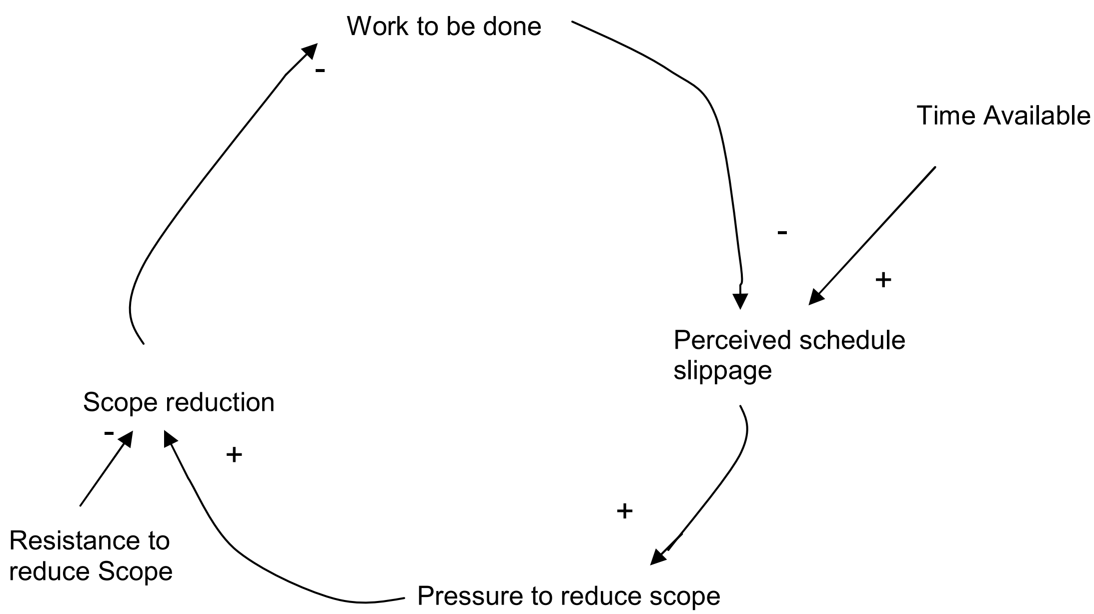
The quality standard (degree to which high quality is pursued in project outcomes) drives quality (degree to which tasks outcomes fulfill project requirements). Quality is the antecedent of the proportion of good work and bad work generated. Bad work generates rework (delaying the work completion), and good work increases the amount of work done. The level of work to be done, compared with the time available until deadline, increases or decreases the perceived schedule slippage. An increasing perceived schedule slippage might lead to a pressure to reduce the quality standard, in order to accelerate the progress and reduce the slippage, but reducing the quality of work performed, increasing the level of rework required and then reducing the level of work done, in a cycle reinforcing quality deterioration. On the other hand, a decreasing perceived schedule slippage would lead to a decreasing pressure to reduce quality standards, reinforcing quality. In addition, a higher level of good work will reduce the perceived gap between the quality of the products and the quality standards, reducing the pressure to reduce the project requirements.

Labor Structure



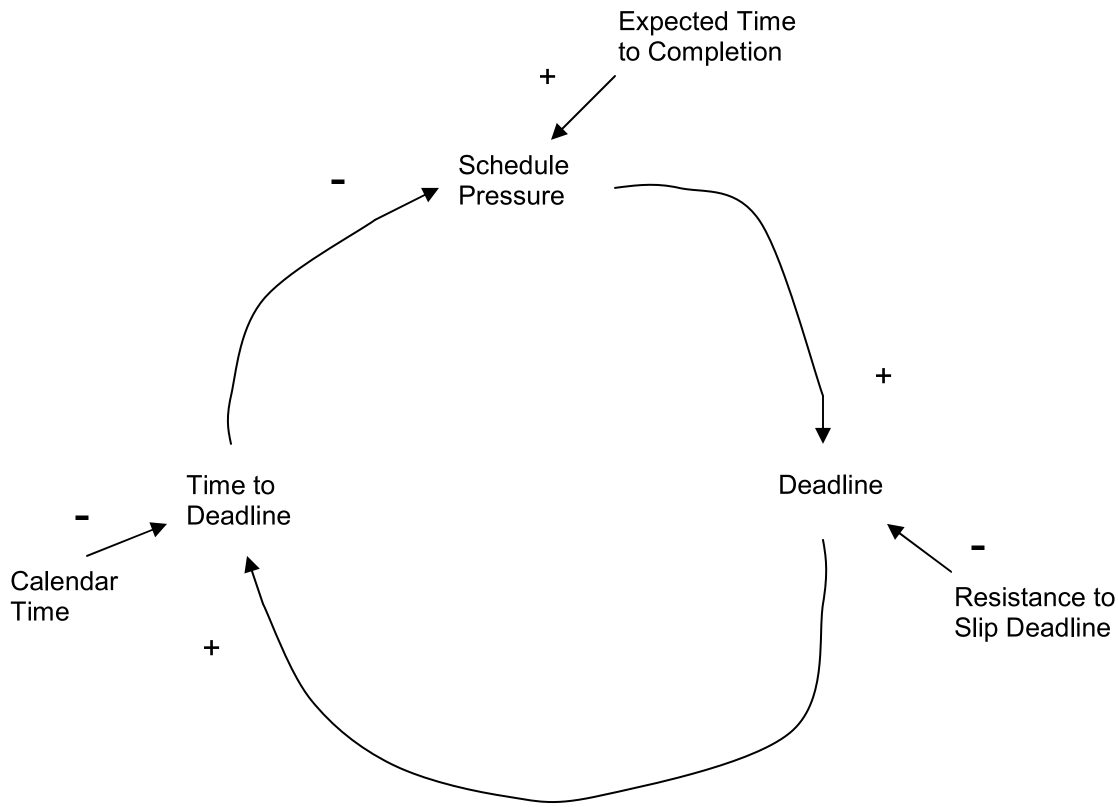
The effort deployed to generate progress in completing project tasks is a result of the head count and labor intensity, which are driven by the schedule pressure (pressure to complete the project on schedule). The effort deployed to complete the project is translated into progress, and then into work done, which reduces the time required to completion. The time require to complete the project is compared with the time available. A negative difference (perceived project slippage) would reinforce a higher schedule pressure, inducing higher labor intensity and head count, in a balancing cycle.

Scope Structure



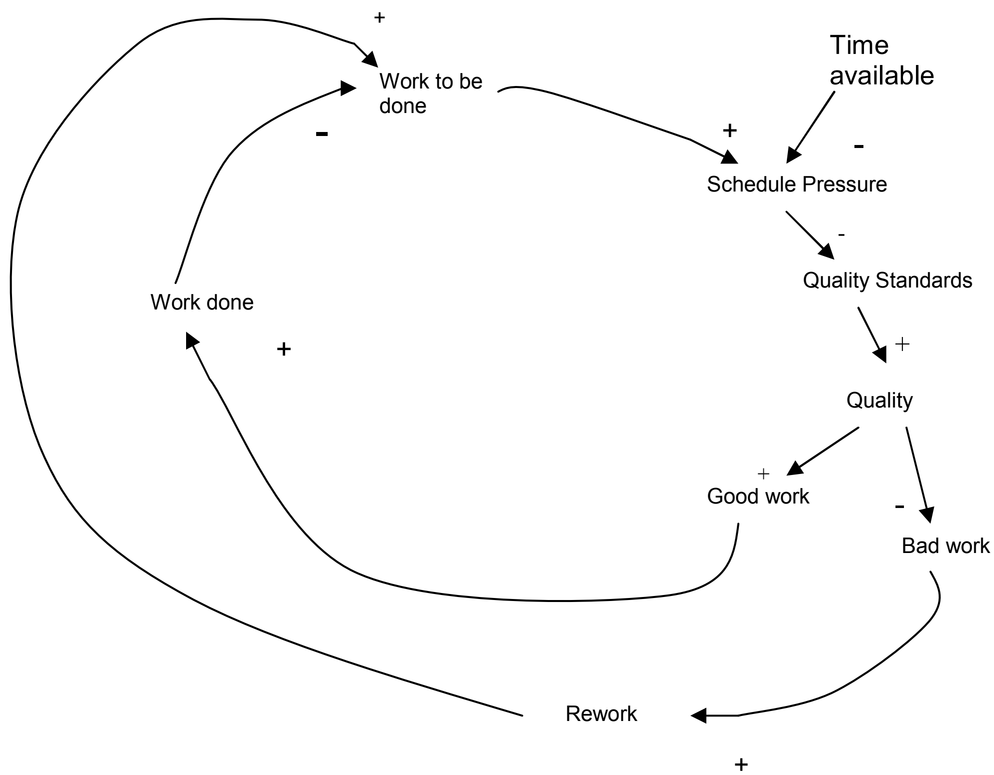
The amount of work to be done compared with the amount of time available would lead to a perceived schedule slippage and then to a higher pressure to reduce scope in order to catch up with the schedule. This pressure might cause a schedule reduction if it can overcome the resistance to reduce scope associated with project team commitment with project objectives. A reduction of work to be done increases the proportion of work done, thus reducing the perceived schedule slippage and the pressure to reduce scope in a balancing feedback cycle.

