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An Assessment Of Alignment Between Project Complexity And Project Management Style

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AN ASSESSMENT OF
ALIGNMENT BETWEEN
PROJECT COMPLEXITY AND
PROJECT MANAGEMENT STYLE

by

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ABSTRACT

The main drivers for this research are the complexities associated with the project management and an organization's project management style in dealing with these complexities. This research aims to demonstrate that alignment between project complexity and project management style increases project performance and decreases project issues, and also, with increased project issues, project performance deteriorates. In order to test these claims, this research developed measures for assessing project complexity, project management styles and project issues by employing a survey of project management professionals. The measure for project complexity is based on a taxonomy with four categories: organizational complexity, product complexity, methods (process) complexity and goal complexity. Project management style is defined as the management paradigm that guides the managers of an organization in perceiving and dealing with management problems. The measure for project management style is based on the plan-do-study-act (PDSA) cycle and the Newtonian and complexity paradigms. Also the measures for project issues are developed after an extensive content analysis on the literature on project issues, risks and success factors.

A self-administered survey instrument (paper-based and on-line) with 40 questions (seven point Likert scale) was utilized. The respondents were the project management professionals from different industries in the Central Florida region. Each respondent was asked to answer questions for two different kinds of projects: a successful project and a challenged project. Based on the data collected by the survey instrument, the results of confirmatory and

exploratory factor analyses provide strong evidence that the final measures for project technology complexity, project management styles, project issues and project performance have adequate validity and reliability.

Results of the hypothesis tests demonstrate that increased alignment of project complexity and project management style leads to increased project performance and decreased project issues, and also increased project issues leads to project decreased performance. From the perspective of project management, the results of this study have illustrated the importance of aligning a project's complexity and management style. These results suggest that project or program managers can improve the performance of their projects by any attempt to increase the alignment between project complexity and project management style. Project management professionals and theoreticians can use the methodologies provided in this dissertation to assess project complexity, project management style and alignment.

Dedicated to

My loving mother and father

Ceyhan and Mehmet Camci

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CHAPTER ONE: INTRODUCTION

1.1 Problem Statement

During the second half of the 20th century, project management has become a major management discipline for many organizations in different industries such as construction, aerospace and information technology (Morris, 1994). Many prominent human achievements like the development of nuclear energy and space exploration can be attributed to project management during this period (Morris, 1994). With the increased complexity in technology and society it is natural to assume that projects are complex, non-linear endeavors and project organizations are complex systems where long-term forecasting is impossible (Bardyn and Fitzgerald, 1999).

The main drivers for this research are the complexity associated with the project management and an organization's project management style in dealing with these complexities and uncertainties. Projects are complex endeavors and project outcomes are far from being certain (DeMeyer et al., 2002). There is ample evidence in the literature that the majority of the projects either fail to achieve their goals or fail completely (Johnson, 2001). Management style determines how decision makers in an organization perceive and comprehend stimuli and how they choose to respond (Rowe and Mason, 1988). This research aims to demonstrate that alignment between the project complexity and the project management style increase project performance and decrease the issues faced during a project's life.

Management style is a dominant paradigm that guides a manager in dealing with the management problems. According to Kuhn (1962), humans approach problematic situations, like uncertainty or complexity, using a certain paradigm, which provides models, organizes and guides mental processes in solving a problem like an accepted judicial decision in the common law. Classical project management is based on production management theories of the early 20th century and these management theories are all based on mechanistic and reductionist thinking of the Newtonian paradigm (Koskela and Howell, 2002; Wheatley, 1999). Project management practice has been dominated by the Newtonian paradigm in forms of work breakdown structures and discrete tasks with linear temporal relationships (Singh & Singh, 2002). The Newtonian paradigm views the universe and everything in it as a machine. This mechanistic view leads to the belief that studying the parts of the machine is key to understanding the whole (Brown and Eisenhardt, 1998). But as the world becomes a more complex, interconnected and highly volatile space, the Newtonian paradigm fails to understand the whole system for it cannot help but focus on the parts of the system.

The complexity paradigm has been emerging from the scientific domains of quantum physics, theoretical biology, chemistry, and ecology as an alternative to the Newtonian paradigm (Kauffman, 1995; Mandelbrot, 1983; Prigogine, 1996; Maturana & Varela, 1987). Even though the complexity paradigm has its roots in the physical and biological sciences, it has been explored by social and organizational scientists to understand complex human systems (Lewin, 1992; Stacey, 1996).

As a new century began, the idea that projects are deterministic Newtonian systems was challenged and the idea that projects are nonlinear complex systems where outcomes can not be predicted emerged (Bardyn and Fitzgerald, 1999; Singh and Singh, 2002). In nonlinear complex systems organizations musts work with the complexity rather than against it for project success and this requires a paradigm shift in the organizations (Bardyn and Fitzgerald, 1999).

The purpose of this research is to investigate (characterize, conceptualize, demonstrate, and generalize) how alignment of project management style (the Newtonian or the complexity) and project complexity affect project management issues and overall project performance.

1.2 Research Question

This research addresses the question:

How does the alignment of the project management style and the complexity of a project affect the issues faced during the project's life and the overall project performance?

The related sub-questions are:

1. What are the characteristics of the project management domain?
2. How is project performance measured?
3. What are the main issues associated with projects?
4. What is project complexity?
5. What is project management style?
6. What are scientific paradigms?
7. How do scientific paradigms affect the project management style of an organization?
    a. What are the characteristics of the Newtonian project management style?
    b. What are the characteristics of the complexity project management style?
8. What is alignment between project management style and project complexity?

1.3 Operationalized Research Question

One of the main purposes of project management research is to help organizations to improve their performance in managing projects. For this reason, there is a plethora of project management literature on how to better manage projects. Even researchers of project management can feel overwhelmed by the multitude of approaches on project management. There are also well-established bodies of knowledge on project management (e.g. Project Management Institute's Project Management Body of Knowledge) aimed to be guides in project management.

This research differs from the previous body of knowledge by integrating the characteristics of the scientific paradigms, which are mental models in solving problems, into the project management process. These mental models dictate the project's management style, which is how the project managers and the team members approach a problematic or a complex situation during the project's life cycle. This research will provide practicing project managers insights into how an organization's project management style will affect the project management outcomes in different project complexity levels. Thus, this research will answer:

In managing projects in complex environments, what kind of a management style should a project manager have in order to deal with the complexity of the project?

1.4 Conceptual Model

The overall conceptual model for this research is given in Figure 1. The conceptual model shows the causal relationships between the project management style, project complexity, project management issues and project management performance. In this model, the alignment part is where the researcher matches the style of a project with its complexity. Alignment requires the matching of high complexity projects with the complexity management style and low complexity projects with the Newtonian management style.

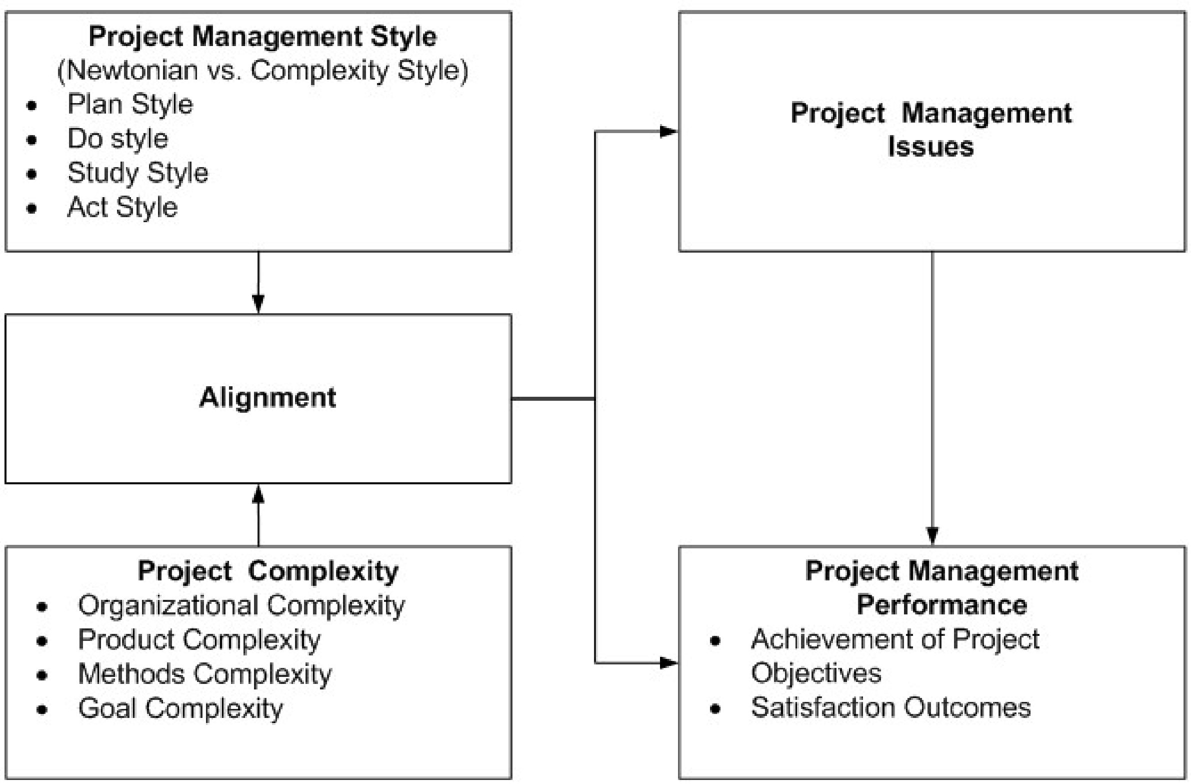


Figure 1: Overall conceptual model for the research

1.5 Definitions of Terms

Project Management Style: The way managers perceive and comprehend stimuli and how they choose to respond (Rowe and Mason, 1987) or the management paradigm that the managers of that organization use to deal with problematic situations.

Paradigm: Paradigms provide models, organize and guide mental processes in solving problematic situations (Kuhn, 1962).

Newtonian Paradigm: Scientific paradigm that assumes that the universe is deterministic, linear and outcomes can be predicted simply by looking at the inputs or the components of the system.

Complexity Paradigm: Scientific paradigm that assumes that the universe is nonlinear and chaotic. Only short term predictions can be made and systems survive basically by adapting to new situations.

Project Complexity: Project complexity is the inadequacy of the knowledge needed to understand and determine the outcomes of a project (adapted from Fioretti and Visser, 2004).Complexity is defined and measured in terms of the number of its constituent parts, their diversity and relationships (Fioretti and Visser, 2004). In this dissertation, the components of project complexity are identified as:

Organizational Complexity: Complexity related to the project's organization (project team, parent organization, customer(s), vendors or consultants).

Product Complexity: Complexity of product that the project intends to deliver.

Methods Complexity: Complexity of the methods (processes, tools, technologies) that the project uses to deliver its product.

Goal Complexity: Complexity of the goals (schedule, cost, product performance, customer requirements) of the project.

Alignment: The extent to which two or more organizational dimensions meet theoretical norms of mutual consistency (Sabherwal et al., 2001).

Project Management Issues: Problems or obstacles that arise to threaten to disrupt the progress of a project (Glass, 1998).

Project Management Performance: A project is deemed successful if it achieves its predetermined objectives (completed within budget, within schedule, conforming to customer requirements and specifications) and satisfies the main stakeholders (customer, senior management and project management).

1.6 Research Delimitations

The main focus of this research is on the project management style and project complexity and the effects of these characteristics on the overall performance of the project management process, project outcomes and the issues faced during the project. The main research delimitations are as follows:

1. The characteristics of the project management styles will be limited to those stemming from the Newtonian and the complexity paradigms.
2. The focus will be on three main areas of the complexity paradigm: (1) dynamic systems, (2) chaos theory, and (3) complex adaptive systems.
3. This research does not intend to contribute to the Newtonian or the complexity paradigm sciences. It will use the current status of paradigm research to analyze the characteristics of these paradigms on project management process.

1.7 Research Purpose

The current project management discipline is based on the reductionist and determinist views of the Newtonian paradigm (Koskela & Howell, 2002, Wheatley, 1999, Singh & Singh, 2002). Complexity and uncertainty is inevitable for most projects (DeMeyer et al., 2002) and the majority of the projects are either cancelled before completion or completed but failed to achieve the project goals (Johnson, 2001). The purpose of this research is to investigate the effects of a paradigm shift from the Newtonian paradigm to the complexity paradigm for project management styles on the project management outcomes.

1.8 Research Objectives

The objectives of this research are to develop:

1. A list of issues of the project management domain after a thorough analysis of the available literature.
2. A comprehensive taxonomy of project complexity.
3. A list of characteristics of project management styles based on the Newtonian and the complexity paradigms to cope with the complexity of the project. These characteristics can be used as guidelines for adapting a project management style for a project organization.

1.9 Research Hypothesis

This research is based on the hypothesis:

Organizations, with project management style having the complexity paradigm characteristics, are more successful than those with the Newtonian paradigm characteristics in dealing with complex projects.

The success of a project will be measured in terms of the issues faced during the projects life cycle and the project's overall performance.

1.10 Contribution of the Research

The main contribution of this research is to connect the knowledge areas of the project management domain, project management styles and scientific paradigms (Figure 2). These three knowledge areas are standalone topics in numerous publications. Some of these publications will be reviewed in Chapter 2 of this dissertation. Some researchers connected the project management domain and scientific paradigms (e.g. Bardyn and Fitzgerald, 1999, Singh and Singh, 2002) and project management domain and project management styles (Lewis et al.,2002, Shenhar and Dvir, 2004). But connecting the project management domain, project management styles and scientific paradigms remains an unexplored territory.

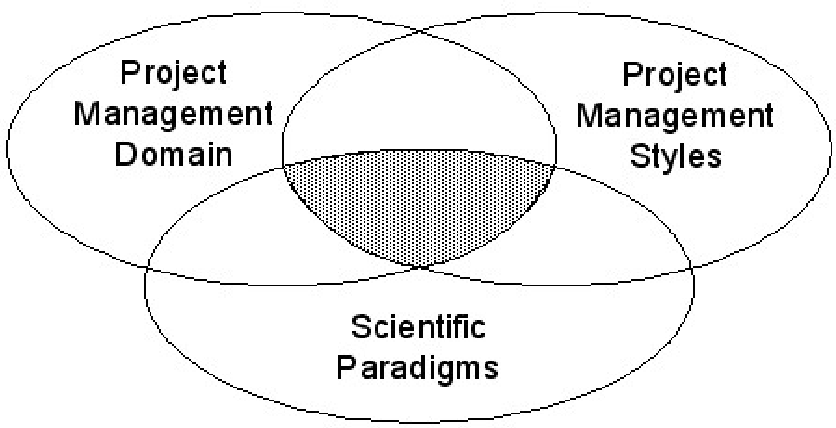


Figure 2: The area of contribution of this research.

1.11 Overall Research Plan

During this research, the main approach being utilized is the Hypothetico-deductive method. The Hypothetico-deductive approach is based on one or more hypothetical assumptions that would form a theory to provide an explanation for a phenomenon. Figure 3 outlines the overall research process based on the Hypothtico-deductive method (Popper, 1962, Lawson, 2000, Babbie, 1998).