Schedule Structure



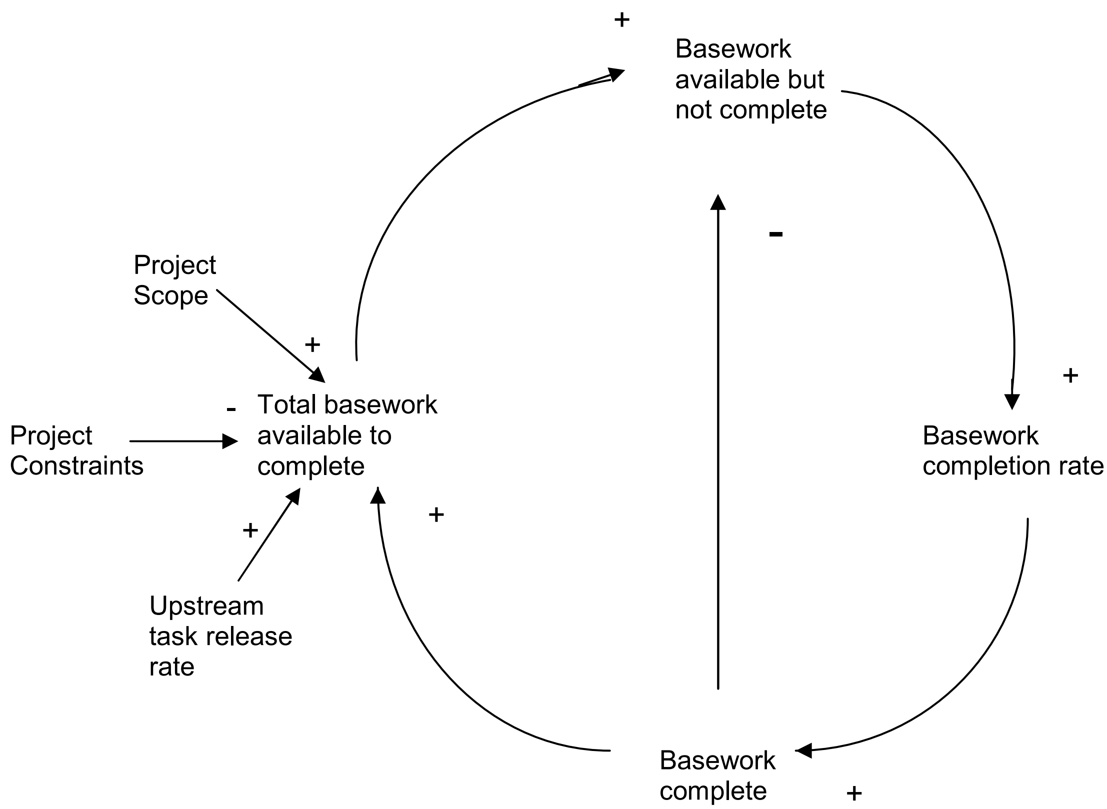
The time remaining at a given moment to the project deadline is compared to the expected required time to finish the project. If the perception is that there is not enough time to complete the project before the deadline, schedule pressure is generated. The higher the schedule pressure, the higher the drive to postpone the deadline, but a resistance to slip the deadline (produced by the relative importance of the time goal) should be overcome. If the deadline is postponed, the time to deadline will be increased, reducing the schedule pressure in a balancing feedback loop.

Rework Structure



The rework structure depicts how work is accomplished along the project life, incorporating the quality control activity. The "work to be done" stock is transformed through progress (or task performing) into work to be checked by quality control and, depending upon the quality of the work, it becomes either good work (approved) or bad work (rejected). The good work is work completed (work done) and reduces the amount of work to be done; while the bad work needs rework and, after this process, it becomes again work to be checked, where it is separated by quality control in good and bad work, repeating the cycle the number of times it is required until all the work is approved and the work to be done stock is completely depleted (project completion). The quality level drives the proportion of good and bad work. The level of work that remains to be done, and the time available until the deadline influence the schedule pressure. A higher level of schedule pressure might induce a reduction in the quality standards, thus lowering the quality level. Lower quality implies more work that needs rework, reducing the amount of work done, increasing the schedule pressure in a reinforcing feedback loop.

Basework Structure



Basework is work performed for the first time. An enlargement of the project scope or an increase in the upstream work increases the total basework available to complete, but project constraints might reduce that availability. The more basework is available to complete, the higher the basework completion rate will be and more basework will be completed. This basework completed reduces the stock of basework available but not complete, but also might increase the total basework available to complete (the basework completed can be required to perform subsequent tasks)

11- Is there any other issue you would like to mention concerning how the level of goal alignment among partners affected project performance?

APPENDIX B: MODELS VALIDATION QUESTIONNAIRE

Models Validation Questionnaire

Purpose

The purpose of this questionnaire is to assess the validity of two models developed to describe how the level of goal alignment might affect performance in a multi-organizational project.

Definitions

A multi-organizational project is a project accomplished by two or more different and independent organizations, each one having their own goals for the project. Goal alignment is the degree to which participants organizations in a multi-organizational project agree in the level of priority for the quality, schedule, scope and cost goals. Project performance is the degree to which project goals concerning quality, scope, cost and schedule are accomplished.

Models

The two models presented here were developed from two case studies of multi-organizational projects.

Task Statement

For each model, please review the associated figure and statements, and assess to what extent the models reflect your experiences in multi-organizational projects. Then write your assessment of each statement, pointing out what you think needs to be added, eliminated or modified. If you consider it appropriate, add comments not related specifically to any statement. However, please keep in mind that the models attempt to describe only how the level of goal alignment might affect project performance, and not other possible project dynamics.

If your experience in multi-organizational projects applies to just one of the models, please comment only that model's statements.