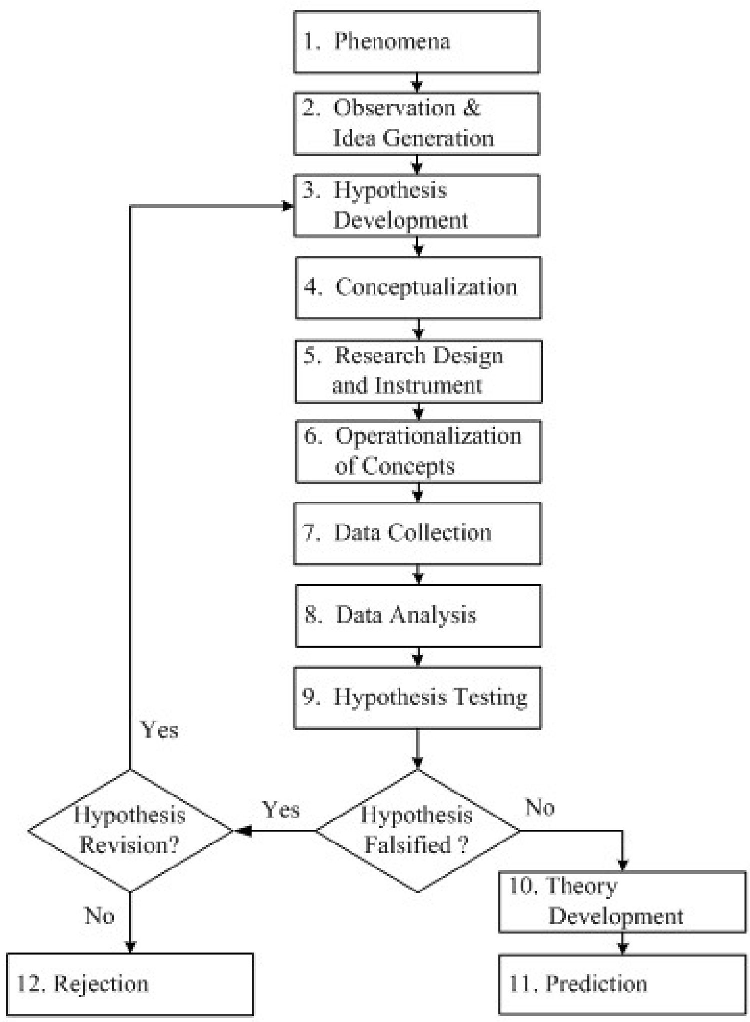


Figure 3: Overall research process (Popper, 1962, Lawson, 2000, Babbie, 1998).

The areas of inquiry are the main blocks of a research plan. In this research these areas are: project management issues, project management complexity and effects of scientific paradigms on project management process. The research plan outlining this research is given below in Figure 4.

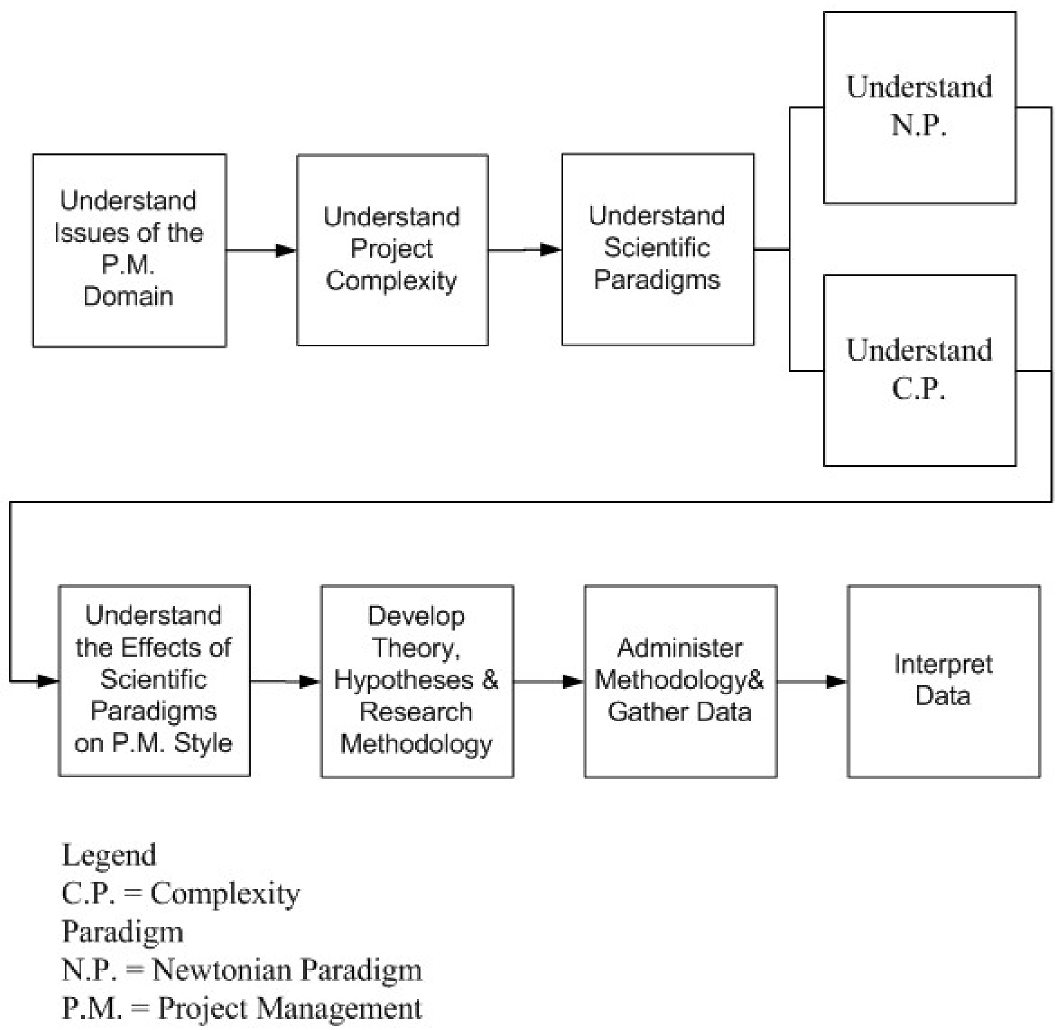


Figure 4: Overall research plan.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The literature review of this dissertation covers the domains of multiple disciplines in order to understand the influences of the Newtonian and the complexity paradigms on project management style. Figure 5 shows the model for exploring the main knowledge areas for this dissertation. The literature review starts with the introduction to the project management domain, which outlines the main characteristics of the project management discipline and a chronology of how the project management discipline evolved into a mainstream management discipline. This chronology also demonstrates the clues of a paradigm shift in the project management discipline. After this introduction, the literature on project complexity is reviewed. The result of the project complexity discussion is a taxonomy of project complexity. The next topic is the issues affecting the project management during the course of a project. Later in the chapter, the main discussion will be about the project management styles and how the project management styles are influenced by the Newtonian and the complexity paradigms. Using the discussions on project complexity and project management styles, the topic of alignment and how alignment can be quantified will be discussed. Finally, at the end of this literature review chapter, the main research hypotheses will be presented.

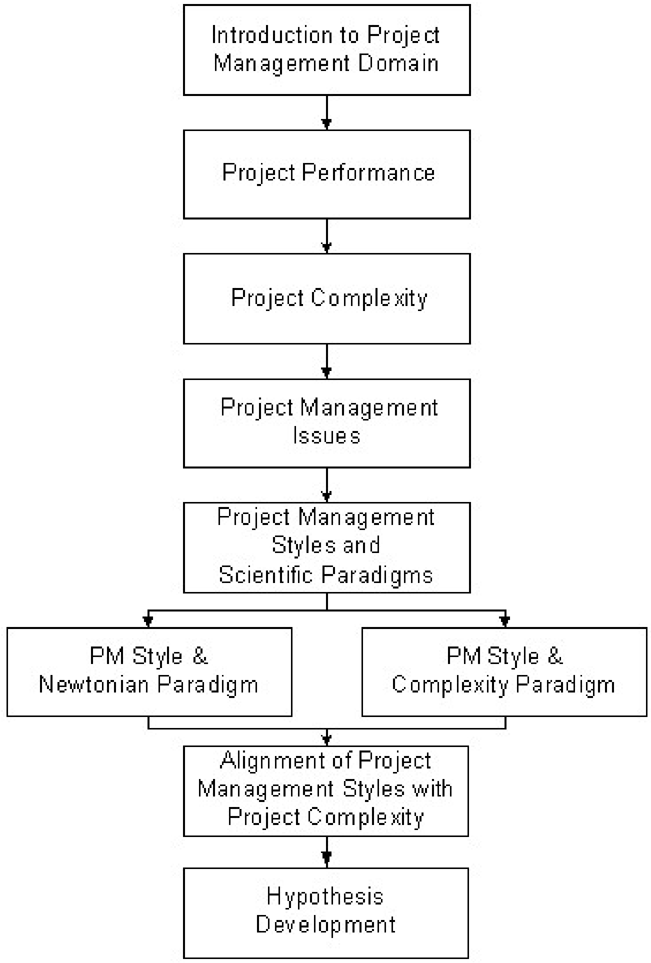


Figure 5: Outline of the literature review.

2.2 Project Management Domain

The starting point of this research is to explore the project management literature to understand the underlying factors that may instigate a paradigm shift. This section contains the main characteristics of the project management discipline using widely accepted references. For more in-depth information, these references can be consulted directly.

2.2.1 Project Management Process

There is almost a consensus throughout the project management literature on the definition of the term "project":

> "A project is a unique, temporary endeavor with clearly defined objectives and consumes limited resources (Kertzner, 1989, Cleland, 1999, Project Management Institute, 2000)."

Kertzner (1989) sees a project as a series of activities and tasks. Similarly Dawson (2000) defines a project as a complex process made up of different phases and sub-processes, encompassing different levels of an organization or different organizations and having metrics like, time, cost, quality, scope and resources.

Turner and Muller (2003) describe three essential features of a project that ultimately set projects apart from other production processes:

- Uniqueness: No previous or subsequent project will be exactly the same.
- Novel processes: No previous or subsequent project will use exactly the same approach.
- Transient: A project has a beginning and an end.

Similarly, Khabanda and Pinto (1996) points to four dimensions of projects:

- Finite budget and schedule constraints
- Complex and interrelated activities
- Clearly defined goals
- Uniqueness.

According to Turner and Muller (2003), these unique characteristics of projects create three main implications in managing projects:

- Projects are subject to uncertainty such that it is never certain that project plans will deliver the required project outcomes or desired beneficial change.
- Projects require integration of the resources required to deliver the project between different parts of the project and between the project and the organization.
- Projects are subject to urgency of delivering the desired outcomes within the desired timescales.

The complex and uncertain nature of projects is the reason why project management requires a different approach than other production management disciplines (Turner and Muller, 2003). Another characteristic of projects that affects project management is that they have a beginning and an end (Turner and Muller, 2003), or a finite life. Usually projects are undertaken following certain processes during the life of the projects. The Project Management Institute's Project Management Body of Knowledge guide (Project Management Institute, 2000) gives the definition of project management as a process which is a combination of the application of knowledge, skills, tools, and techniques to project activities to meet project requirements.

The Project Management Institute (2000) classifies project management processes into five categories:

- Initiating Processes
- Planning Processes
- Executing Processes
- Monitor and Controlling Processes
- Closing Processes.

These five processes are executed during the life of every project (Project Management Institute, 1996, 2000, 2004). During each of these processes, different project management tools and techniques are used (Milosevic, 2004). The Project Management Institute (2000) further grouped these five processes into the plan-do-study-act (PDSA) cycle (Figure 6) where initiation and closure steps are separate from the PDSA cycle. However, Kotnour (1999) also links the PDSA cycle to the Project Management Institute's Project Management Body of Knowledge (PMBOK). In Kotnour’s PDSA model, in the “plan” phase, the project team determines the nature of the problem and constructs a plan (Kotnour, 1999), thus incorporating the initiation process into “plan” phase. Similarly, the "act" phase involves the management decisions to make necessary changes or to finish the process, thus incorporating the closure process into the “act” phase (Kotnour, 1999).

Using Kotnour’s (1999) PDSA model, the main project processes and how they fit into the PDSA cycle are given as follows:

- The “plan” phase consists of two main steps, determination to solve a problem (initiation) and construction of a plan to accomplish the desired outcome (planning) (Kotnour, 1999).Thus “plan” component of the PDSA cycle includes the initiation and planning processes which involve decisions to authorize a project or a project stage (initiation) and to define the objectives and to plan the course of action required to attain the project objectives and scope (planning).
- The “do” component of the PDSA cycle corresponds to executing processes when project management integrates people and other resources to carry out the project management plan (Kotnour, 1999).
- Outcomes of the “do” phase (execution) create a reality which might be different than the goals and objectives set by the “plan” phase. During the "study" phase, the project team reflects on the differences between the plans and the outcomes of the execution. (Kotnour, 1999). The “study” component of the PDSA cycle corresponds to the monitoring portion of the monitoring and controlling process group of PMBOK when project management measures and monitors progress of the project to identify variances from the project management plan (Project Management Institute, 2004).
- The "act" phase is the final step to close the loop when the decisions to continue or terminate the project process are made (Kotnour, 1999). The “act” component of the PDSA cycle corresponds to the controlling portion of the monitoring and controlling process group and the closure process group of PMBOK when the lessons learned through the study cycle are incorporated into the project plan or saved for future projects.

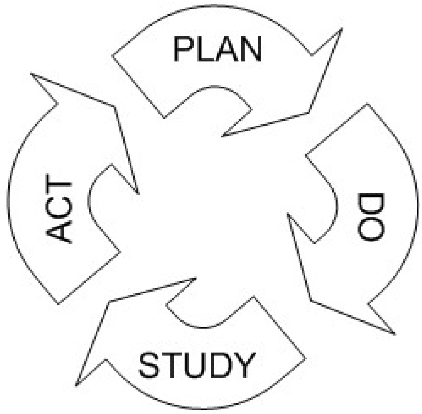


Figure 6: Plan-Do-Study-Act (PDSA) cycle for project management.

2.2.2 A Brief History of Project Management

During the second half of the 20th century, project management became a major management discipline for many organizations in different industries such as construction, aerospace and information technology (Morris, 1994). In this section, how the paradigm in managing projects has evolved is discussed. The evolution of the project management discipline will demonstrate the clues of a paradigm change in the project management discipline. Morris (1994) gives a fairly detailed chronology for the emergence and evolution of the project management discipline till the end of the 1980s (Figure 7):

- According to Morris, modern project management emerged between the 1930s and 1950s, mainly during World War II (WWII), but project management dates back to the dawn of mankind with projects like Stonehenge, the pyramids and St. Peter's Basilica. Developments in the management field that affected the project management discipline before WWII include Taylor's scientific management, Gantt charts and Procter and Gamble's product management concepts.

- During WWII, operation overlord (invasion of Europe) and the Manhattan Project were massive undertakings which required extensive government support, strong leadership, the highest level of secrecy and involvement of hundreds of thousands of people. But Morris (1994) states that he regards only the Manhattan project as a contributor to the project management discipline.
- The 1950s saw the development of the concepts of systems management and engineering, as well as PERT and CPM methods. These concepts were developed during the height of the cold war nuclear arms race when the US felt the need to develop long-range bombers and ballistic missiles capable of carrying nuclear warheads. During its infancy, the project management discipline was largely deterministic, based on the scientific management theories of Taylor. But as the projects and the environment got more complex and uncertain, probabilistic techniques like PERT began to emerge.
- Worldwide acceptance of project management as a new management discipline happened in 1960s when there was an explosion of development and usage of systems integrations and new project management tools. Some of these tools were: precedence diagramming, work breakdown structures and earned value. This decade saw the major undertaking of sending men to the moon in the Apollo program, which was a showcase for the modern project management discipline. One other development for this decade was the formation of the Project Management Institute (PMI).
- During the 1970s, the project management discipline continued its growth and became a mainstream management practice. Also during this decade, the public started to have

influence on several major projects which had never occurred before, thus adding more complexity for the decision makers.

- By the 1980s, the project management discipline begcame a mature management discipline, with degree programs and professional certification. Advances in computing enabled the development of computerized project management systems. This decade also witnessed the emergence of information technology (IT) projects as a way to increase organizational effectiveness. But IT projects were usually well over budget and schedule.

Morris' chronology of project management ends at the end of the 1980s (1994). Articles by Pinto (2002) and Urli and Urli (2000) outline the recent changes in the project management environment:

- During this period (1990s to present), the project management discipline has expanded its boundaries beyond its traditional areas. Organizations have begun to use project management as a tool for organizational change and implementing quality programs. Project management evolved into management by projects (Urli and Urli, 2000).
- Shortened product life cycles and narrow product launch windows, as well as increasingly complex and technical products put an immense pressure on organizations to come up with successful projects. During the same period, increasing globalization and low inflation forced organizations to become more efficient and competitive (Pinto, 2002).
- Proliferation of computers, internet and web technologies enabled the emergence of virtual project teams and groups that may not be in the same physical location but still work for the project's success (Pinto, 2002).

- This period witnessed the emergence of heavyweight project organizations and increasing use of project management offices (PMOs) (Pinto, 2002). According to Pinto (2002), in heavyweight project organizations the survival of the organizations depends on the delivery of successful projects. Similarly, Kotnour (1999) states that delivery of a single successful project is not enough for the organization and the overriding objective is to deliver a series of successful projects and to build capabilities to deliver them.
- Pinto (2002) also stresses the increased emphasis on the risk management methodologies. This fact can be detected by comparing the Project Management Institute's PMBOK's 1996 issue and 2000 issue. The 2000 issue has more detailed risk management content than 1996 issue (Project Management Institute, 1996, 2000).

The relevance of this chronology to this dissertation is that it shows project management discipline has been changing and adapting to the complexities of the world. It also shows the idea that projects are not deterministic emerged during the early days of the project management discipline with the development of stochastic tools.

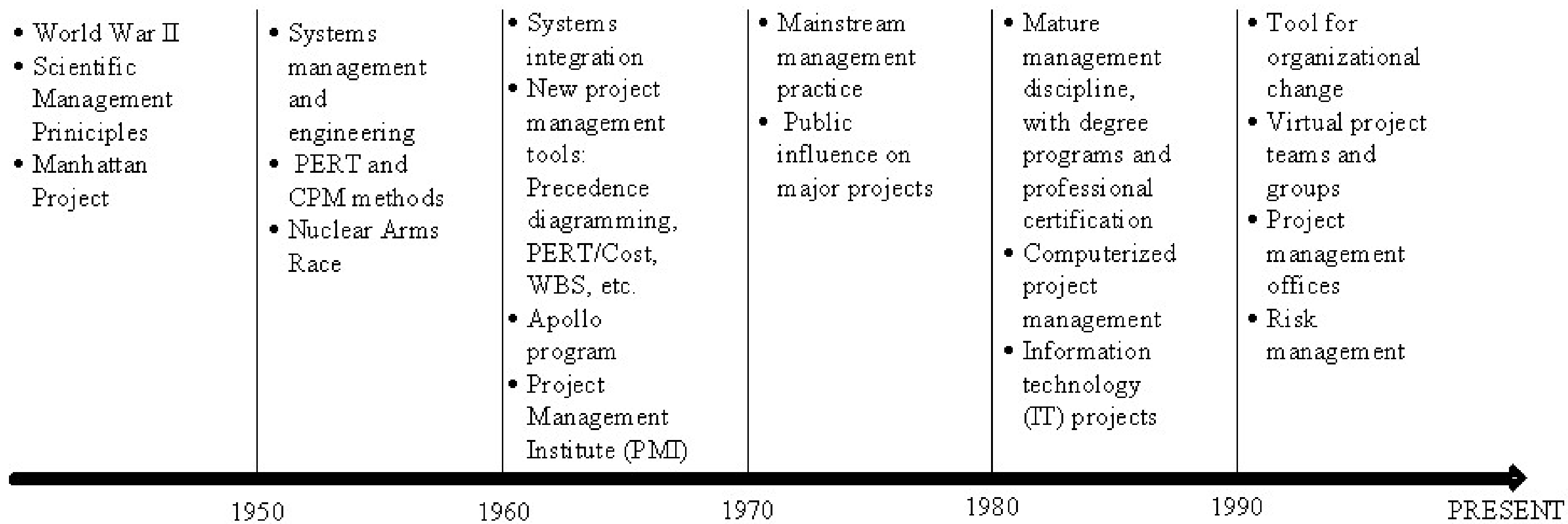


Figure 7: Time-line for the emergence and evolution of the project management discipline (Morris, 1994, Pinto, 2002, Urli and Urli, 2000)

2.3 Project Management Performance

In this section, the factors affecting the project performance will be discussed. Traditionally, time, cost and technical performance have been the three main objectives of any project and they are usually represented in a triangular form (Figure 8) (Kerzner, 1989, Cleland, 1999). This triangular representation shows how a change in one of the objectives affects the other two or the tradeoffs between the objectives.

Figure 8: Time-Cost-Technical Performance triangle.

But this simplistic view of the project management performance measure is largely disputed (Kerzner, 1989, Shenhar et al.,2001, Tukel and Rom, 1998 and White and Fortune, 2001). Kerzner (1989) concludes that, in addition to the basic performance measures, a project is successful when it is completed without any negative affects on the organization and its culture. Taking a strategic perspective, Shenhar et al. (2001) identifies impact on the customer, direct business and organizational success and preparing the organization for the future as the other important success measures for projects.

This dissertation focuses on the project managers perceptions on the performance of their most recent completed projects. According to two empirical studies conducted by Tukel and Rom (1998) and White and Fortune (2002), cost, time and technical performance (quality) are the main criteria used to assess project success for the majority of the project managers. Further analysis shows that other criteria, like credibility of the organization and getting new projects depend on those three main criteria (Tukel and Rom, 1998; White and Fortune, 2002).

Finally, Tatikonda (1999) offers a classification for project success by incorporating satisfaction of various stakeholders (customer, project management and senior management) with the classical project success factors (technical performance, cost, and schedule):

- Achievement of Project Objectives
    - Technical performance objective
    - Cost objective
    - Schedule
- Satisfaction Outcomes
    - Senior Management
    - Project Management
    - Customers

2.4 Project Complexity

In this section, project complexity is discussed. Projects are complex endeavors and project outcomes are far from certain (DeMeyer et al., 2002). Project management owes its existence as a management discipline to the complex undertakings like the space program and nuclear arms development (Morris, 1984). Even though the project management discipline has been around for almost sixty years, delivering successful projects is still an obstacle for many organizations.

2.4.1 Project Failures

There is ample evidence in the literature that the majority of projects fail or are unable to achieve their initial goals (Morris, 1994, Johnson, 2001). Morris (1994) reports that, in the early 1980s, out of 1449 projects he found in public records, only 12 were on or below the budget. He also added that he found similar results when he repeated the exercise with over 3000 projects (Morris, 1994). According to a survey study of 120 major organizations in the UK by KPMG Ltd., 62% of respondents experienced a runaway project, which is described as a project that failed significantly to achieve its objectives and/or exceeded its original budget by at least 30% (Cole, 1995). Another well known study is the Standish Group's "Chaos Study" which reports that in 2000 only 28% of all IT application development projects have succeeded, while 23% failed (cancelled before completion or never implemented) and 49% were challenged (completed but failed to achieve the project goals like cost, time or specifications) (Johnson, 2001). Johnson (2001) also provides the results of the previous studies conducted by the Standish Group. Table 1 outlines the results of these studies (Johnson, 2001).

Table 1: Project (IT) outcomes according to the Standish Group's Chaos Studies (Johnson, 2001)

	1994	1996	1998	2000
Succeeded	16%	27%	26%	28%
Failed	31%	40%	28%	23%
Challenged	53%	33%	46%	49%

Projects with exceeded budgets are also common in the public sector (Edwards, 2003). Cato Institute's Tax and Budget Bulletin, gives some examples of budget overruns in government projects (Edwards, 2003) (Table 2).

Table 2: Selected Government Cost Overruns (Edwards, 2003)

PROJECT	**Estimated Cost and Date of Estimate**	
	Original	Latest or Actual
Transportation		
Boston "Big Dig"	$2.6b (1985)	$14.6b (2002)
Denver International Airport	$1.7b (1989)	$4.8b (1995)
Virginia "Mixing Bowl"	$241m(1994)	$676m (2003)
Seattle Light Rail Sytem	$1.7b (1996)	$2.6b (2000)
Kennedy Center parking lot	$2.8m (1998)	$88m (2003)
Energy		
Yucca mountain radioactive waste	$6.3b (1992)	$8.4b (2001)
Hanford nuclear fuels site	$715m (1995)	$1.6b (2001)
Idaho Falls nuclear fuels site	$124m (1998)	$273m (2001)
National ignition laser facility	$2.1b (1995)	$3.3b (2001)
Weldon Springs remedial action	$358m (1989)	$905m (2001)
Defense (per unit)		
F/A-22 Raptor fighter	$89m (1992)	$248m (2002)
V-22 Osprey aircraft	$23m (1987)	$90m (2001)
RAH-66 Comanche helicopter	$31m (2000)	$52m (2002)
CH-47F cargo helicopter	$8m (1998)	$18m (2002)
SBIRS satellite system	$732m (1998)	$1.6b (2002)
Patriot advanced missile	$4m (1995)	$10m (2002)
EX-171 guided munitions	$39,000 (1997)	$147,000 (2002)
Space		
International Space Station	$17b (1995)	$30b (2002)

Project failures also affect private companies, sometimes with catastrophic results. Unlike government organizations, with virtually no chance to go bankrupt, private companies can not tolerate project failures. A Computerworld magazine (2002) survey listed major IT project failures in the private sector as shown in Table 3.

Table 3: Major IT project failures in private organizations.

COMPANY	PROJECT	OUTCOME
AMR Corp., Budget Rent A Car Corp., Hilton Hotels Co.	The "Confirm" hotel and rental car reservation system	After four years and $125 million spent on development, the project crumbled in 1992 when it became clear that Confirm would miss its deadline by as much as two years.
Snap-on Inc.	Conversion to a new order entry system from The Baan Co.	Despite three years of design and implementation, a new order entry system installed in December 1997 cost the tools company $50 million in lost sales for the first half of 1998.
FoxMeyer Corp.	SAP ERP system	Drug distributor FoxMeyer has claimed that a bungled enterprise resource planning (ERP) installation in 1996 helped drive it into bankruptcy.
W.W. Grainger Inc.	SAP ERP system	Grainger spent at least $9 million on SAP software and services in 1998 and 1999. During the worst six months, Grainger lost $19 million in sales and $23 million in profits.
Greyhound Lines Inc.	Trips, a reservation and bus-dispatch system	Greyhound spent at least $6 million in the early 1990s building Trips. The debacle spurred a $61.4 million loss for the first half of 1994.
Hershey Foods Corp.	IBM-led installation and integration of SAP, Manugistics Group Inc. and Siebel Systems Inc.	To meet 1999's Halloween and Christmas candy rush, Hershey compressed the rollout of a new $112 million ERP system by several months. Sales fell 12% in the quarter after the system went live.
Norfolk Southern Corp.	Systems integration with merger target Consolidated Rail Corp.	Norfolk Southern lost more than $113 million in business during its 1998-1999 railroad merger with Conrail.
Oxford Health Plans Inc.	New billing and claims processing system based on Unix International and Oracle Corp. databases	A 1996 migration to a new set of applications resulted in hordes of doctors and patients who were angry about payment delays. All told, Oxford overestimated revenue by $173.5 million in 1997 and $218.2 million in 1998.
Tri Valley Growers	Oracle ERP and application integration	A giant agricultural co-operative, Tri Valley bought at least $6 million worth of ERP software and services from Oracle in 1996. Tri Valley eventually stopped using the Oracle software and stopped paying the vendor. Oracle denied all claims. The case was settled in January 2002.
Universal Oil Products LLC	Software for estimating project costs and figuring engineering specifications, to be built and installed by Andersen Consulting	After a 1991 ERP deal with Andersen resulted in unusable systems for Universal Oil, the industrial engineering firm cried fraud, negligence and neglect in a $100 million lawsuit in 1995.

2.4.2 Review of Literature on Project Complexity

The examples of project management failures mentioned above are good indicators of how complex the project management environment is. Fioretti and Visser (2004) define complexity in terms of inadequacy of knowledge needed to solve a problem. According to organization theory, complexity is an objective characteristic of an organization, defined and measured in terms of the number of its constituent parts, their diversity and relationships (Fioretti and Visser, 2004). Similarly, Baccarini (1996) proposes a definition for project complexity as consisting of many varied interrelated parts and suggests that this definition can be operationalized in terms of differentiation, which is the number of varied elements, and interdependency or connectivity, which is the degree of interrelatedness between these elements.

Williams (1999) structures project complexity in two dimensions. The first dimension, based on the work by Baccarini (1996), is structural complexity, which is the combination of the number of elements in a project and the level of interdependence between these elements. The other dimension is uncertainty: Williams (1999) uses the framework by Turner and Cochran (1993) to classify project uncertainty into two dimensions: uncertainty in the goals and uncertainty in the methods.

In project management literature, the concept of complexity emerged during the 1980s and 90s (McFArlan, 1981, Clark and Wheelwright, 1993, Turner and Cochrane, 1993, Baccarini, 1996, Williams, 1999, Shenhar and Dvir, 2004). Based on these sources in literature on project complexity, a taxonomy of project complexity emerges (Figure 9). According to this taxonomy, project complexity is classified into four distinct groups:

- Organizational complexity,
- Product complexity,
- Goal complexity,
- Methods complexity.

The project complexity classification is further discussed in the following sections. Also, in Table 4, main resources in project complexity literature and their comparisons to the project complexity taxonomy given above are presented.

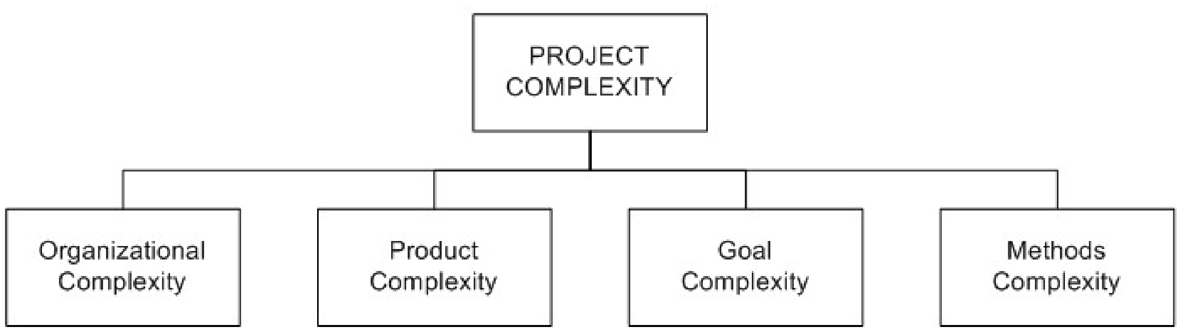


Figure 9: Taxonomy of project complexity.