Questions

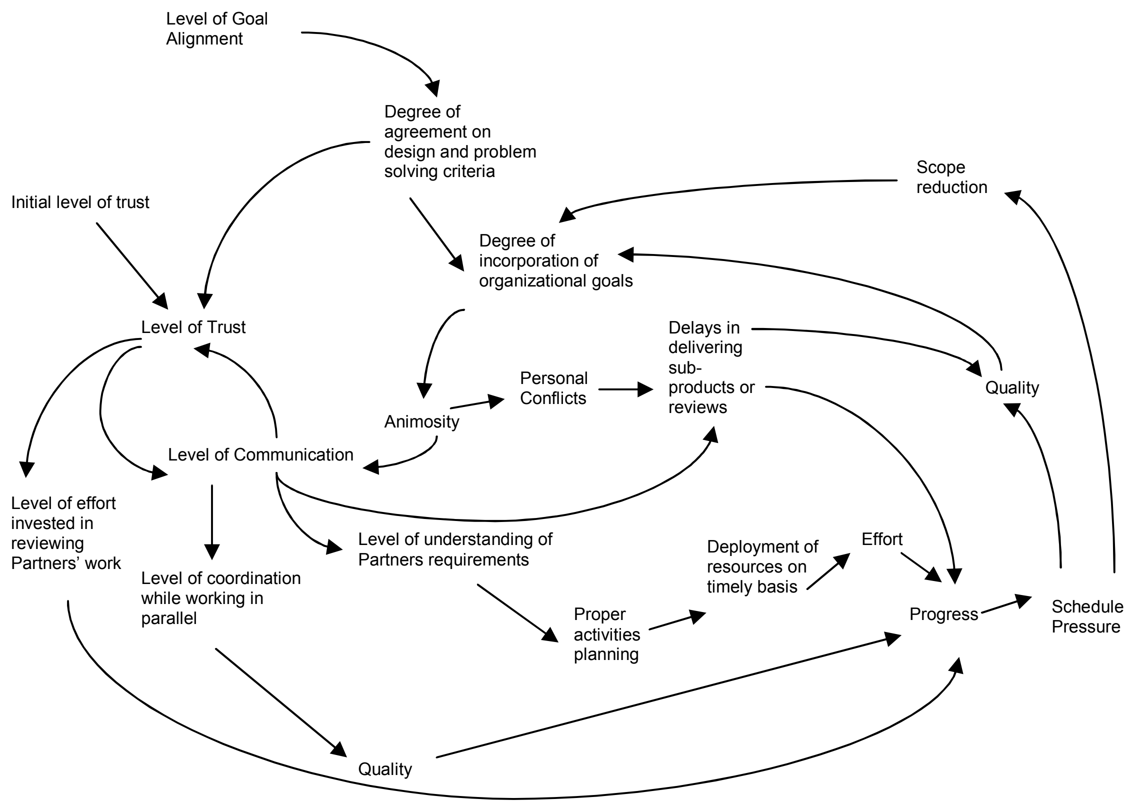
Please direct questions to xxxxxxxxx, or call xxxxxxxx.

Thank you very much for your cooperation. It will be very valuable for the success of this research effort.

Best regards

Atilio Moran

Model Case 1.



Model Case 1 Statements:

1. The level of goal alignment leads to the degree of agreement on the design and problem solving criteria (or the criteria to perform the trade-offs between the project cost, schedule, quality and scope priorities)

2. The degree of agreement on design and project solving criteria leads to the degree of Partners' satisfaction with the trade-offs performed in the project concerning the cost, schedule, quality and scope priorities.

3. Lack of satisfaction with the trade- offs performed in the project lead to animosity and to personal conflicts among the project team members, affecting the level of communication.

4. Personal conflicts and low level of communication among the project team members produce delays in information exchange and products reviews. That hinders the project progress, or leads to work based on preliminary information, that in turns leads to low quality, rework, schedule pressure and reduced progress.

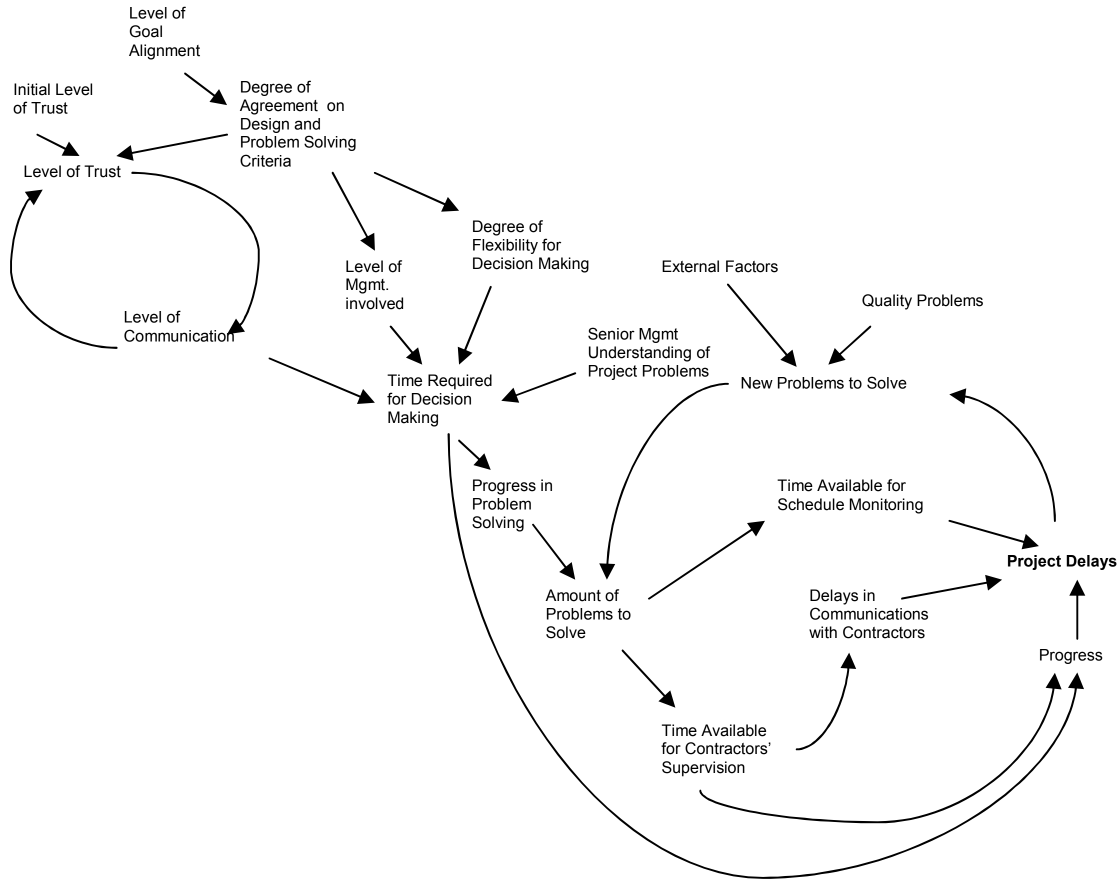
5. The level of trust among the project team members is a function of past experiences with the same Partners (initial level of trust) and of the degree of agreement on design and project solving criteria. The level of trust affects the level of communication (communications are driven in part by the expectations about the outcomes of the exchange). On the other hand, open communication - leading to understanding of Partners' behaviors, motivations and project developments- generates higher levels of trust.

6. The level of communication among partners affects the level of understanding of the inputs required by the other partners to perform their work, the adequacy of activities planning and the deployment of resources on a timely basis. The deployment of resources on a timely basis affects the level of effort and project progress.

7. The level of communication among partners affects the level of coordination when partners are working in a parallel or concurrent way. This might affect the sub-products' integration later in the project. Problems with sub-products integration could generate rework, schedule pressure and possible scope reduction, affecting project progress

8. The level of trust among partners affects the level of effort allocated to review Partners' work. A higher level of effort allocated to review Partners' products might take resources from doing work, generating delays and affecting project progress.

Model Case 2



Model Case 2 Statements:

1. The level of goal alignment leads to the degree of agreement on the design and problem solving criteria (or the criteria to perform the trade-offs between the project cost, schedule, quality and scope priorities)

2. A low degree of agreement on design and problem solving criteria among partners leads to the involvement of a higher level of management in the decision making process.

3. A low degree of agreement on design and problem solving criteria among partners provides a low degree of flexibility for decision making (requiring a stricter adherence to written agreements).

4. The level of trust among partners is influenced by the experiences lived during the negotiations and project planning phases (initial level of trust) and by the degree of agreement on design and problem solving criteria. The level of trust affects the level of communication (communications are driven in part by the

expectations about the outcomes of the exchange). On the other hand, open communication (leading to understanding of Partners' expectations and behaviors), generates higher levels of trust.

5. The level of communication among partners, the level of management involved, the management's level of understanding of the project problems, and the degree of decision flexibility available influence the amount of time required for decision making.

6. The amount of time required for decision making determines the progress in problem solving, and then the accumulation of problems to solve.

7. The accumulation of problems to solve defines the amount of time available to partners for the supervision of contractors and for project schedule monitoring.

8. Longer decision making times and less time available for contract supervision leads to delays in product reviews and in communications with the contractors, affecting creating project delays.

9. Less time available for schedule monitoring prevents partners to proactively identify causes of potential project delays, increasing their probability of occurrence.