Table 4: Summary of literature on project complexity

<table>
<tr><th></th><th>Organizational</th><th>Product</th><th>Methods</th><th>Goal</th><th>GAP</th></tr>
<tr><td>McFarlan (1981)</td><td>Size of the project</td><td></td><td>Level of knowledge on the technology being used</td><td>Level of certainty of the outputs of the project</td><td>Mainly deal with uncertainty. Only “Size” is mentioned as organizational complexity</td></tr>
<tr><td>Turner and Cochrane (1993)</td><td></td><td></td><td>Uncertainty in the delivery methods to achieve project’s goals</td><td>Users' requirements are difficult to specify and consequently not frozen.</td><td>Mainly deal with uncertainty. Organizational and product complexities are not mentioned.</td></tr>
<tr><td>Baccarini (1996)</td><td>Organization’s hierarchical structure, the number of organizational units and the task structure.</td><td colspan="2">The variety or diversity of inputs, outputs, tasks, number of specialties involved on a project and their interdependencies.</td><td></td><td>Focus is on structural complexity No differentiation between product and methods complexities. Goal complexity is not mentioned.</td></tr>
<tr><td rowspan="2">Shenhar et al. (2004)</td><td colspan="2">Structural Complexity
Assembly
System
Array</td><td rowspan="2">Uncertainty:
Low-Tech,
Medium-Tech,
High-Tech
Super High-Tech</td><td rowspan="2">Pace: Criticality of time goal.</td><td rowspan="2">Boundaries between the complexity types are not clear.</td></tr>
<tr><td></td><td>Uncertainty:
Breakthrough,
Platform,
Derivative</td></tr>
<tr><td>Clark & Wheel-wright (1993)</td><td></td><td>Uncertainty
Research or advanced development,
Breakthrough development,
Platform or generational,
Derivative or incremental</td><td></td><td></td><td>Main focus is the product uncertainty.</td></tr>
<tr><td>Williams (1999)</td><td colspan="2">Structural Complexity
Number of elements
Interdependence of elements</td><td>Uncertainty in methods</td><td>Uncertainty in goals</td><td>Narrow view of organizational and product complexities, while only uncertainties in goal and methods are considered.</td></tr>
</table>

2.4.2.1 Organizational Complexity

Daft (2001) defines an organization as a social entity that is goal-oriented, designed as deliberately structured and coordinated activity systems and linked to the external environment. According to organization theory, complexity is an objective characteristic of an organization, defined and measured in terms of the number of its constituent parts, their diversity and relationships (Fioretti and Visser, 2004).

According to McFarlan (1981), the main determinant for the organizational complexity is the project size, which encompasses monetary value, level of staffing, schedule duration, and the organizations and functional departments involved in the project. Taking a wider perspective, Baccarini (1996) defines organizational complexity in terms of differentiation and interdependency. Differentiation-based complexity can be either vertical or horizontal (Baccarini, 1996). Vertical differentiation is the depth of the project's hierarchical structure, including the parent organization and vendors/subcontractors. Horizontal differentiation is determined by the number of organizational units from the parent organization involved in the project. Interdependency-based organizational complexity is the degree of operational interdependencies and interactions between organizational elements.

Shenhar and Dvir (2004) use a hierarchical framework of systems to define and distinguish among different levels of organizational complexity with a systems approach and suggest three different levels:

- Level 1 - Assembly projects - Assembly projects involve creating a collection of elements, components and modules combined into a single unit or entity that is performing a single function.
- Level 2 - System projects - System projects involve a complex collection of interactive elements and subsystems, jointly dedicated to a wide range of functions to meet a specific operational need.
- Level 3 - Array projects - Array projects deal with large, widely dispersed collections of systems (sometimes called "super systems") that function together to achieve a common purpose such as city public transportation systems, national air defense systems or interstate telecommunication infrastructures.

The main determinants of organizational complexity can be summarized as:

- The size of the project (McFarlan, 1981, Baccarini, 1996)
- The number of the vendors/subcontractors (vertical differentiation) (Baccarini, 1996)
- The number of departments involved in the project (horizontal differentiation) (Baccarini, 1996)
- The number of projects dependent on this project (interdependency) (Baccarini, 1996, Shenhar and Dvir, 2004)

Since complexity is defined as inadequacy of knowledge needed to solve a problem (Fioretti and Visser, 2004), project complexity depends on the cognitive capabilities of the project organization. Table 5 presents organizational complexity as a continuum with characteristics of low and high organizational complexity relative to a typical project in the project organization.

Table 5: Organizational complexity continuum.

LOW ⟷	HIGH
• Very small project size	• Very large project size
• Very few or no vendors/contractors involved in the project	• Very high number of vendors/contractors involved in the project
• Very few or no departments involved in the project	• Very high number of departments involved in the project
• Very few or no projects are dependent on the project	• Very high number of projects are dependent on the project

2.4.2.2 Product Complexity

Product complexity relates to the complexity of product that the project intends to deliver. According to McFarlan (1981) and Baccarini (1996) product complexity is a subcategory of technological complexity, which covers complexities related to products and processes. The distinctions between product complexity and methods (process) complexity are well documented in product development literature (Clark and Wheelwright, 1993, Tatikonda, 1999). Clark and Wheelwright (1993) classify projects based upon the degree of technological uncertainty involved in the final product into four categories:

- Research and development (R&D) Projects: Purpose of these projects is to invent new science or to develop new technologies so that results can be further used in specific development projects.
- Breakthrough Projects: Breakthrough projects aim to create the first generation of an entirely new product and process.
- Platform Projects: Platform projects are the base projects that enable future product developments and they are made up of subsystems that may be easily added, modified or removed.
- Derivative Projects: Derivative projects refine and improve selected performance dimensions in existing products to meet the customer demands.

Using the product novelty model by Clark and Wheelwright (1993), Shenhar and Dvir (2004) suggest that there are three major new product categories in project management discipline – derivatives, platforms, and breakthroughs.

The variables for product complexity are:

- The novelty/newness of the product (Clark and Wheelwright,1993; Shenhar and Dvir, 2004).
- The number of the product subassemblies (Baccarini, 1996; Tatikonda, 1999).
- The impact of a design change of one subassembly on another subassembly (Tatikonda, 1999).

Table 6 presents product complexity as a continuum with characteristics of low and high product complexity relative to a typical project.

Table 6: Product complexity continuum.

LOW ⟵⟶	HIGH
• No novelty or improvement in the technology in the product	• Very high number of novelties or improvements in the technology in the product
• Very few or single product subassemblies.	• Very high number of product subassemblies.
• Very low or no impact of a design change of one sub assembly on another sub assembly	• Very high impact of a design change of one sub assembly on another sub assembly

2.4.2.3 Methods Complexity

Methods complexity relates to the complexity of the methods (processes, tools, technologies) that the project uses to deliver its product. Turner and Cochrane (1993) define the complexity regarding the methods of achieving the project goals as one of the main parameters of the project complexity. According to Shenhar and Dvir (2004), the major source of methods complexity is technological uncertainty, which affects development phases, design cycles, testing and design freeze in four levels:

- Type A - Low-Tech Projects: Projects that rely on existing and well-established technologies.

- Type B - Medium-Tech Projects: Projects that use mainly existing or base technology; yet incorporate some new technology or a new feature, which did not exist in previous products.
- Type C - High-Tech Projects: Projects that represent situations in which most of the technologies employed are new, but nevertheless, exist when the project is initiated.
- Type D - Super High-Tech Projects: Projects that are based on new technologies that do not exist at project initiation.

Writing about the complexity of product development projects, Tatikonda (1999) provides the main variables of methods complexity:

- The newness of the production technologies,
- The number of the production processes,
- The impact of a change in one production process on other production processes.

Table 7 presents methods complexity as a continuum with characteristics of low and high methods complexity relative to a typical project in the project organization.

Table 7: Methods complexity continuum.

LOW ⟵	⟶ HIGH
• No novelty or improvement in the process technologies	• Very high number of novelties or improvements in the process technologies
• Very few or single production processes.	• Very high number of production processes.
• Very low or no impact of a change in production process on other production processes.	• Very high impact of a change in production process on other production processes.

2.4.2.4 Goal Complexity

Goal complexity relates to the complexity of the goals (schedule, cost, product performance, customer requirements) of the project. According to Turner and Cochrane (1993) how well defined the goals are, is a major parameter in project complexity. Projects with goal uncertainty are often changed since users' requirements are difficult to specify and consequently not frozen. Uncertainty or changes in some requirements will mean that interfacing elements also need to change (Williams, 1999).

The variables for goal complexity are:

- The number of the requirement changes,
- The potential impact of a change in one requirement on the other requirements,
- The impact of not realizing the goals of the project on the organization.

Table 8 presents goal complexity as a continuum with characteristics of low and high goal complexity relative to a typical project in the project organization.

Table 8: Goal complexity continuum.

LOW ⟵	⟶ HIGH
• Very few or no requirement changes. • Very low or no impact of a change in one requirement on the other requirements. • Very low or no impact of not realizing the goals of the project on the organization.	• Very high number of requirement changes • Very high impact of a change in one requirement on the other requirements. • Very high impact of not realizing the goals of the project on the organization.

2.5 Issues of the Project Management Domain

Glass (1998) defines a project issue as a problem or an obstacle that arises to threaten to disrupt the progress of a project and gives the distinction between risks and issues; as risks are issues that are anticipated to happen during the course of the project. In order to determine and to classify the contemporary project management issues a simple content analysis was conducted. Holsti (1969) defines content analysis as, "any technique for making inferences by objectively and systematically identifying specified characteristics of messages" (p. 14). Content analysis is a technique where researchers are able to sort through large amount of data and to discover and describe the focus of individual, group, institutional, or social attention (Weber, 1990). The main steps taken in determining the project management issues are as follows:

1. Data Collection: Project management literature provides the data required to analyze the project management issues. The project management literature covers the project management issues under two main research areas: project management success factors and project management risks. Most of the research conducted in the area of project management issues (success factors or risks) is based on surveys of project management professionals and is anecdotal. In Table 9, a summary of the literature on the project management issues is presented.
2. After collecting and tabulating the issues, some of them are eliminated for being overly industry specific, technical (i.e. construction or software) or ambiguous. The remaining issues are then classified using the project complexity taxonomy given above into the categories of organizational, project delivery, product and goal issues.

3. After classifying the issues under these disciplines, a further regrouping and consolidation of the data is performed. The remaining list gives us a final list of unique issues faced by project environment (Table 10).

Table 9: Summary of literature on project management issues.

Reference	Description of Classification	Basis
Addison (2003)	1) Issues related to user/customer requirements, attracting new customers, scope. 2. Business and supply chain issues. 3. Methodology issues. 4. Strategic planning/management/direction. 5. Management and user support/commitment. 6. Web page design considerations. 7. Security issues. 8. System integrity, testing and conversion issues. 9. Staff issues. 10. Technical environment.	Three phase Delphi technique with 32 software project managers
Baker et al. (1983)	1) Characteristics contributing to the success of the project 2) Characteristics contributing to the failure of the project 3) Characteristics related to both the success and the failure of the project	Empirical research on 650 projects.
Barki etal (1993)	Software development risks and uncertainty factors	Survey of 120 projects
Belassi and Tukel (1996)	1) Factors related to the project 2) Factors related to the project manager and the team members 3) Factors related to the organization 4) Factors related to the external environment	Empirical survey study with 91 respondents.
Chan et al. (2004)	1) Project Management Actions 2) Project Procedures 3) Project-related Factors 4) External Environment 5) Human Related Factors	Literature review of seven major management journals.
Elonen and Artto (2003)	1) Inadequate definition, planning and management of single projects 2) Resource shortage and allocating resources improperly 3) Lacking commitment and unclear responsibilities 4) Inadequate portfolio level activities 5) Others	A combination of case and survey research in two organizations.
Harris (1999)	1) Corporate Factors 2) Project Opportunity 3) External/Market Factors 4) Competitive Position	Action research in on of the top ten European logistics operators

Table 9: (Continued) Summary of literature on project management issues

Reference	Description of Classification	Basis
Jiang and Klein (2000)	1) Technological acquisition 2) Project size 3) Lack of team's general expertise 4) Lack of team's expertise with the task 5) Lack of team's development expertise 6) Lack of user support 7) Intensity of conflicts 8) Extent of changes brought 9) Resources insufficient 10) Lack of clarity of role definitions 11) Application complexity 12) Lack of user experience	Survey of 86 project managers
Lientz and Rea (1995)	1) Twenty ways to fail as a project manager 2) Twenty five ways to succeed as a project manager	Anecdotal
Morris and Hough (1987)	1) Project definition 2) Planning, design and technology management 3) Politics/Social factors 4) Schedule duration 5) Schedule urgency 6) Finance 7) Legal agreements 8) Contracting 9) Project implementation 10) Human factors	Case studies of 8 major projects
Moynihan (1997)	Risk Assessment by Experienced Project Managers	Survey of 14 project managers.
Pinto and Prescott (1988)	1) Conceptual Phase 2) Planning Phase 3) Execution Phase 4) Termination Phase 5) Project Definition	Questionnaire with 409 respondents among PMI members
Schmidt et al. (2001)	1) Corporate Environment 2) Sponsorship/ Ownership 3) Relationship Management 4) Project Management 5) Scope 6) Requirements 7) Funding 8) Scheduling 9) Development Process 10) Personnel 11) Staffing 12) Technology 13) External Dependencies 14) Planning	Three simultaneous Delphi surveys in three different countries.

Table 9: (Continued) Summary of literature on project management issues

Reference	Description of Classification	Basis
Shenhar et al. (2001)	1) Project Efficiency 2) Impact on the Customer 3) Business Success 4) Preparing for the Future	Evidence from literature and author's observations.
Wallace et al (2004)	1) Team 2) Organizational environment 3) Requirements 4) Planning and control 5) User 6) Complexity	Survey research with 507 software project managers
White and Fortune (2002)	Factors critical to project's outcome	Survey research with 236 respondents
Yeo (2002)	1) Process driven issues 2) Context driven issues 3) Content driven issues	Survey research with 92 respondents

Table 10: Issues faced during the project life cycle.

ORGANIZATIONAL ISSUES	
Customer	**Project Organization**
Customer commitment/support/involvement in the project and its deliverables	Definition of roles and responsibilities Commitment and participation of project team
Conflicts with and within the user organization	Conflict between team members
Communicating/consulting with the customer	Complexity of team structure
Technological competency of client	Structural Complexity of the project
Understanding the customer's organization and the effect of the project on it	Clear Communication Channels Legal guidelines, bureaucracy
Complexity of the user organization	Project organization structure
	Connections between the project and other systems/projects
Project Manager	Finding and retaining skilled staff for the project
Effective Leadership/Authority	
Effective Management style/Influence	**Strategic Level**
Project Manager's commitment to the project	Political/Economical/Environmental Issues
Project Manager's ability to communicate and coordinate	Changes in the parent organization
Project Manager's ability to delegate	Public support for the project
Project Manager's ability to listen, learn and adapt	Top Management Support/Project Champion
Project Manager's ability to deal with uncertainty	
Project Manager's social skills	
Project Manager's ability to make timely decisions	**Contractor/Vendor**
Project Manager's communication and relationship with the team members	Determining the type and time required for bidding Contract terms to protect the organization
Project Manager's ability to manage the project	Excessive dependence on vendors/consultants.
	Controlling and monitoring Contractor's work
Portfolio/Program	Inadequate contractor skills
Parent organization's commitment to the project deliverables	
Involvement and commitment of functional departments	
Underfunding of project	
Prioritizing projects in the portfolio	

Table 10: (Continued). Issues faced during the project life cycle.

PROJECT DELIVERY METHODS ISSUES	
Project experience/expertise of project personnel	Proper monitoring and control of the project
Ability to learn from past experiences	Accurate cost estimating
Risk assessment and analysis	Effective project planning
Project management skills of project personnel	Effective methodologies for project processes
Technological competency of project personnel	Effective development methodology
Proper change management	Effective usage of project management tools and techniques
	Quality Assurance, Safety and Security

PROJET PRODUCT ISSUES	
Technological competency of organization	Ability to understand the project and its effects
Final product require utilization multiple technologies	Freezing design effectively
Use of technology that the organization was not familiar with	

PROJECT GOAL ISSUES	
Managing customer requirements/expectations	Unclear / uncertain scope (scope creep)
Sufficient and appropriate resources	Clearly defined success criteria
Clear and realistic schedules	Aligning project goals with overall business strategy

There is strong evidence that some of the issues mentioned in Table 10 have deeper impact on the project success (White and Fortune, 2002; Schmidt et al.,2001; Bellasi and Tukel, 1996). These issues are:

- Customer commitment to the project and its deliverables
- Top management support to the project
- Experience/expertise of project personnel
- Involvement and commitment of functional departments
- Excessive dependence on vendors/consultants.

2.6 Project Management Styles

Management style can be defined as management's approach to influence, coordinate, and direct people's activities towards group objectives (Lu and Wang, 1997). Similarly Merz et al. describe management style as the strategic orientation that a manager uses as business philosophy that guides the firm through business environments (1994). These descriptions are parallel with the dictionary definition of the word “style”: A manner of executing a task or performing an action or operation (Oxford English Dictionary, 1989, vol. XVI, p.1009). All these descriptions are related to how managers execute the decisions, not how they receive and process information before making the decisions.

Rowe and Mason (1987) equates management style to decision style and defines it as the way managers perceive and comprehend stimuli and how they chose to respond. And finally, the definition of management style by Merz et al. (1994) as the strategic orientation or business philosophy, strengthens the assumption that the management style in an organization is basically the management paradigm that guides the managers of an organization in dealing with problematic situations.

In management literature, the discussion on management styles is mostly on how particular managers or leaders manage their subordinates. One of the best known works on management styles is the book, "The Human Side of Enterprise” by McGregor (1960) which classifies managers in two main groups based on the theories of individuals’ behavior at work. McGregor (1960) named the groups, “Theory X” and “Theory Y”:

- "Theory X" managers assume that the average employees have natural aversion for their work and dislike responsibility and will avoid working if they can. Thus, because of their dislike for work, most people must be controlled and threatened before they will work hard enough.
- "Theory Y" managers assume that the average employee learns not only to accept but to seek responsibility under proper conditions. Thus control and punishment are not the only ways to make people work, man will direct himself if he is committed to the aims of the organization.

Similar to McGregor's model, Likert (1961) identifies four main styles of leadership based on managers' decision-making and the level of involvement by the others in the decision making process:

- Exploitive authoritative: In this style, similar to McGregor's "Theory X" style managers (1960), the leaders, who have negative opinions on employees, use fear-based methods like threats to achieve conformance.
- Benevolent authoritative: The leaders add empathy to the people to their authoritative styles and use rewards to encourage higher performance.
- Consultative: Even though the leaders pay attention to ideas of others and encourage their participation, the decision making is still centralized.
- Participative: At this level, the leaders engage and encourage employees of the organization in decision-making by making them feel psychologically comfortable and responsible for the organizational goals.

While McGregor (1960) and Likert (1961) focus on the leadership styles, taking a wider perspective, Quinn et al. (1990) describe four dominant management styles for organizations and identify the main roles for a manager for each management style. These roles are innovator, broker, producer, director, coordinator, monitor, facilitator and mentor and within each style only two of these management roles are dominant. The four management models identified by Quinn et al. (1990) are:

- The Rational Goal Model concerns with profit and the bottom line. Tasks and objectives are made clear through planning and identifying goals. Instructions are given from a decisive authority. The main management roles for this model are producer, director.
- The Internal Process Model is hierarchical with stability and control preferred. Emphasis is on measurement with roles defined by rules to be followed. The main management roles for this model are coordinator, monitor.
- The Human Relations Model concerned with cohesion and morale in the work group. Information is shared and decision-making is participative. The team is lead by a process oriented leader comfortable with empathetic orientation. The main management roles for this model are monitor and facilitator.
- The Open Systems Model is an organic or flat system. It is adaptable and focused to external support. Innovation and creativity are commonplace and managers inspire staff, rather than control them. External legitimacy is maintained through political astuteness, persuasion and influence. The main management roles for this model are innovator and broker.

In this research, the focus is on the management styles that organization adopt while executing the projects, not the managerial styles that McGregor (1960) and Likert (1961) mention in their studies. Instead of classifying the project management styles in distinct groups of management models as Quinn et al.(1990), this research explores the underling effects of scientific paradigms in the project management. In the next section, the paradigms that dominated the physical and social sciences and their effects on the project management process is explored.

2.6.1 Paradigms and Paradigm Shifts

In the previous section, management styles were discussed and basically defined as the paradigms that organizations utilize to make decisions. Before proceeding further into the discussion for project management styles, it is pertinent in this section of the dissertation to discuss the paradigms and paradigm shifts in order to understand how project management styles are affected by the scientific paradigms.

The literature about paradigm changes and especially the shift to the complexity paradigm have one common reference, Thomas Kuhn's "The Structure of Scientific Revolutions" (Capra, 1996; Prigogine and Stengers, 1984; Gleick, 1987; Gell-Mann, 1994). Thus, in this research the concept of paradigm change in project management will be based on Thomas Kuhn's model (1962).

In The Structure of Scientific Revolutions, Thomas Kuhn (1962) described the evolution of science through shifts in paradigms, which he describes as "achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice" (p. 10). The Oxford English Dictionary (1989) gives the meaning of paradigm as "pattern, example", but in Kuhn's model," a paradigm is not an object for replication, rather it is an object for further articulation and specification under new or more stringent conditions like an accepted judicial decision in the common law" (p.23) (Kuhn, 1962).

Kuhn describes the characteristics of a paradigm as:

- "Sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity." (p. 10)
- "Sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve." (p. 10)

In Kuhn's model, in the development phase of any scientific discipline (pre-paradigm), there are different descriptions and interpretations for the same range of phenomena, but when an individual or a group develops a synthesis which is able to attract most of the practitioners, these divergences disappear eventually and give way to a dominant paradigm. Kuhn's model for paradigm shifts is given in Figure 10. According to Kuhn, normal science, which is dominated by a particular paradigm, mostly deals with solving puzzles that no one before has solved or solved satisfactorily. On the other hand, revolutionary science, which occurs rarely, requires shifting from one paradigm to another. But revolutions do not happen frequently. First, in normal science anomalies arise with regular frequency such that they can no longer be ignored. Then a crisis occurs when the anomaly becomes more than another puzzle for the normal science. Kuhn states that all crises in science end in one of three ways:

- The anomalies that caused the crisis are handled within normal science, even if some scientists considered it a paradigm-changing event.
- The problem resists even to the radically new solutions and then it is set aside for a future generation to solve.
- A new candidate for paradigm emerges and competes against the dominant paradigm for acceptance.

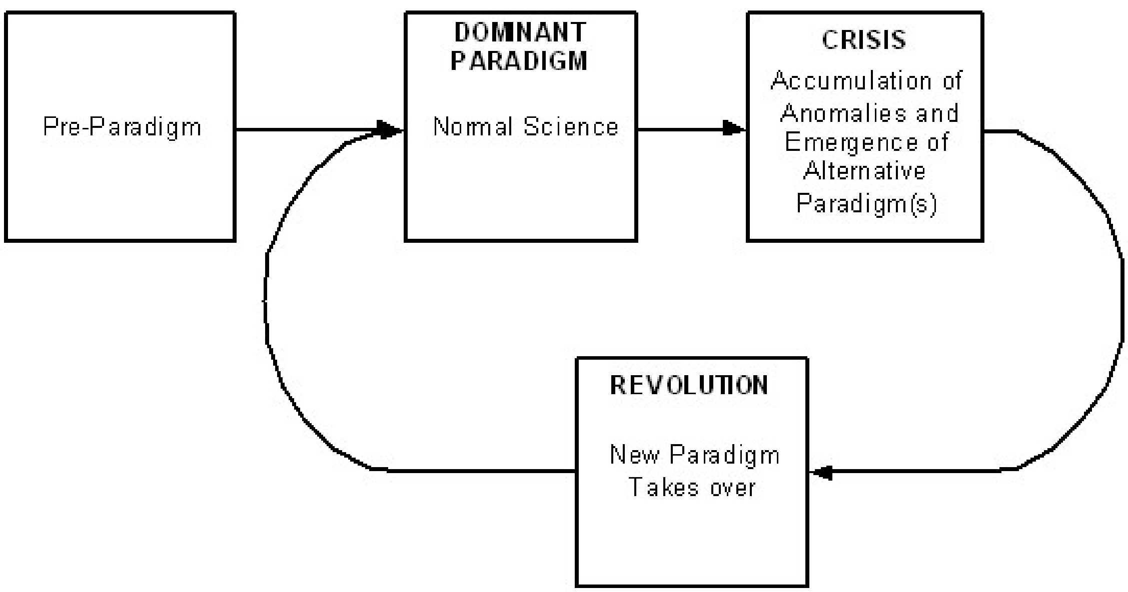


Figure 10: Kuhn's Model for paradigm shifts.

In Kuhn's model, the transition to a new paradigm is scientific revolution, which he describes as "non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one" (p. 92).

Skyttner (1996) provides a chronology of development of human knowledge and thinking in the history starting from ancient Greece, and summarizes the major paradigms as (Figure 11): 1) The Scholastic (Pre-scientific) Paradigm: (Ancient Greece – till Renaissance): During this period nature was viewed as an organism created by God, and the natural forces were beyond human control. Mysticism wins over reason. Life was considered to be only a passage to heaven. Universe was of static nature. The connection with reality was unformulated, imprecise, implicit and indeterminate. Observation and experimentation, were considered to be irrelevant or offensive

2) Renaissance paradigm (16th century – 18th century): According to this paradigm, science is capable of describing phenomena and becomes a source for development of new technologies. Increased knowledge in astronomy enabled humans to see the universe was larger than the universe described by the Church dogma. This gave way to the separation of religion and science. Science became independent and neutral, and concepts such as impartiality and objectivity became the symbols of this paradigm, enabling science to become the primary influence in modern civilization.

3) Newtonian Paradigm (18th century): This period was dominated by Isaac Newton's mechanistic universe, in which known positions and velocities for a planet in the solar systems at any given time are sufficient to determine its position and velocities for all future time. Newton's laws are directly related to the doctrine of determinism, which implies the orderly flow of cause and effect in a static universe and the scientific worldview. Rationalism and empiricism replaced tradition and speculation. The conception was that the reality was determined, exact,

formulated, and explicit and that it was possible to control the forces of nature. It was believed that there was cause to every effect and there was a reaction to every action

4) Complexity Paradigm (early 20th century to present): Early 20th century witnessed major breakthroughs in physics in Einstein's Relativity Theory and Planck's Quantum Theory. The 1950s witnessed the rise of system thinking, which emerged as a response to the failure of mechanistic thinking in the attempt to explain social and biological phenomena. The underlying principle of systems thinking is that the whole is more than the sum of its parts. During the later part of the 20th century, the disciplines of chaos theory and complex adaptive systems emerged from the scientific domains of physics, mathematics, chemistry and biology.

The Newtonian and the complexity paradigms, which dominated the scientific world of the 20th century, are discussed in more detail in the next sections.

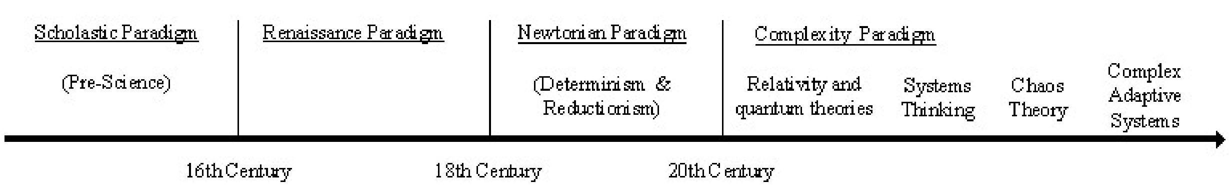


Figure 11: Timeline for scientific paradigms (Skyttner, 1996).

2.6.2 Main Scientific Paradigms Affecting the Project Management Styles

According to Kuhn (1962), the scientific paradigms provide models, organize and guide mental processes in solving problematic situations. Like any other social or physical science discipline, project management is directly influenced by the scientific paradigms. In this section, the dominant and emerging paradigms and their implications on the project management discipline will be explored.

2.6.2.1 The Newtonian Paradigm

The dominant paradigm in social and natural sciences for the last couple of hundred years has been the mechanistic/reductionistic view based on the teachings of Newton and Descartes (Wheatley, 1999). The Newtonian paradigm views the universe and everything in it as a machine. This mechanistic view leads to the belief that studying the parts of the machine is essential in understanding the whole (Brown and Eisenhardt, 1998). Some of the key points of the Newtonian paradigm are as follows (Ottosson, 2003, Dooley et al, 1995):

- Equilibrium and control are core beliefs in the Newtonian paradigm, where equilibrium is considered as the natural state of a system. (Dooley et. al 1995). And in order to keep the system at or close to equilibrium state, control mechanisms like feedback are needed (Wheatley, 1999).
- The Newtonian paradigm treats systems as closed systems, which are not connected to or do not have any exchanges with their environments. These systems are linear, one best solution exists and it is a matter of planning and using the right tools to find the best solution.

- The reductionistic view is that the whole system can be broken down into pieces that can be studied separately and reassembled afterwards to form the initial totality (i.e. fragmentation, reduction, and isolation). The whole equals the sum of its pieces.
- Newtonian systems are deterministic, lawful and reversible (Prigogine and Stengers, 1984). Any future state of a system (trajectory) can be derived from knowing the forces that are acting on the system and the system's initial condition.

2.6.2.2 Complexity Paradigm

The Newtonian paradigm has been immensely successful in the development in human society over the past three centuries. But as the world becomes a more complex, interconnected and highly volatile space, the reductionist Newtonian paradigm fails to understand the whole system for it cannot help focus on the parts of the system.

The need for a new paradigm emerged when the number of variables affecting the outcome is huge and the relationships between these variables make it impossible to come up with simplified formulas to predict natural or social systems (Levy, 2000).