10. Quality problems, project delays and external factors create new problems to solve.

APPENDIX C: IThink ™ MODELS EQUATIONS PRINT OUTS

CASE 1 MODEL

Alignment

align = 1-((ABS(prior_qual1-prior_qual_2))*weight_qual_pri+((ABS(scope_pri1-scope_pri2))*(1-weight_qual_pri)))
weight_qual_pri = 0.5

Effort

effort1 = tot_effort1-effort1_rev-effort1_rew
effort1_rev = tot_effort1*(1-trustin2)+per_rev_eff1*tot_effort1
effort2 = tot_effort2-effort2_rev-effort2_rew
effort2_rev = per_rev_eff2*tot_effort2+(1-trustin1)*tot_effort2
tot_effort1 = planeffort1+addeffort1+cooreffort1*effcomcoor1
tot_effort2 = planeffort2+addeffort2+effcomcoor2*cooreffort2
addeffort1 = GRAPH(effschpradeff1)
(0.00, 0.00), (0.1, 0.375), (0.2, 1.03), (0.3, 1.45), (0.4, 1.93), (0.5, 2.33), (0.6, 2.83), (0.7, 3.33), (0.8, 3.88), (0.9, 4.42), (1, 4.93)
addeffort2 = GRAPH(effschpradeff2)
(0.00, 0.075), (0.1, 0.475), (0.2, 0.875), (0.3, 1.40), (0.4, 1.90), (0.5, 2.45), (0.6, 3.00), (0.7, 3.43), (0.8, 3.90), (0.9, 4.53), (1, 4.95)
cooreffort1 = GRAPH(TIME)
(1.00, 3.00), (2.00, 3.00), (3.00, 2.95), (4.00, 2.95), (5.00, 2.95), (6.00, 2.95), (7.00, 2.95), (8.00, 2.95), (9.00, 2.95), (10.0, 2.95), (11.0, 2.95), (12.0, 2.95), (13.0, 3.00)
cooreffort2 = GRAPH(TIME)
(1.00, 2.95), (2.00, 3.00), (3.00, 2.95), (4.00, 2.95), (5.00, 2.95), (6.00, 2.95), (7.00, 2.95), (8.00, 2.95), (9.00, 2.95), (10.0, 2.95), (11.0, 2.95), (12.0, 2.95), (13.0, 2.95)
effcomcoor1 = GRAPH(comm)
(0.00, 0.055), (0.1, 0.39), (0.2, 0.53), (0.3, 0.685), (0.4, 0.78), (0.5, 0.86), (0.6, 0.9), (0.7, 0.95), (0.8, 0.99), (0.9, 0.995), (1, 1.00)
effcomcoor2 = GRAPH(comm)
(0.00, 0.05), (0.1, 0.29), (0.2, 0.45), (0.3, 0.57), (0.4, 0.675), (0.5, 0.775), (0.6, 0.855), (0.7, 0.915), (0.8, 0.955), (0.9, 0.975), (1, 1.00)
effort1_rew = GRAPH(per_rew_eff1)
(0.00, 0.1), (0.1, 0.5), (0.2, 0.9), (0.3, 1.50), (0.4, 1.98), (0.5, 2.60), (0.6, 3.18), (0.7, 3.60), (0.8, 4.13), (0.9, 4.53), (1, 5.00)
effort2_rew = GRAPH(per_rew_eff)
(0.00, 0.05), (0.1, 0.4), (0.2, 0.825), (0.3, 1.25), (0.4, 1.70), (0.5, 2.20), (0.6, 2.63), (0.7, 3.13), (0.8, 3.73), (0.9, 4.35), (1, 5.00)
effschpradeff1 = GRAPH(sch_press1)
(0.00, 0.045), (0.1, 0.245), (0.2, 0.385), (0.3, 0.52), (0.4, 0.66), (0.5, 0.78), (0.6, 0.865), (0.7, 0.92), (0.8, 0.965), (0.9, 0.985), (1, 1.00)
effschpradeff2 = GRAPH(sch_press_2)
(0.00, 0.03), (0.1, 0.3), (0.2, 0.47), (0.3, 0.605), (0.4, 0.725), (0.5, 0.825), (0.6, 0.895), (0.7, 0.95), (0.8, 0.98), (0.9, 0.995), (1, 1.00)
per_rev_eff1 = GRAPH(work_to_be_used_by_1)

(0.00, 0.00), (2.00, 0.11), (4.00, 0.215), (6.00, 0.285), (8.00, 0.38), (10.0, 0.47), (12.0, 0.555), (14.0, 0.655), (16.0, 0.78), (18.0, 0.9), (20.0, 0.99)
per_rev_eff2 = GRAPH(work_to_be_used_by2)
(0.00, 0.00), (2.00, 0.1), (4.00, 0.185), (6.00, 0.265), (8.00, 0.35), (10.0, 0.45), (12.0, 0.555), (14.0, 0.64), (16.0, 0.77), (18.0, 0.87), (20.0, 1.00)
per_rew_eff = GRAPH(rework_2)
(0.00, 0.005), (2.00, 0.1), (4.00, 0.165), (6.00, 0.255), (8.00, 0.385), (10.0, 0.48), (12.0, 0.6), (14.0, 0.695), (16.0, 0.8), (18.0, 0.9), (20.0, 0.995)
per_rew_eff1 = GRAPH(rework_1)
(0.00, 0.005), (2.00, 0.12), (4.00, 0.21), (6.00, 0.29), (8.00, 0.395), (10.0, 0.51), (12.0, 0.605), (14.0, 0.715), (16.0, 0.825), (18.0, 0.925), (20.0, 1.00)
planeffort1 = GRAPH(TIME)
(1.00, 10.0), (2.00, 9.95), (3.00, 9.95), (4.00, 9.95), (5.00, 9.90), (6.00, 9.90), (7.00, 9.65), (8.00, 8.90), (9.00, 8.40), (10.0, 7.95), (11.0, 7.35), (12.0, 6.25), (13.0, 4.40)
planeffort2 = GRAPH(TIME)
(1.00, 10.0), (2.00, 10.0), (3.00, 9.60), (4.00, 9.30), (5.00, 8.95), (6.00, 8.65), (7.00, 8.25), (8.00, 7.80), (9.00, 7.30), (10.0, 6.85), (11.0, 6.30), (12.0, 5.50), (13.0, 4.15)

Progress-Rework

rework12(t) = rework12(t - dt) + (badwork12 - rew12_trans) * dt
INIT rework12 = 0

INFLOWS:
badwork12 = (work_to_be_used_by2/durrev12)*(1-quality1)
OUTFLOWS:
rew12_trans = GRAPH(rework12/inftrandur)
(0.00, 0.00), (10.0, 0.00), (20.0, 0.00), (30.0, 0.00), (40.0, 0.00), (50.0, 0.00), (60.0, 0.00), (70.0, 0.00), (80.0, 0.00), (90.0, 0.00), (100, 0.00)
rework21(t) = rework21(t - dt) + (badwork21 - rew21trans) * dt
INIT rework21 = 0

INFLOWS:
badwork21 = (work_to_be_used_by_1/durrev21)*(1-quality2)
OUTFLOWS:
rew21trans = rework21/inftrandur
rework_1(t) = rework_1(t - dt) + (badwork_1 + rew12_trans - rework_rate_1) * dt
INIT rework_1 = 0

INFLOWS:
badwork_1 = (work_to_be_checked_1/dur_prog1)*(1-quality1)
rew12_trans = GRAPH(rework12/inftrandur)
(0.00, 0.00), (10.0, 0.00), (20.0, 0.00), (30.0, 0.00), (40.0, 0.00), (50.0, 0.00), (60.0, 0.00), (70.0, 0.00), (80.0, 0.00), (90.0, 0.00), (100, 0.00)
OUTFLOWS:
rework_rate_1 = rework_1/dur_rework1
rework_2(t) = rework_2(t - dt) + (rew21trans + badwork2 - rework_rate2) * dt

INIT rework_2 = 0

INFLOWS:
rew21trans = rework21/inftrandur
badwork2 = (work_to_be_checked_2/dur_prog2)*(1-quality2)
OUTFLOWS:
rework_rate2 = rework_2/dur_rework2
scope_red1(t) = scope_red1(t - dt) + (scope_red_rate_1) * dt
INIT scope_red1 = 0