Even though there is not a single well accepted complexity theory, main topics of complexity paradigm can be identified as the nonlinear dynamic systems, the chaos theory and the complex adaptive systems. Each of these topics is an area of research by themselves but, in order to understand the applicability of complexity paradigm to project organizations, they have to be studied together.

a) Nonlinear Dynamic Systems: The starting point of the complexity paradigm is the study of the nonlinear dynamical systems (Goldstein, 1994). The nonlinear dynamic systems are systems that constantly change, but there is no linear relationship between the changes in inputs and the changes in the output thus outcomes are unpredictable (Lewin, 1992). Being complex, open and ever changing, organizational systems have the characteristics of the nonlinear dynamic systems (Millett, 1998).

One of the most important concepts in dynamic systems is finding and characterizing the feedback processes. Most complex behaviors usually stem from the interactions (feedbacks) between the constituents of the systems (Sterman, 2000). There are two kinds of feedback processes: self-correcting (or negative) and self-reinforcing (or positive) feedback. Negative feedback opposes change, and tries to hold the system at the original situation, where as positive feedback reinforces or amplifies any change in the system (Sterman, 2000). The Newtonian systems use only negative feedback to create order but nonlinear dynamic systems use both negative feedback (control) and positive feedback (change).

b) The Chaos Theory: The second building block of complexity paradigm is the chaos theory. The chaos theory is based on the nonlinear dynamical systems. Kellert (1993) defines chaos theory as the qualitative study of unstable periodic behavior in the deterministic nonlinear dynamical systems. Some of the main characteristics of systems according to the chaos theory are (Levy, 1994, Dooley et al., 1995):

- Chaotic system behaviors are highly sensitive to initial conditions and can exhibit unpredictability over time.

- Long-term planning is very difficult.
- Chaotic systems do not reach a stable equilibrium. Systems that are pushed far-from-equilibrium (at the edge of chaos) can self-organize into new structures.
- Dramatic change can occur unexpectedly.
- Short-term forecasts and predictions of patterns can be made.

c) The Complex Adaptive Systems: Stacey (1996) defines a complex adaptive system as one whose components, or agents, interact with each other according to set of rules called schemas in order to improve their behavior and thus the behavior of the system which they belong to. Organizational complex adaptive systems are learning organizations where the organizations get information and resources from the environment in order to survive (Dooley et.al, 1995). Pascale (1999) outlines four basic principles for complex adaptive systems:

- For complex adaptive systems, stable equilibrium is a sign of death. For this reason, a system may adapt to such a far-from-equilibrium state. The systems, which place themselves "at the edge of chaos", are the most adaptive and creative (Dooley et.al, 1995).
- Complex adaptive systems exhibit the capacity of self-organization where random and independent behavior would settle into patterns without any governing mechanisms.
- Complex adaptive systems tend to move toward the edge of chaos when provoked by a complex task.
- Complex adaptive systems are characterized by weak cause-and-effect linkages. So a complex adaptive system can not be directed but can be disturbed.

2.6.3 Comparison of the Newtonian and the complexity project management styles

In this dissertation the effects of the Newtonian and the complexity paradigms on project management style are investigated by looking at the approach that project management takes during the project plan-do-study-act (PDSA) cycle.

2.6.3.1 "Plan" Phase of PDSA cycle

Newtonian Style: Newtonian project management gives the greatest emphasis on project planning (Koskela and Howell, 2002). According to Herroelen and Leus (2003) the majority of the project planning tools assume complete information about the scheduling problem to be solved and a static deterministic environment within which the pre-computed baseline schedule will be executed. According to Bardyn and Fitzgerald (1999), the Newtonian paradigm's appeal to project managers is its assumption that the world is an orderly place and just by using better tools and better resources the "chaos" or disorderly feedback can be eliminated. The theory of classical project management is based on the transformation theory (or view) of production where, the total transformation is decomposed hierarchically into smaller transformations, tasks, and minimizing the cost of each task independently (Koskela and Howell, 2002). This view is directly parallel with the reductionist view of the Newtonian paradigm. In contemporary project management practice, the work breakdown structures, which are graphical representations of the project deliverables broken down hierarchically, embody reductionist principles (Milosevic, 2003, Singh and Singh, 2002). Also, the Newtonian project style considers the projects to be closed systems, where any exchange of information and resources with other projects is out of question.

Complexity style: The most important principle of the complexity style project management is the sensitivity to the initial conditions, according to which, even the slight changes in initial conditions can cause huge disruptions in the outcomes. (Levy, 1994, Dooley et al., 1995, Bardyn and Fitzgerald, 1999). The consequences of the sensitivity to initial conditions on project management style are:

- The complexity style assumes that at their initiations, projects are chaotic systems, where the whole determinants of the project can not be comprehended (Bardyn and Fitzgerald, 1999, Schawaber and Beedle, 2002). Instead of developing full scale designs, a project starts with an initial basic design and plan, and these initial conditions are modified through iterations as the project progresses
- It is impossible to make long term predictions due to the sensitivity to the initial conditions, for even the slightest changes in the initial conditions will result in large changes in outcomes as the project progresses. Thus, the complexity paradigm rejects the idea of long-term planning but short-term planning is possible due to the emergent nature of the chaotic environments (Bardyn and Fitzgerald, 1999, Schawaber and Beedle, 2002, Levy, 1994, Dooley et al., 1995). Thus, project plans should be prepared for short periods and revised throughout the life of the project.
- Another approach to mitigate the effects of the changes to the initial conditions is to set up continuous communications with the customers and involving customers in the project planning process during the projects life (Bardyn and Fitzgerald, 1999, Schawaber and Beedle, 2002).

Comparison of the Newtonian and the complexity project management styles during "Plan" phase of PDSA cycle is given in Table 11.

Table 11: Comparison of the Newtonian and the complexity project management styles during "Plan" phase of PDSA cycle.

Newtonian Paradigm	Complexity Paradigm	References
A detailed final solution is designed and never modified during the project's life.	Instead of a detailed final solution, a simple basic solution is designed and later modified during the project's life.	(Bardyn and Fitzgerald, 1999, Schawaber and Beedle, 2002)
The customer is not involved in the decision making process.	The customer is involved in the decision making process from start of the project.	(Bardyn and Fitzgerald, 1999, Schawaber and Beedle, 2002)
Once completed, project plans are not revised.	Project plans is revised periodically in short intervals.	(Levy, 1994, Dooley et al., 1995, Schawaber and Beedle, 2002)

2.6.3.2 "Do" Phase of PDSA cycle

Newtonian Style: In classical project management, project execution involves assigning tasks to project team members (Koskela and Howell, 2002). The Newtonian project management assumes that when tasks are assigned to project team, the information and resources are complete and ready and the project team fully understands, starts and completes the task according to the plan once authorized (Koskela and Howell, 2002). "Do" phase starts with finding the team members for the roles determined by the planning process (Project Management Institute, 2000), the roles and performances for these roles are assumed to be standard.

Complexity Style: While the main mode of execution in the Newtonian project style is directing, assigning tasks to team members (Koskela and Howell 2002), the complexity project style rejects the idea of directing, for a complex system cannot be directed but rather disturbed or adjusted (Pascale, 1999). Directing role of the project manager becomes the role of a coordinator and manipulator of the team members, who participate in the planning and execution processes and decision making. Execution is also connected with the monitoring and control process where the projects variables are continuously monitored. Project managers use this information to detect the trends that might oscillate widely (positive feedback).

Comparison of the Newtonian and the complexity project management styles during "Do" phase of PDSA cycle is given in Table 12.

Table 12: Comparison of the Newtonian and the complexity project management styles during "Do" phase of PDSA cycle.

Newtonian Paradigm	**Complexity Paradigm**	**References**
Project manager decide which tasks the team members will complete.	In interaction with project manager, team members decide which tasks they will complete.	(Koskela and Howell, 2002, Schawaber and Beedle, 2002)
Project management contacts team members to ask the status of the tasks assigned to team members.	Team members continuously report the status of their tasks to team leader or the project manager.	(Koskela and Howell, 2002, Schawaber and Beedle, 2002)
The main role of the project manager is to direct the team members and make sure that their tasks are completed.	Instead of directing the team members, the main role of the project manager is to work with the customer, management of the organization and the project team in order to remove any obstacles to the progress of the project.	(Koskela and Howell, 2002, Schawaber and Beedle, 2002)

2.6.3.3 "Study" Phase of PDSA cycle

Newtonian Style: The Classical (Newtonian) project control process is based upon the mechanistic thermostat model (Koskela and Howell, 2002), where the system reacts to variations from the equilibrium (baseline) and works to bring it back to the equilibrium. The main objective of "study" phase for the Newtonian style projects is to monitor for variations from the baseline set by the project plan. Control theory only takes the negative feedbacks into account and a system acts like a thermostat (Koskela and Howel 2002). In the Newtonian projects, the project team only monitors a limited number of variables (usually the cost and schedule) in intervals rather than continuously and this information is usually incomplete and out-of-date (Singh and Singh, 1999).

Complexity Style: In dynamic systems, the project management process monitors the system to detect positive feedbacks as well as negative feedbacks. While in the Newtonian systems, the "study" phase of the project management cycle is based on the mechanistic thermostat control model and only tries to detect the negative feedback processes, in the complexity paradigm systems, in addition to negative feedback processes, positive feedback processes also have impacts (Koskela and Howel 2002). Positive feedback reinforces or amplifies any change in the system (Sterman, 2000). In order to detect positive feedback cycles and protect the project from possible harmful effects, the project team should continuously monitor and gather information about the project and inform the project management in time using the available communication channels (Bardyn and Fitzgerald, 1999, Schawaber and Beedle, 2002). Monitoring is a continuous process and requires timely information sharing and communications.

Comparison of the Newtonian and the complexity project management styles during "Study" phase of PDSA cycle is given in Table 13.

Table 13: Comparison of the Newtonian and the complexity project management styles during "Study" phase of PDSA cycle.

Newtonian Paradigm	Complexity Paradigm	References
Project management gathers information about the limited number of project variables periodically.	Project management received just-in-time information about the progress of the project.	(Bardyn and Fitzgerald, 1999, Koskela and Howel 2002, Schawaber and Beedle, 2002)
Project team members do not investigate the causes for non-realization of their assigned tasks.	Project team members investigate and report the causes for non-realization of their assigned tasks.	(Bardyn and Fitzgerald, 1999)
The project team does not share information about the progress of the project to the management of the organization and the customer unless requested.	The project team regularly presents the progress of the project to the management of the organization and the customer.	(Schawaber and Beedle, 2002)

2.6.3.4 "Act" Phase of PDSA cycle

Newtonian Style: During the "act" phase, organizations take action using the information gained during the study phase. In Newtonian systems, this action is based upon the mechanistic thermostat control model, where the system reacts to variations from the equilibrium (baseline) and works to bring it back to the equilibrium (Koskela and Howell, 2002). Mechanistic control theory only takes the negative feedbacks into account and the main purpose for systems is to remain unchanged (Koskela and Howel 2002), thus neither plans nor the organization are modified, the project management utilizes extra resources to bring the project back to its planned condition. Also being a closed system, the Newtonian projects do not exchange information with other projects and lessons learned during the project are not kept to be used in future projects.

Complexity Style: While in Newtonian systems, the "act" phase of the project management cycle is based upon the mechanistic thermostat control model which aims to keep the project unchanged (Koskela and Howel 2002), the complexity style assumes projects are learning organizations and learning and adaptation to the changing conditions is essential for the success of the project (Dooley et.al, 1995, Harkema, 2003). The project team is responsible to gather, document and share the lessons learned within the organization. Also the lessons learned and information gathered during the "study" phase help the project team to revise project plans and to change the structure and the roles of the project team in order to adapt to the changing project conditions (Schwaber and Beedle, 2002).

Comparison of the Newtonian and the complexity project management styles during "Act" phase of PDSA cycle is given in Table 14.

Table 14: Comparison of the Newtonian and the complexity project management styles during "Act" phase of PDSA cycle.

Newtonian Paradigm	Complexity Paradigm	References
Lessons learned during the project do not affect the project plans, deviations from the plans are corrected using additional resources.	Project plans were revised regularly using the lessons learned during the project.	Schwaber and Beedle, (2002)
The structure and the roles of the project team do not change through out the project.	The structure and the roles of the project team changes to adapt to the changing project conditions.	Schwaber and Beedle, (2002)
The lessons learned during the project are not kept, documented or shared within the organization.	The lessons learned during the project are kept, documented and shared within the organization.	Dooley et al.(2002), Harkema (2003)

2.7 Alignment between organizational complexity and project management style

Kotnour et al. (1998) define organizational alignment as “the organization doing the right thing, the right way with the right people at the right time (p.19)”. After stating its importance for effective organizational performance, Sabherwal et al.(2001) gives a more specific definition of alignment as the extent to which two or more organizational dimensions meet theoretical norms of mutual consistency . Thus, organizational alignment by definition is to adjust two or more organizational dimensions relative to each other, such that these two dimensions will work in unison and perform flawlessly as a group.

Kotnour et al. (1998) classifies organizational alignment into two groups: external and internal. External alignment is matching the products and services of the organizations to the market and costumer needs (Kotnour et al., 1998). In order to align itself externally, an organization should define its goals, core values and core processes. These definitions will be the basis for the organization to align itself internally (Kotnour et al., 1998).

Some of the common themes of alignment, covered in organizational management literature are: Business Strategy vs. IT Strategy/Processes (e.g. Grant, 2004, Peak and Guynes, 2003, Luftman, 2003), Business Strategy vs. Organizational Processes (e.g. Maheshkumar et al. 2003, Ravi and Porth, 2003, McAdam and Bailie, 2002).

Venkatraman (1989) provides an overview of various types of fit or alignment and methods and assumptions to analyze them. For alignment of two independent dimensions or variables, Venkatraman (1989) suggests two types of alignment, they are: (a) matching, (b) moderation:

a) Matching: Alignment is conceptualized as a match between two independent variables. According to this perspective, the alignment exists when the independent variables match. Then the effects of this match on the dependent variable are tested. The matching perspective can be analyzed using three different methods: deviation score analysis, residual analysis and analysis of variance.

b) Moderation: Alignment as moderation can be conceptualized as the interaction between two variables. “According to the moderation perspective, the impact that a predictor variable has on a criterion variable is dependent on the level of a third variable, termed here as a moderator. The fit between the predictor and the moderator is the primary determinant of the criterion variable” (Venkatraman, 1989, p.424).

In this dissertation, the alignment between the project management style and the project complexity is investigated. In the conceptual model shown in Figure 1 (see Chapter 1), the alignment is conceptualized as the matching between the values of two independent variables, project management style and the project complexity. Thus, in this dissertation, the alignment will be analyzed using the “matching” perspective (Venkatraman, 1989).

2.8 Hypothesis Development

The researcher needs to develop hypotheses in order to refine the research even further. A hypothesis can be defined as a general question or statement that suggests a possible (and therefore testable) relationship between two or more things (Babbie, 1998). A hypothesis provides both a focus for research and a clearly-defined objective for the data collection step (the researcher is going to collect data that will test the hypothesis). Once a hypothesis has been developed, the researcher can move onto the next step in the process - the collection of data to test the hypothesis. Figure 12 shows the conceptual model with the main hypotheses of this research.