INFLOWS:
scope_red_rate_1 = GRAPH((1-resis_to_red_scope1)*sch_press1)
(0.00, 0.00), (0.1, 0.025), (0.2, 0.075), (0.3, 0.25), (0.4, 0.5), (0.5, 0.7), (0.6, 1.10), (0.7, 1.65), (0.8, 2.30), (0.9, 3.40), (1, 5.00)
scope_red2(t) = scope_red2(t - dt) + (scope_red_rate_2) * dt
INIT scope_red2 = 0

INFLOWS:
scope_red_rate_2 = GRAPH(sch_press_2*(1-resis_to_red_scope2))
(0.00, 0.00), (0.1, 0.05), (0.2, 0.125), (0.3, 0.325), (0.4, 0.725), (0.5, 1.08), (0.6, 1.48), (0.7, 2.02), (0.8, 2.70), (0.9, 3.33), (1, 5.00)
work_done_1(t) = work_done_1(t - dt) + (goodwork1) * dt
INIT work_done_1 = 0

INFLOWS:
goodwork1 = (work_to_be_checked_1/dur_prog1)*quality1
work_done_2(t) = work_done_2(t - dt) + (goodwork2) * dt
INIT work_done_2 = 0

INFLOWS:
goodwork2 = (work_to_be_checked_2/dur_prog2)*quality2
work_to_be_checked_1(t) = work_to_be_checked_1(t - dt) + (progress_1 + rework_rate_1 - goodwork1 - badwork_1 - work_12) * dt
INIT work_to_be_checked_1 = 0

INFLOWS:
progress_1 = (work_to_be_done_1/dur_prog1)*(1-frac_to_be_coord)+(work_to_be_done_1/dur_prog1)*frac_to_be_coord*comm
rework_rate_1 = rework_1/dur_rework1
OUTFLOWS:
goodwork1 = (work_to_be_checked_1/dur_prog1)*quality1
badwork_1 = (work_to_be_checked_1/dur_prog1)*(1-quality1)
work_12 = (work_to_be_checked_1/inftrandur)*work_1_used_by2
work_to_be_checked_2(t) = work_to_be_checked_2(t - dt) + (progress_2 + rework_rate2 - goodwork2 - work_21 - badwork2) * dt
INIT work_to_be_checked_2 = 0

INFLOWS:
progress_2 = (work_to_be_done_2/dur_prog2)*(1-frac_to_be_coord)+(work_to_be_done_2/dur_prog2)*frac_to_be_coord*comm
rework_rate2 = rework_2/dur_rework2
OUTFLOWS:
goodwork2 = (work_to_be_checked_2/dur_prog2)*quality2
work_21 = (work_to_be_checked_2/inftrandur)*work_2_used_by1
badwork2 = (work_to_be_checked_2/dur_prog2)*(1-quality2)
work_to_be_done_1(t) = work_to_be_done_1(t - dt) + (goodwork21 - progress_1 - scope_red_rate_1) * dt
INIT work_to_be_done_1 = 100

INFLOWS:
goodwork21 = (work_to_be_used_by_1/durrev21)*quality2
OUTFLOWS:
progress_1 = (work_to_be_done_1/dur_prog1)*(1-frac_to_be_coord)+(work_to_be_done_1/dur_prog1)*frac_to_be_coord*comm
scope_red_rate_1 = GRAPH((1-resis_to_red_scope1)*sch_press1)
(0.00, 0.00), (0.1, 0.025), (0.2, 0.075), (0.3, 0.25), (0.4, 0.5), (0.5, 0.7), (0.6, 1.10), (0.7, 1.65), (0.8, 2.30), (0.9, 3.40), (1, 5.00)
work_to_be_done_2(t) = work_to_be_done_2(t - dt) + (goodwork12 - progress_2 - scope_red_rate_2) * dt
INIT work_to_be_done_2 = 100

INFLOWS:
goodwork12 = (work_to_be_used_by2/durrev12)*quality1
OUTFLOWS:
progress_2 = (work_to_be_done_2/dur_prog2)*(1-frac_to_be_coord)+(work_to_be_done_2/dur_prog2)*frac_to_be_coord*comm
scope_red_rate_2 = GRAPH(sch_press_2*(1-resis_to_red_scope2))
(0.00, 0.00), (0.1, 0.05), (0.2, 0.125), (0.3, 0.325), (0.4, 0.725), (0.5, 1.08), (0.6, 1.48), (0.7, 2.02), (0.8, 2.70), (0.9, 3.33), (1, 5.00)
work_to_be_used_by2(t) = work_to_be_used_by2(t - dt) + (work_12 - goodwork12 - badwork12) * dt
INIT work_to_be_used_by2 = 0

INFLOWS:
work_12 = (work_to_be_checked_1/inftrandur)*work_1_used_by2
OUTFLOWS:
goodwork12 = (work_to_be_used_by2/durrev12)*quality1
badwork12 = (work_to_be_used_by2/durrev12)*(1-quality1)
work_to_be_used_by_1(t) = work_to_be_used_by_1(t - dt) + (work_21 - goodwork21 - badwork21) * dt
INIT work_to_be_used_by_1 = 0

INFLOWS:
work_21 = (work_to_be_checked_2/inftrandur)*work_2_used_by1
OUTFLOWS:
goodwork21 = (work_to_be_used_by_1/durrev21)*quality2
badwork21 = (work_to_be_used_by_1/durrev21)*(1-quality2)
frac_to_be_coord = 0.5
work_1_used_by2 = 0.5
work_2_used_by1 = 0.5
durrev12 = GRAPH(effort2_rev)
(0.00, 2.00), (1.00, 1.58), (2.00, 1.37), (3.00, 1.21), (4.00, 1.03), (5.00, 0.92), (6.00, 0.81), (7.00, 0.71), (8.00, 0.66), (9.00, 0.65), (10.0, 0.61)
durrev21 = GRAPH(effort1_rev)
(0.00, 2.00), (1.00, 1.73), (2.00, 1.40), (3.00, 1.17), (4.00, 1.02), (5.00, 0.88), (6.00, 0.78), (7.00, 0.68), (8.00, 0.62), (9.00, 0.62), (10.0, 0.62)
dur_prog1 = GRAPH(effort1)
(0.00, 4.90), (1.00, 3.38), (2.00, 2.65), (3.00, 2.23), (4.00, 1.78), (5.00, 1.55), (6.00, 1.40), (7.00, 1.33), (8.00, 1.20), (9.00, 1.15), (10.0, 1.05)
dur_prog2 = GRAPH(effort2)
(0.00, 4.90), (1.00, 3.23), (2.00, 2.55), (3.00, 2.18), (4.00, 1.95), (5.00, 1.75), (6.00, 1.50), (7.00, 1.23), (8.00, 1.03), (9.00, 1.00), (10.0, 1.00)
dur_rework1 = GRAPH(effort1_rew)
(0.00, 2.00), (1.00, 1.63), (2.00, 1.40), (3.00, 1.20), (4.00, 1.09), (5.00, 0.95), (6.00, 0.87), (7.00, 0.78), (8.00, 0.7), (9.00, 0.62), (10.0, 0.6)
dur_rework2 = GRAPH(effort2_rew)
(0.00, 2.00), (1.00, 1.74), (2.00, 1.36), (3.00, 1.14), (4.00, 1.00), (5.00, 0.85), (6.00, 0.72), (7.00, 0.66), (8.00, 0.64), (9.00, 0.62), (10.0, 0.6)

Quality
iniqual_1 = 1
iniqual_2 = 1
prior_qual1 = 0.5
prior_qual_2 = 0.2
quality1 = iniqual_1*effcommqual1*effpriqual1*(1-effschpressqual1)*frac_to_be_coord+iniqual_1*effpriqual1*(1-effschpressqual1)*(1-frac_to_be_coord)
quality2 = iniqual_2*effcommqual2*effpriqual2*(1-effschpressqual2)*frac_to_be_coord+iniqual_2*(1-effschpressqual2)*effpriqual2*(1-frac_to_be_coord)
effcommqual1 = GRAPH(comm)
(0.00, 0.01), (0.1, 0.225), (0.2, 0.425), (0.3, 0.55), (0.4, 0.66), (0.5, 0.74), (0.6, 0.825), (0.7, 0.895), (0.8, 0.955), (0.9, 0.98), (1, 0.995)
effcommqual2 = GRAPH(comm)
(0.00, 0.04), (0.1, 0.285), (0.2, 0.42), (0.3, 0.53), (0.4, 0.62), (0.5, 0.715), (0.6, 0.795), (0.7, 0.87), (0.8, 0.935), (0.9, 0.985), (1, 1.00)
effpriqual1 = GRAPH(prior_qual1)

(0.00, 0.015), (0.1, 0.175), (0.2, 0.325), (0.3, 0.44), (0.4, 0.565), (0.5, 0.695), (0.6, 0.775), (0.7, 0.84), (0.8, 0.915), (0.9, 0.95), (1, 1.00)
effpriqual2 = GRAPH(prior_qual_2)
(0.00, 0.025), (0.1, 0.24), (0.2, 0.395), (0.3, 0.505), (0.4, 0.61), (0.5, 0.69), (0.6, 0.775), (0.7, 0.84), (0.8, 0.92), (0.9, 0.97), (1, 1.00)
effschpressqual1 = GRAPH(sch_press1)
(0.00, 0.00), (0.1, 0.02), (0.2, 0.05), (0.3, 0.11), (0.4, 0.175), (0.5, 0.235), (0.6, 0.295), (0.7, 0.36), (0.8, 0.45), (0.9, 0.67), (1, 1.00)
effschpressqual2 = GRAPH(sch_press_2)
(0.00, 0.00), (0.1, 0.035), (0.2, 0.06), (0.3, 0.09), (0.4, 0.155), (0.5, 0.205), (0.6, 0.29), (0.7, 0.395), (0.8, 0.525), (0.9, 0.725), (1, 1.00)

Schedule

sch_slipp1 = IF(exp_work_done1-work_done_1)<=0THEN(0)ELSE(exp_work_done1-work_done_1)
sch_slipp_2 = IF(exp_work_done2-work_done_2)<=0THEN(0)ELSE(exp_work_done2-work_done_2)
effscopered2 = GRAPH(scope_red2)
(0.00, 0.015), (10.0, 0.245), (20.0, 0.415), (30.0, 0.56), (40.0, 0.67), (50.0, 0.76), (60.0, 0.825), (70.0, 0.895), (80.0, 0.95), (90.0, 0.975), (100, 1.00)
effscopered_1 = GRAPH(scope_red1)
(0.00, 0.00), (10.0, 0.17), (20.0, 0.345), (30.0, 0.475), (40.0, 0.58), (50.0, 0.675), (60.0, 0.755), (70.0, 0.825), (80.0, 0.885), (90.0, 0.94), (100, 1.00)
exp_work_done1 = GRAPH(TIME)
(1.00, 0.00), (2.00, 4.50), (3.00, 13.5), (4.00, 25.0), (5.00, 39.0), (6.00, 49.0), (7.00, 63.0), (8.00, 73.0), (9.00, 81.0), (10.0, 88.0), (11.0, 93.0), (12.0, 97.0), (13.0, 100)
exp_work_done2 = GRAPH(TIME)
(1.00, 0.00), (2.00, 5.00), (3.00, 15.5), (4.00, 29.0), (5.00, 43.0), (6.00, 57.0), (7.00, 70.0), (8.00, 79.0), (9.00, 87.5), (10.0, 94.0), (11.0, 97.5), (12.0, 99.0), (13.0, 99.5)
sch_press1 = GRAPH((IF(sch_slipp1)<=0THEN(0)ELSE(sch_slipp1))*(1-effscopered_1))
(0.00, 0.015), (10.0, 0.015), (20.0, 0.015), (30.0, 0.07), (40.0, 0.135), (50.0, 0.22), (60.0, 0.32), (70.0, 0.455), (80.0, 0.58), (90.0, 0.745), (100, 1.00)
sch_press_2 = GRAPH((IF(sch_slipp_2)<=0THEN(0)ELSE(sch_slipp_2))*(1-effscopered2))
(0.00, 0.00), (10.0, 0.00), (20.0, 0.055), (30.0, 0.11), (40.0, 0.185), (50.0, 0.255), (60.0, 0.32), (70.0, 0.41), (80.0, 0.56), (90.0, 0.71), (100, 1.00)

Scope

resis_to_red_scope1 = effscope_pri1
resis_to_red_scope2 = effscope_pri2
scope_pri1 = 0.5
scope_pri2 = 0.5
effscope_pri1 = GRAPH(scope_pri1)
(0.00, 0.005), (0.1, 0.245), (0.2, 0.395), (0.3, 0.56), (0.4, 0.65), (0.5, 0.74), (0.6, 0.815), (0.7, 0.875), (0.8, 0.92), (0.9, 0.97), (1, 1.00)

effscope_pri2 = GRAPH(scope_pri2)
(0.00, 0.025), (0.1, 0.235), (0.2, 0.36), (0.3, 0.51), (0.4, 0.655), (0.5, 0.735), (0.6, 0.815), (0.7, 0.89), (0.8, 0.95), (0.9, 0.995), (1, 1.00)

Trust-Communication

knowabout1(t) = knowabout1 (t - dt) + (know1form) * dt
INIT knowabout1 = 0.2

INFLOWS:
know1form = GRAPH(comm)
(0.00, 0.0005), (0.1, 0.07), (0.2, 0.175), (0.3, 0.275), (0.4, 0.365), (0.5, 0.465), (0.6, 0.545), (0.7, 0.655), (0.8, 0.785), (0.9, 0.885), (1, 1.00)
knowabout2(t) = knowabout2(t - dt) + (know2form) * dt
INIT knowabout2 = 0

INFLOWS:
know2form = GRAPH(comm)
(0.00, 0.01), (0.1, 0.11), (0.2, 0.2), (0.3, 0.3), (0.4, 0.415), (0.5, 0.53), (0.6, 0.625), (0.7, 0.72), (0.8, 0.8), (0.9, 0.88), (1, 0.985)
comm = inicomm*efftrucom1*efftrucom2
inicomm = 0.5
initialtrustin2 = 0.5
intialtrustin1 = 0.5
trustin1 = intialtrustin1*(1-(if(knowabout1)>1then(1) ELSE(knowabout1))+(if(knowabout1)>1then(1)ELSE(knowabout1))*(align))
trustin2 = initialtrustin2*(1-(if(knowabout2)>1then(1)ELSE(knowabout2))+(if(knowabout2)>1then(1)ELSE(knowabout2))*align)
efftrucom1 = GRAPH(trustin2)
(0.00, 0.00), (0.1, 0.245), (0.2, 0.48), (0.3, 0.64), (0.4, 0.73), (0.5, 0.805), (0.6, 0.875), (0.7, 0.92), (0.8, 0.96), (0.9, 0.98), (1, 1.00)
efftrucom2 = GRAPH(trustin1)
(0.00, 0.00), (0.1, 0.22), (0.2, 0.415), (0.3, 0.55), (0.4, 0.675), (0.5, 0.765), (0.6, 0.84), (0.7, 0.89), (0.8, 0.95), (0.9, 0.965), (1, 1.00)
inftrandur = GRAPH(comm)
(0.00, 5.00), (0.1, 4.28), (0.2, 3.20), (0.3, 2.55), (0.4, 2.20), (0.5, 1.98), (0.6, 1.78), (0.7, 1.53), (0.8, 1.48), (0.9, 1.48), (1, 1.48)

CASE 2 MODEL

Contractor Supervison

time_ava_for_super(t) = time_ava_for_super(t - dt) + (- red_time_ava_for_contr) * dt
INIT time_ava_for_super = 50

OUTFLOWS:
red_time_ava_for_contr = GRAPH(prob_to_be_solved)
(0.00, 0.00), (30.0, 1.00), (60.0, 2.00), (90.0, 3.50), (120, 5.25), (150, 8.25), (180, 11.3), (210, 16.0), (240, 22.0), (270, 31.8), (300, 50.0)
eff_time_super_effrev = GRAPH(time_ava_for_super)
(0.00, 0.00), (5.00, 0.25), (10.0, 0.435), (15.0, 0.575), (20.0, 0.665), (25.0, 0.75), (30.0, 0.825), (35.0, 0.9), (40.0, 0.955), (45.0, 0.985), (50.0, 0.985)
p_team_eff_rev = GRAPH(eff_time_super_effrev)
(0.00, 0.1), (0.1, 0.8), (0.2, 1.80), (0.3, 2.65), (0.4, 3.65), (0.5, 4.75), (0.6, 5.70), (0.7, 6.70), (0.8, 7.70), (0.9, 8.85), (1, 9.75)