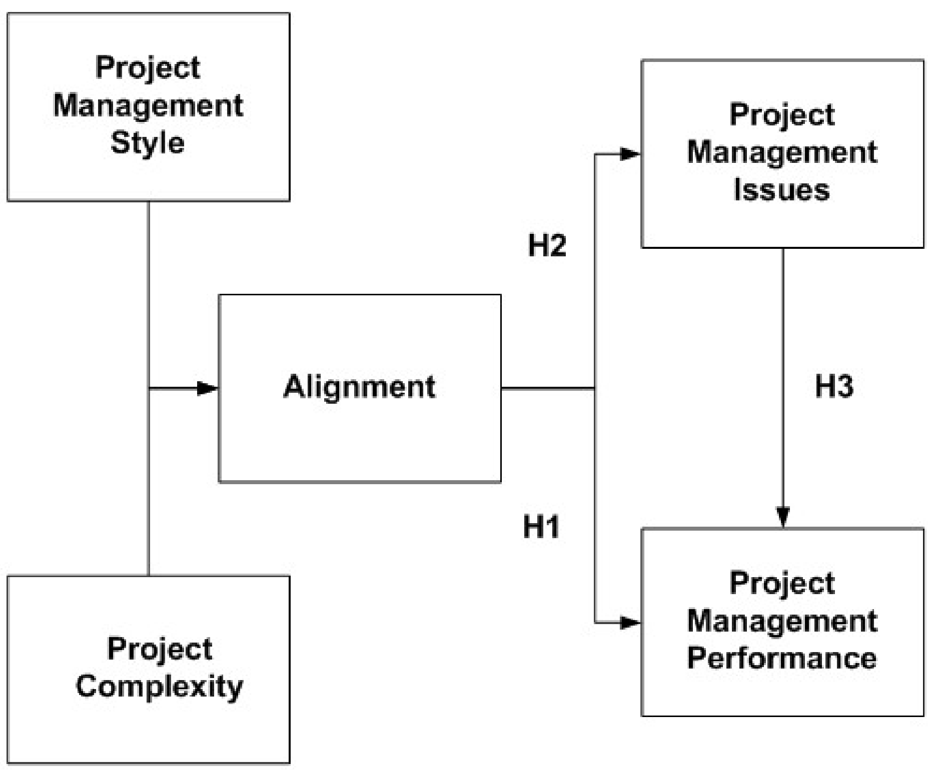


Figure 12: Conceptual model with main hypotheses.

The three main research hypotheses of this dissertation are:

H1: Alignment of project management styles to project complexity leads to increased project performance.

H1A: Newtonian project management style in a low complexity project leads to increased project performance.

H1B: Complexity project management style in a high complexity project leads to increased project performance.

H2: Alignment of project management styles to project complexity leads to a decrease in project management issues.

H2a: Newtonian project management style in a low complexity project leads to a decrease in project management issues.

H2b: Complexity project management style in a high complexity project leads to a decrease in project management issues.

H3: Increase in project management issues leads to decreased project performance.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, details of the research methodology used in this study are presented. A wider look at the concept of research and research methodologies is presented in Appendix A. The selection criteria for the research design are investigated with respect to the objectives of the research. The main research constructs and their factors are defined and operationalized. The processes to test the validity and the reliability of the survey instrument, which is the main component of the investigation developed to measure the constructs, are discussed. Finally, this chapter describes the statistical processes to test the research hypotheses.

As given in the conceptual model in Figure 1 (see Chapter 1), this research aims to investigate the effects of alignment between the project management style and project complexity on the issues a project organization faces and on the project performance. The research approach for this dissertation is the Hypothetico-deductive approach. The Hypothetico-deductive approach is based on one or more hypothetical assumptions that would form a theory to provide an explanation for a phenomenon (Popper, 1959, Lawson, 2000, Babbie, 1998). Figure 13 outlines the main research steps in the Hypothtico- deductive method. The first three steps, understanding the phenomena, idea generation and hypothesis development are among the topics of the previous two chapters. This chapter begins the conceptualization step.

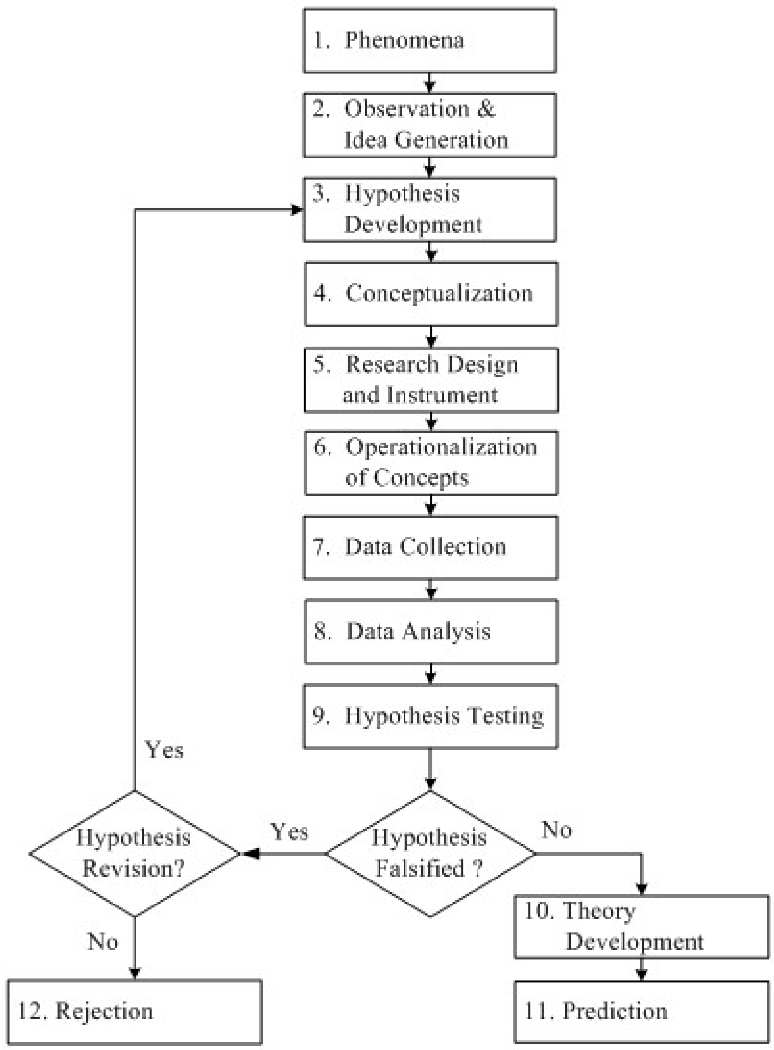


Figure 13: The Hypothetico-deductive research approach (Popper, 1962, Lawson, 2000, Babbie, 1998).

3.2 Conceptualization

The conceptual model describing this research is given in Figure 1 in Chapter 1 and the main constructs of this conceptual model are described in the following subsections:

3.2.1 Conceptualization of Project Complexity

The project complexity construct is conceptualized as a relative (depending on the respondents experience) composite measure, which considers the degree of impact of four main complexities (organizational, product, methods and goal) associated with a project. Table 15 presents project complexity as a continuum with characteristics of low and high product complexity relative to a typical project in the project organization.

- Organizational complexity of a project is the inadequacy of knowledge needed to make a decision due to size of the organization and its constituent parts, their diversity and relationships (adapted from Fioretti and Visser, 2004). Organizational complexity of a project is conceptualized as a perceived characteristic by a project manager relative to the other projects that this particular project manager completed. The determinants of the organizational complexity are the size of the project (in terms of personnel, schedule and budget), its relationships with other organizations and documentation that the organization needed during the project's life. Since the organizational complexity is a relative characteristic, the measures of organizational complexity for similar projects can differ for different project managers with different project experiences.
- Product complexity of a project is the inadequacy of knowledge needed to make a decision due to the characteristics of the final product of the project. Product complexity of a project is conceptualized as a perceived characteristic by a project manager relative

to the other projects that this particular project manager completed. The determinants of the product complexity are the newness of the product, number of modules and the impact of changes in the product technologies. Since the product complexity is a relative characteristic, the measures of complexity for similar products can differ for different project managers with different project experiences.

- Methods complexity of a project is the inadequacy of knowledge needed to make a decision due to characteristics of the methods needed to produce the final product. Methods complexity of a project is conceptualized as a perceived characteristic by a project manager relative to the other projects that this particular project manager completed. The determinants of the methods complexity are the newness and the diversity of the production technologies and the impacts of changes in production methods on other production methods and the final product design. Since the methods complexity is a relative characteristic, the measures of methods complexity for similar projects can differ for different project managers with different project experiences.
- Goal complexity of a project is the inadequacy of knowledge needed to make a decision due to characteristics of the requirements and goals of the project. Goal complexity of a project is conceptualized as a perceived characteristic by a project manager relative to the other projects that this particular project manager completed. The determinants of the goal complexity are the number of requirement changes, impacts of the changes in a requirement on other requirements and impacts of the failure to achieve project goals on the organization. Since the goal complexity is a relative characteristic, the measures of goal complexity for similar projects can differ for different project managers with different project experiences.

Table 15: Project complexity continuum.

	LOW ⟵	⟶ HIGH
Organizational Complexity	• Very small project size • Very few of or no vendors/contractors involved in the project • Very few or no departments involved in the project • Very few or no projects are dependent on this project	• Very large project size • Very high number of vendors/contractors involved in the project • Very high number departments involved in the project • Very high number of projects are dependent on this project
Product Complexity	• No novelty or improvement in the technology in the product • Very few or single product subassemblies. • Very low or no impact of a design change of one sub assembly on another sub assembly	• Very high number of novelties or improvements in the technology in the product • Very high number of product subassemblies. • Very high impact of a design change of one sub assembly on another sub assembly
Methods Complexity	• No novelty or improvement in the process technologies • Very few or single production processes. • Very low or no impact of a change in production process on other production processes.	• Very high number of novelties or improvements in the process technologies • Very high number of production processes. • Very high impact of a change in production process on other production processes.
Goal Complexity	• Very few or no requirement changes. • Very low or no impact of a change in one requirement on the other requirements. • Very low or no impact of not realizing the goals of the project on the organization.	• Very high number of requirement changes • Very high impact of a change in one requirement on the other requirements. • Very high impact of not realizing the goals of the project on the organization.

3.2.2 Conceptualization of Project Management Style

Project Management Style is conceptualized as approaches to management of different phases of the project management. The phases of project management are characterized by the plan-do-study-act (PDSA) cycle (Kotnour, 1999). In this dissertation, management styles of each phase of plan-do-study cycle are conceptualized as a continuum with the Newtonian paradigm and the complexity paradigm at its extremes (Figure 14 and Table 16).

- “Plan” Style includes the approaches for initiation and planning processes which involve decisions to authorize a project or a project stage (initiation) and to define the objectives and to plan the course of action required to attain the project objectives and scope (planning).
- “Do” Style includes the approaches to executing processes when project management integrates people and other resources to carry out the project management plan.
- “Study” Style includes the approaches to monitoring portion of the monitoring and controlling process group when project management measures and monitors progress of the project to identify variances from the project management plan.
- “Act” Style includes the approaches to the controlling portion of the monitoring and controlling process group and the closure process group when the lessons learned through the study cycle are incorporated to the project plan or saved for future projects.

Figure 14: Conceptualization of project management styles on a continuum.

Table 16: Project management style continuum for PDSA cycle phases.

	Newtonian Style	Complexity Style
"Plan Phase	• A detailed final solution. • The customer is not involved. • Project plans are not revised.	• A simple basic solution to be modified during the project's life. • The customer is involved. • Project plans is revised periodically.
"Do" Phase	• Project manager decides which tasks the team members will complete. • Project management checks the status of the tasks assigned to team members. • The main role of the project manager is to direct the team members and make sure that their tasks are completed.	• Team members decide which tasks they will complete. • Project management continuously receives reports from the team members about the status of their tasks. • The main role of the project manager is to work with stakeholders to remove any obstacles to the progress of the project.
"Study" Phase	• Project management gathers information about the limited number of project variables periodically. • Project team members do not investigate the causes for non-realization of their assigned tasks. • The project team does not share information about the progress of the project.	• Project management receives just-in-time information about the progress of the project. • Project team members investigate and report the causes for non-realization of their assigned tasks. • The project team regularly presents the progress of the project.
"Act" Phase	• Lessons learned during the project do not affect the project plans. • The structure and the roles of the project team do not change through out the project. • The lessons learned during the project are not kept, documented or shared within the organization.	• The lessons learned during the project are used in revising the project plans. • The structure and the roles of the project team changes to adapt to the changing project conditions. • The lessons learned during the project are kept, documented and shared within the organization.

3.2.3 Conceptualization of Alignment

In this dissertation, alignment is conceptualized as the extent to which project complexity and project management style dimensions meet theoretical norms of mutual consistency (Sabherwal et al., 2001). The alignment will be determined as a function of two independent variables, project complexity and project management style using the "alignment as matching" perspective. According to this perspective, the level of alignment depends on the match between the project complexity values and the project management style values. For example, when both the project complexity and the project management style values are the same (high-high or low-low) the alignment is high. On the other hand, when there is a difference between these two values, the alignment value decreases.

3.2.4 Conceptualization of Project Management Issues

The project management issues are defined as obstacles that arise during the project and factors lack of which threaten to disrupt the project progress (Glass, 1998). A thorough literature search yields a high number of issues that affects the project management process. More detailed empirical research concludes that there are only a handful of project issues that significantly affect the project outcomes (White and Fortune, 2002; Schmidt et al.,2001; Bellasi and Tukel, 1996). These issues are:

- Customer commitment to the project and its deliverables
- Top management support to the project
- Experience/expertise of project personnel
- Involvement and commitment of functional departments
- Excessive dependence on vendors/consultants

3.2.5 Conceptualization of Project Performance

The two measures of project performance are conceptualized (adapted from Tatikonda, 1999). The first one is the composite achievement of project objectives measure, which considers the degree of achievement of each of the three main project objectives:

- Completion within budget (cost performance)
- Completion within schedule (time performance)
- Conformity to customer requirements and specifications (technical performance).

The second measure addresses satisfaction of the project's main stakeholders:

- Senior management
- Project management
- Customers

3.3 Research Design and Instrument

After conceptualization of the research and determining the conceptual definitions, the next step is to decide how to operationalize the concepts into something that can be defined and measured (Babbie, 1998). Research design and research instruments help the researcher to transform the concepts which are abstract ideas into measurable entities.

3.3.1 Research Design

In determining the research design, the taxonomy outlined by Gliner and Morgan (2000) will be used as a guideline in this dissertation (Figure 15). According to Gliner and Morgan (2000), the general purpose of all research studies, except those that are purely descriptive, is to look for the relationships between variables. Since this dissertation also deals with the relationships between variables, the descriptive approach is not pertinent for this dissertation.

At the next step, the decision criteria involve the type of independent variables used in the research. According to Gliner and Morgan (2000) if the research has an active independent variable (variable controlled by the researcher), then the researcher can utilize the experimental research methods, but when the independent variable can not be controlled (attribute independent variable), non-experimental research methods are more appropriate.

The independent variables in this research are the project management style of an organization and the project complexity, both of which are attribute independent variables. Thus, the research methodology used in this research will be non-experimental.

As seen in Figure 15, the non-experimental quantitative research methods are classified into two major categories: comparative and associational (Gliner and Morgan 2000). While the comparative research designs compare the group characteristics, the associational research designs attempt to determine how two (or more) variables are related. In the associational research approach, the independent variables are usually continuous or have several ordered categories (Gliner and Morgan 2000).

The goal of this research is to determine the relationships between two attribute independent variables and two dependent variables, thus the design of choice will be associational. Associational designs use regression and correlation analyses for testing the research hypotheses (Gliner and Morgan , 2000).