Decision Making

time_req_for_dec_making(t) = time_req_for_dec_making(t - dt) + (inc_time_req_for_dec_making - red_time_for_dec_making) * dt
INIT time_req_for_dec_making = 50

INFLOWS:
inc_time_req_for_dec_making = GRAPH((1-comm)*(1-mgmt_unders)*(1-deg_of_flex)*lev_of_mgmt)
(0.00, 0.00), (0.1, 0.2), (0.2, 0.5), (0.3, 1.05), (0.4, 1.70), (0.5, 2.20), (0.6, 2.80), (0.7, 3.85), (0.8, 4.90), (0.9, 7.10), (1, 10.0)
OUTFLOWS:
red_time_for_dec_making = GRAPH(if(time_req_for_dec_making)<5then(0) else(comm*mgmt_unders*deg_of_flex*(1-lev_of_mgmt)))
(0.00, 0.00), (0.1, 2.75), (0.2, 4.20), (0.3, 5.35), (0.4, 6.35), (0.5, 7.20), (0.6, 7.95), (0.7, 8.85), (0.8, 9.30), (0.9, 9.70), (1, 10.0)
mgmt_unders = 0.5
dec_mak_eff_on_prog = GRAPH(time_req_for_dec_making)
(0.00, 0.995), (5.00, 0.97), (10.0, 0.925), (15.0, 0.865), (20.0, 0.8), (25.0, 0.725), (30.0, 0.63), (35.0, 0.5), (40.0, 0.355), (45.0, 0.175), (50.0, 0.015)
deg_of_flex = GRAPH(align)
(0.00, 0.005), (0.1, 0.105), (0.2, 0.195), (0.3, 0.3), (0.4, 0.395), (0.5, 0.485), (0.6, 0.59), (0.7, 0.685), (0.8, 0.785), (0.9, 0.895), (1, 1.00)
lev_of_mgmt = GRAPH(align)
(0.00, 0.99), (0.1, 0.92), (0.2, 0.84), (0.3, 0.77), (0.4, 0.705), (0.5, 0.635), (0.6, 0.555), (0.7, 0.45), (0.8, 0.355), (0.9, 0.275), (1, 0.195)

Problem Solving

prob_to_be_solved(t) = prob_to_be_solved(t - dt) + (rate_of_prob__add - rate_of_prob_sol) * dt
INIT prob_to_be_solved = 0

INFLOWS:
rate_of_prob__add = GRAPH(ext_factors+sch_slipp+quality_problems)
(0.00, 0.00), (10.0, 7.50), (20.0, 16.0), (30.0, 25.0), (40.0, 35.5), (50.0, 46.5), (60.0, 57.0), (70.0, 67.0), (80.0, 78.5), (90.0, 88.5), (100, 99.5)
OUTFLOWS:
rate_of_prob_sol = GRAPH(time_req_for_dec_making)
(0.00, 98.0), (10.0, 96.5), (20.0, 93.5), (30.0, 89.0), (40.0, 82.0), (50.0, 74.5), (60.0, 68.5), (70.0, 58.5), (80.0, 40.0), (90.0, 25.5), (100, 0.00)
ext_factors = RANDOM(0,100)
quality_problems = GRAPH(quality)
(0.00, 0.00), (0.1, 4.00), (0.2, 8.75), (0.3, 12.8), (0.4, 16.8), (0.5, 23.0), (0.6, 28.3), (0.7, 32.8), (0.8, 37.8), (0.9, 44.3), (1, 50.0)

Progress- Rework

review (t) = review(t - dt) + (work_per_to_be_rev - rev_badwork - rev_goodwork) * dt
INIT review = 0

INFLOWS:
work_per_to_be_rev = (work_with_pot_errors*frac_work_to_be_rev)/inf_trans_dur
OUTFLOWS:
rev_badwork = (review*(1-quality))/dur_rev
rev_goodwork = (review*quality)/dur_rev
rework_lev(t) = rework_lev(t - dt) + (badwork + inf_transf_rate - rework_rate) * dt
INIT rework_lev = 0

INFLOWS:
badwork = (work_with_pot_errors*(1-quality))/dur_progress
inf_transf_rate = rework_rev/inf_trans_dur
OUTFLOWS:
rework_rate = rework_lev/rew_dur
rework_rev(t) = rework_rev(t - dt) + (rev_badwork - inf_transf_rate) * dt
INIT rework_rev = 0

INFLOWS:
rev_badwork = (review*(1-quality))/dur_rev
OUTFLOWS:
inf_transf_rate = rework_rev/inf_trans_dur
work_done(t) = work_done(t - dt) + (goodwork + rev_goodwork) * dt
INIT work_done = 0

INFLOWS:
goodwork = (work_with_pot_errors*quality)/dur_progress
rev_goodwork = (review*quality)/dur_rev
work_to_be_done(t) = work_to_be_done(t - dt) + (- progress) * dt
INIT work_to_be_done = 100

OUTFLOWS:
progress =
(work_to_be_done/dur_progress)*frac_of_work_req_feedback*dec_mak_eff_on_prog+(
work_to_be_done/dur_progress)*(1-frac_of_work_req_feedback)
work_with_pot_errors(t) = work_with_pot_errors(t - dt) + (progress + rework_rate -
badwork - goodwork - work_per_to_be_rev) * dt
INIT work_with_pot_errors = 0

INFLOWS:
progress =
(work_to_be_done/dur_progress)*frac_of_work_req_feedback*dec_mak_eff_on_prog+(
work_to_be_done/dur_progress)*(1-frac_of_work_req_feedback)
rework_rate = rework_lev/rew_dur
OUTFLOWS:
badwork = (work_with_pot_errors*(1-quality))/dur_progress
goodwork = (work_with_pot_errors*quality)/dur_progress
work_per_to_be_rev = (work_with_pot_errors*frac_work_to_be_rev)/inf_trans_dur
frac_of_work_req_feedback = 0.5
frac_work_to_be_rev = 0.5
inf_trans_dur = 3
quality = 0.5
dur_progress = GRAPH(effort)
(0.00, 4.90), (2.00, 4.15), (4.00, 3.53), (6.00, 2.88), (8.00, 2.43), (10.0, 2.13), (12.0, 1.88),
(14.0, 1.68), (16.0, 1.63), (18.0, 1.63), (20.0, 1.65)
dur_rev = GRAPH(p_team_eff_rev)
(0.00, 4.93), (1.00, 4.10), (2.00, 3.35), (3.00, 2.90), (4.00, 2.63), (5.00, 2.38), (6.00, 2.13),
(7.00, 1.85), (8.00, 1.63), (9.00, 1.53), (10.0, 1.53)
rew_dur = GRAPH(effort_rew)
(0.00, 5.00), (1.00, 4.45), (2.00, 3.75), (3.00, 3.35), (4.00, 2.88), (5.00, 2.58), (6.00, 2.27),
(7.00, 2.02), (8.00, 1.80), (9.00, 1.58), (10.0, 1.53)

Trust-Communication

knowabout1(t) = knowabout1(t - dt) + (know1form) * dt
INIT knowabout1 = 0.5

INFLOWS:
know1form = GRAPH(comm)
(0.00, 0.005), (0.1, 0.07), (0.2, 0.13), (0.3, 0.2), (0.4, 0.295), (0.5, 0.39), (0.6, 0.485), (0.7,
0.59), (0.8, 0.69), (0.9, 0.805), (1, 1.00)

knowabout2(t) = knowabout2(t - dt) + (know2form) * dt
INIT knowabout2 = 0.5

INFLOWS:
know2form = GRAPH(comm)
(0.00, 0.00), (0.1, 0.055), (0.2, 0.155), (0.3, 0.245), (0.4, 0.34), (0.5, 0.425), (0.6, 0.54), (0.7, 0.64), (0.8, 0.775), (0.9, 0.885), (1, 0.98)
align = 0.5
comm = inicomm*efftrsuton_comm2*efftrustoncomm1
inicomm = 0.9
initialtrustin2 = 0.5
intialtrustin1 = 0.5
trustin1 = intialtrustin1*(1-(if(knowabout1)>1then(1)ELSE(knowabout1)))+(if(knowabout1)>1then(1)ELSE(knowabout1))*align
trustin2 = initialtrustin2*(1-(if(knowabout2)>1then(1)ELSE(knowabout2)))+(if(knowabout2)>1then(1)ELSE(knowabout2))*align
efftrsuton_comm2 = GRAPH(trustin1)
(0.00, 0.025), (0.1, 0.255), (0.2, 0.405), (0.3, 0.55), (0.4, 0.685), (0.5, 0.78), (0.6, 0.845), (0.7, 0.9), (0.8, 0.945), (0.9, 0.975), (1, 0.995)
efftrustoncomm1 = GRAPH(trustin2)
(0.00, 0.025), (0.1, 0.18), (0.2, 0.345), (0.3, 0.495), (0.4, 0.655), (0.5, 0.74), (0.6, 0.84), (0.7, 0.905), (0.8, 0.955), (0.9, 0.99), (1, 1.00)

Effort

effort = add_eff+plan_effort-effort_rew
sch_slipp = IF(exp_work_done-work_done)<=0THEN(0)ELSE(exp_work_done-work_done)
tot_effort = add_eff+effort_rew+plan_effort
add_eff = GRAPH(eff_time_super_add_eff*eff_sch_slipp_add_eff)
(0.00, 0.00), (0.1, 1.05), (0.2, 2.05), (0.3, 2.80), (0.4, 3.75), (0.5, 4.70), (0.6, 5.50), (0.7, 6.50), (0.8, 7.55), (0.9, 8.80), (1, 10.0)
effort_rew = GRAPH(per_req_rew_eff)
(0.00, 0.075), (0.1, 0.8), (0.2, 1.70), (0.3, 2.45), (0.4, 3.20), (0.5, 4.00), (0.6, 5.15), (0.7, 6.50), (0.8, 7.45), (0.9, 8.60), (1, 10.0)
eff_sch_slipp_add_eff = GRAPH(sch_slipp)
(0.00, 0.00), (1.00, 0.26), (2.00, 0.445), (3.00, 0.595), (4.00, 0.72), (5.00, 0.83), (6.00, 0.875), (7.00, 0.93), (8.00, 0.98), (9.00, 1.00), (10.0, 1.00)
eff_time_super_add_eff = GRAPH(time_ava_for_super)
(0.00, 0.00), (5.00, 0.19), (10.0, 0.35), (15.0, 0.475), (20.0, 0.61), (25.0, 0.72), (30.0, 0.83), (35.0, 0.9), (40.0, 0.955), (45.0, 0.99), (50.0, 0.99)
exp_work_done = GRAPH(TIME)
(1.00, 0.00), (2.00, 7.50), (3.00, 19.0), (4.00, 34.5), (5.00, 49.0), (6.00, 70.0), (7.00, 82.0), (8.00, 90.5), (9.00, 94.5), (10.0, 97.5), (11.0, 98.5), (12.0, 99.0), (13.0, 100)

per_req_rew_eff = GRAPH(rework_lev)
(0.00, 0.00), (1.00, 0.095), (2.00, 0.17), (3.00, 0.265), (4.00, 0.395), (5.00, 0.5), (6.00, 0.62), (7.00, 0.72), (8.00, 0.82), (9.00, 0.89), (10.0, 1.00)
plan_effort = GRAPH(TIME)
(1.00, 9.90), (2.00, 9.95), (3.00, 9.95), (4.00, 9.75), (5.00, 9.60), (6.00, 9.40), (7.00, 9.15), (8.00, 8.90), (9.00, 8.40), (10.0, 8.00), (11.0, 7.35), (12.0, 6.80), (13.0, 6.30)

Oklahoma State University Institutional Review Board

Date: Friday, June 09, 2006

IRB Application No EG068

Proposal Title: A Study of the Influence of Goal Alignment in Multi-Organizational Project Performance: A System Dynamics Approach

Reviewed and Processed as: Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 6/8/2007

Principal Investigator(s

Atilio Moran
8116 W. 142nd St.
Overland Park, KS 66223

Paul Rossler
OSU Tulsa 700 N. Green
Tulsa, OK 74106

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☑ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 415 Whitehurst (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C. Jacobs, Chair
Institutional Review Board

Oklahoma State University Institutional Review Board

Date	Friday, November 10, 2006	Protocol Expires:	6/8/2007
IRB Application	EG068		
Proposal Title:	A Study of the Influence of Goal Alignment in Multi-Organizational Project Performance: A System Dynamics Approach		
Reviewed and Processed as:	Exempt **Modification**		

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s) :

Atilio Moran	Paul Rossler
8116 W. 142nd St.	OSU Tulsa 700 N. Greenwood
Overland Park, KS 66223	Tulsa, OK 74106

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

Signature :

Sue C. Jacobs, Chair, OSU Institutional Review Board

Friday, November 10, 2006
Date

VITA

Atilio Moran

Candidate for the Degree of

Doctor of Philosophy

Dissertation: A STUDY OF THE INFLUENCE OF GOAL ALIGNMENT ON MULTI-ORGANIZATIONAL PROJECTS: A SYSTEM DYNAMICS APPROACH

Major Field: Industrial Engineering and Management

Biographical:

Personal Data: Born in Caracas, Venezuela, On September 14, 1963, the son of Atilio and Graciela Moran.

Education: Received a Bachelor of Science in Mechanical Engineering degree from the Simon Bolivar University, Caracas, Venezuela in February, 1987. Received a Master in Business Administration degree from the Catholic University, Caracas, Venezuela in March, 1993. Received a Master of Science in Engineering and Technology Management from Oklahoma State University in May, 2003. Completed the requirements for the Doctor of Philosophy degree with a major in Industrial Engineering and Management at Oklahoma State University in May, 2007.

Experience: Project Engineer, Technology manager, and Human Resources manager in Jantesa, Engineering and Construction, Caracas, Venezuela (1987-2000).Research and teaching assistant at the Industrial Engineering and Management department, Oklahoma State University (2002-2006).

Honors Societies Memberships: Phi Kappa Phi, Alpha Phi Mu.

Name: Atilio Moran Date of Degree: May, 2007

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: A STUDY OF THE INFLUENCE OF GOAL ALIGNMENT ON MULTI-ORGANIZATIONAL PROJECTS: A SYSTEM DYNAMICS APPROACH

Pages in Study: Candidate for the Degree of Doctor of Philosophy

Major Field: Industrial Engineering and Management

Scope and Method of Study: The purpose of this study is to examine how the level of goal alignment among the participant organizations in a multi-organizational project influences project dynamics and performance. Two projects cases were used in the study. Two system dynamics models were developed based on cases' data and previously validated projects system dynamics models. The first model aims to represent how the level of goal alignment affects project dynamics when a project team constituted by representatives of the different participating organizations executes the project. The second model aims to represent the case when the project team manages the project, which is executed by a third party. An assessment of the models' validity was performed by participants in the projects studied. An assessment of the possible use of the models in other contexts was performed through questionnaires completed by a panel of experts, and by comparison of the models' structures to previous research findings in related areas. Simulation experiments were performed to examine to what extent the models outputs represent plausible projects system behaviors according to the cases' data, and to explore the effects of possible moderating factors.

Findings and Conclusions: A pattern was identified in the cases studied concerning the mechanism through which the level of goal alignment affected project performance. That mechanism is the variation of the level of communication and trust among partners. In one case, the low level of communication affected the quality of the tasks that had to be coordinated between partners, as well as the coordination required for resources deployment. In the second case, low levels of trust and communication limited the project team problem solving capabilities, leading to delays in the decision making processes and to the elevation of the conflict to higher levels of management, increasing even more the decision making delays. The delays in the decision making process led to the accumulation of problems to solve, hindering the team effort to be proactive in anticipating incoming problems that might affect project performance. Models' assessments and simulations outputs provide preliminary confidence in models' structures, which can be improved with additional cases replications.

Dr. Paul Rossler

Advisor Approval ____