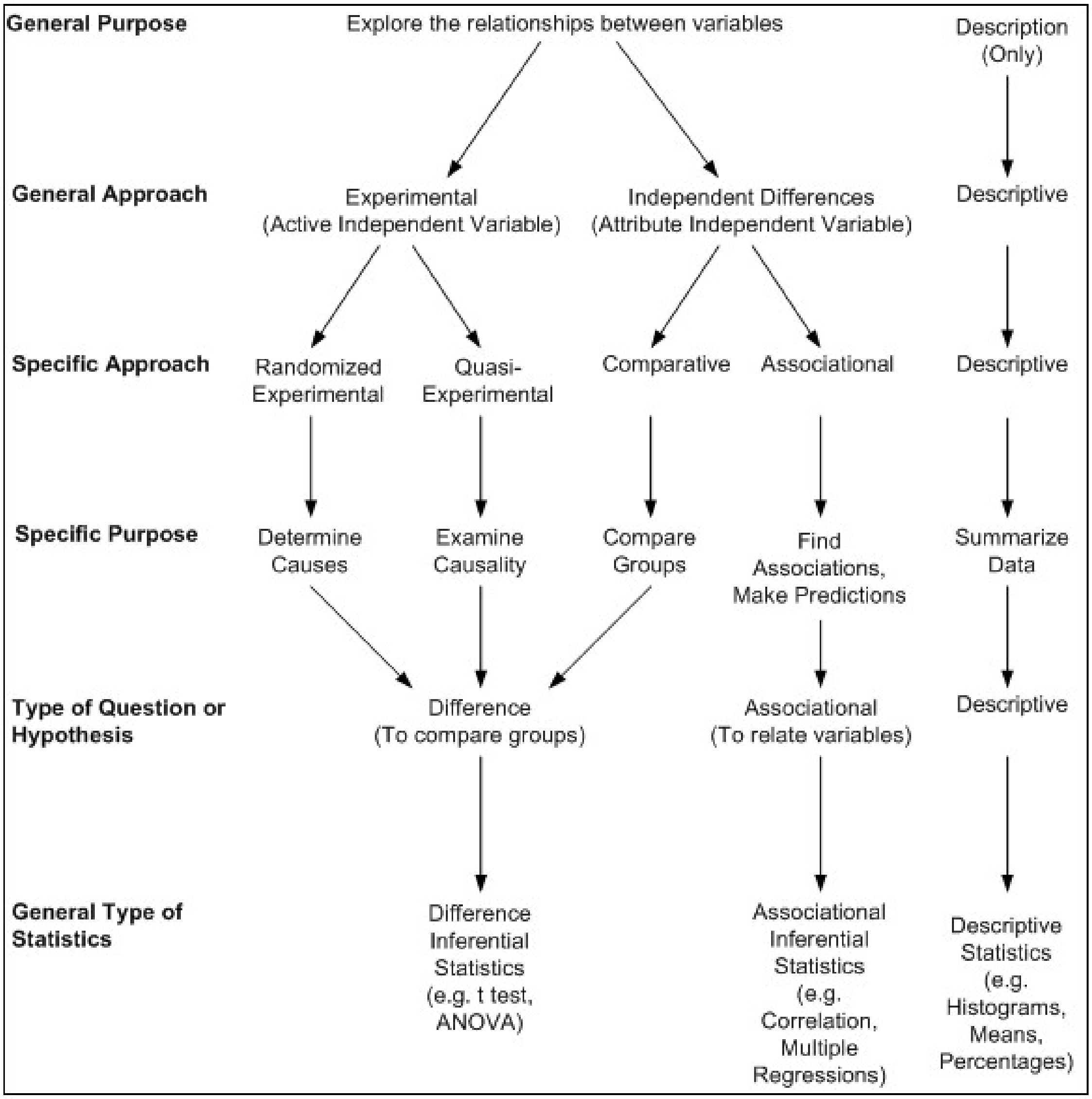


Figure 15: The taxonomy to choose the research approach (Gliner and Morgan , 2000).

3.3.2 Research Instrument

There are many types of techniques and instruments used to collect data. Gliner and Morgan (2000) conceptualize the research approaches and designs as being approximately orthogonal to the data collection techniques, and thus theoretically any type of data collection technique could be used with any research approach and design. Table 17 summarizes the commonly used the data collection techniques within quantitative and qualitative research approaches (adapted from Gliner and Morgan , 2000).

Table 17: Data collection techniques used within quantitative and qualitative research approaches (adapted from Gliner and Morgan , 2000).

	Research Approach		
	Quantitative Research		**Qualitative Research**
Data Collection Techniques	**Experiments & Quasi-Experiments**	**Comparative, Associational, & Descriptive Approaches**	
Researcher report measures			
Structured observations	++	++	+
Narrative analysis	–	+	++
Participant observations	–	+	++
Self-report measures			
Questionnaires	+	++	+
Interviews	+	++	++
Focus groups	–	+	++
Other measures			
Archival measures or documents	–	+	++
Content analysis	–	+	++

++ Quite likely
+ Possibly
– Not likely

Using Table 17 (Gliner and Morgan, 2000) as the reference, we can see that two competing research designs for a quantitative study like this dissertation are structured observation and survey methods. Considering the disadvantages of the structured observation (only applied to the small sample size, and low validity and reliability) (Gliner and Morgan, 2000), survey research design is the obvious choice for this dissertation.

3.3.3 Survey Development Process

Survey development process begins with the output from the literature review. The results of the literature review form the backbone of the survey instrument. During the survey development process the main purposes are to determine:

- Face validity, which is the criterion of whether the concept measures what it is intended to measure (Gliner and Morgan, 2000). Face validity is subjective, thus it is mainly based on the researcher's research and peer reviews of the instrument.
- Content validity, which is also subjective, is concerned with how adequately an instrument represents all of the characteristics of a concept that it is attempting to measure (Singelton et al., 1993). One way to increase content validity is to use research instruments validated during previous research studies. Another way to increase content validity is to solicit feedback from experts (experienced project manager in this case) on the survey instrument. For this purpose, a pilot test which involves trying out procedures or fine-tuning a questionnaire with a few knowledgeable persons in the field (Gliner and Morgan, 2000) will be conducted.

3.4 Operatialization of Concepts

After conceptualization of the research and determining the conceptual definitions, the next step is the operationalization of concepts, which is the transformation of a general, abstract idea into something that can be defined and measured using the research design and data collection methods (Babbie, 1998). The operationalization describes a set of procedures that create a measure of a phenomenon, thus the operationalization of concepts involves the determination of how the researcher will transform conceptual definitions into specific research instruments as well as how the research will be conducted and measured (Babbie, 1998). Operational definitions describe or define variables in terms of the operations used to produce them or techniques to measure them (Gliner and Morgan, 2000). In this research two independent variables (project complexity and project management style) and two dependent variables (project management issues and project performance) are operationalized using a survey instrument.

In Figure 16, the conceptual model with the main constructs, variables and the question numbers for each variable in the survey instrument is given. Since there are different aspects of each construct, there is a different number of questions for each construct (Monette et al., 2002, Tatikonda, 1999).

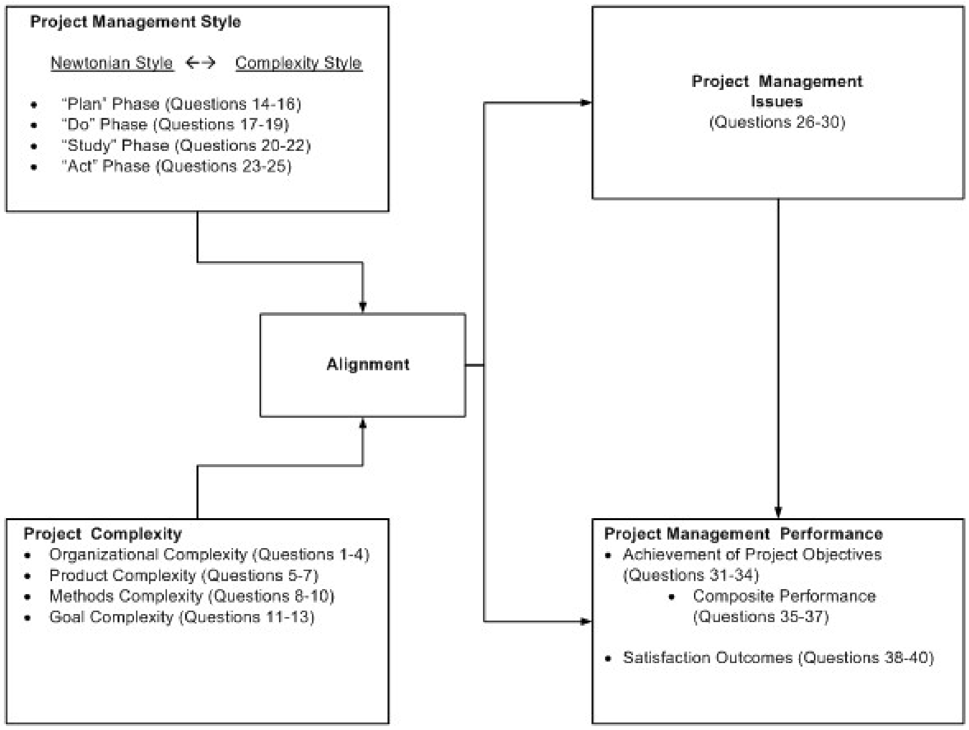


Figure 16: The conceptual model with the main constructs and the question numbers for each construct in the survey instrument.

After responding to questions related to research variables, the respondents will be elicited responses about their organizations, the most recent completed project that they were involved in and their role in that project and experience in project management (Table 18).

Table 18: Questions related to the organization, project and background of the respondent.

Organization	**What is your organization's primary industry?**
	What is your organization's yearly revenue?
	How many employees are in your entire organization?
Project	What type of project was your project?
	What was the approximate dollar value of your project?
	How many employees were in the project?
	What was the time span of your project?
Respondent	What was your position in your project?
	What is your project management experience?

In order to gather data from a large spectrum of projects, respondents are asked to answer questions on research variables for two different kinds of projects:

- The first project type is a successful project which is defined as a specific project where the project team was able to achieve all the project objectives (cost, schedule, technical performance).
- The second project type is a challenged project which is defined as a specific project where the project team was unable (or struggled) to achieve one or more project objectives (cost, schedule, technical performance).

The following subsections discuss the operationalization of the main constructs of the conceptual model in order to gather data for two different kinds of projects.

3.4.1 Operatialization of Project Complexity (X1)

After the initial questions related to the respondent, the main constructs of the conceptual model will be operationalized. The project complexity (X1) construct will be operationalized by soliciting answers of questions related to four different variables (Table 19):

- Organizational Complexity
- Product Complexity
- Methods Complexity
- Goals Complexity

In order to obtain a value for the project complexity (X1) construct, factor scores of four variables (organizational complexity, product complexity, methods complexity, goals complexity) are further analyzed using principal components analysis to obtain the final factor score for the project complexity (X1) construct.

Table 19: Operationalization of Project Complexity (X1) construct.

Variable	**Q**	**Items**	**Scale**	**Reference**
Organizational Complexity		Compared to a typical project completed in your organization…	7 point Likert Scale	Researcher
	1	the size of this project was:		
	2	the number of the vendors/subcontractors was:	Much Lower Than Average → Much Higher Than Average	
	3	the number of departments involved in the project was:		
	4	the number of projects dependent on this project was:		
Product Complexity		Compared to a typical project completed in your organization…	7 point Likert Scale	Tatikonda (1999)
	5	the novelty/newness of the product was:	Much Lower Than Average → Much Higher Than Average	
	6	the number of the product sub assemblies was:		
	7	the impact of a design change of one sub assembly on another sub assembly was:		
Methods Complexity		Compared to a typical project completed in your organization…	7 point Likert Scale	Tatikonda (1999)
	8	the newness of the production technologies was:	Much Lower Than Average → Much Higher Than Average	
	9	the number of the production processes was:		
	10	the impact of a change in one production process on other production processes was:		
Goals Complexity		Compared to a typical project completed in your organization…	7 point Likert Scale	Researcher
	11	the number of the requirement changes was:	Much Lower Than Average → Much Higher Than Average	
	12	the potential impact of a change in one requirement on the other requirements was:		
	13	the impact of not realizing the goals of the project on the organization was:		

3.4.2 Operatialization of Project Management Style (X2)

The project management style (X2) construct will be operationalized by soliciting answers of questions related to four different variables (Table 20):

a) Plan Style
b) Do Style
c) Study Style
d) Act Style

In order to obtain a value for the project management style (X2) construct, factor scores of four variables (plan style, do style, study style, act style) are further analyzed using principal components analysis to obtain the final factor score for the project management style (X2) construct.

Table 20: Operationalization of Project Management Style (X2) construct.

Construct	Q	Items	Scale	Reference
Plan Style	14	Instead of a detailed final solution, a simple basic solution was designed and later modified during the project's life.	7 point Likert Scale Strongly Disagree → Strongly Agree	Researcher
	15	The customer was involved in the decision making process from start of the project.		
	16	Project plans were revised periodically in short intervals.		
Do Style	17	In interaction with project manager, team members decide which tasks they will complete.	7 point Likert Scale Strongly Disagree → Strongly Agree	Researcher
	18	Team members continuously report the status of their tasks to team leader or the project manager.		
	19	Instead of directing the team members, the main role of the project manager is to work with the customer, management of the organization and the project team in order to remove any obstacles to the progress of the project.		
Study Style	20	Project management received just-in-time information about the progress of the project.	7 point Likert Scale Strongly Disagree → Strongly Agree	Researcher
	21	Project team members investigate and report the causes for non-realization of their assigned tasks.		
	22	The project team regularly presents the progress of the project to the management of the organization and the customer.		
Act Style	23	Project plans were revised regularly using the lessons learned during the project.	7 point Likert Scale Strongly Disagree → Strongly Agree	Researcher
	24	The structure and the roles of the project team changes to adapt to the changing project conditions.		
	25	The lessons learned during the project are kept, documented and shared within the organization.		

3.4.3 Operatialization of Alignment

The alignment construct is operationalized using the "Matching" perspective where the alignment is calculated as a match between the project complexity and the project management style values obtained by the survey instrument. In this framework, the scores of the project complexity (X1) and the project management style (X2) constructs are specified as the orthogonal positive axes of a two dimensional coordinate system, where X1 is the horizontal axis and X2 is the vertical axis. For the project complexity (X1) construct, the increased values indicate the increased complexity, where one (1) means the lowest complexity and seven (7) means the highest complexity achievable. For the project management style (X2), the increasing values indicate a shift from the Newtonian style to the complexity style, where one (1) means that the project management style is completely influenced by the Newtonian paradigm and seven (7) means that the project management style is completely influenced by the complexity paradigm. The alignment is determined by the distance between the line passing through the origin (0, 0) with the slope of 45º and the point with the coordinates of the project complexity (X1) and the project management style (X2). The diagonal line passing through the origin represents the highest alignment value and the distance between the line and the alignment point (X1, X2) represents the deviation or delta from the highest alignment value. The graphical representation of the alignment as matching is given in Figure 17 and the alignment values for different project complexity (X1) and project management style (X2) combinations are given in Table 21. In this perspective the alignment is calculated using the formula:

$$\text{Alignment} = 7 - |\text{Project Complexity} - \text{Project Management Style}|$$

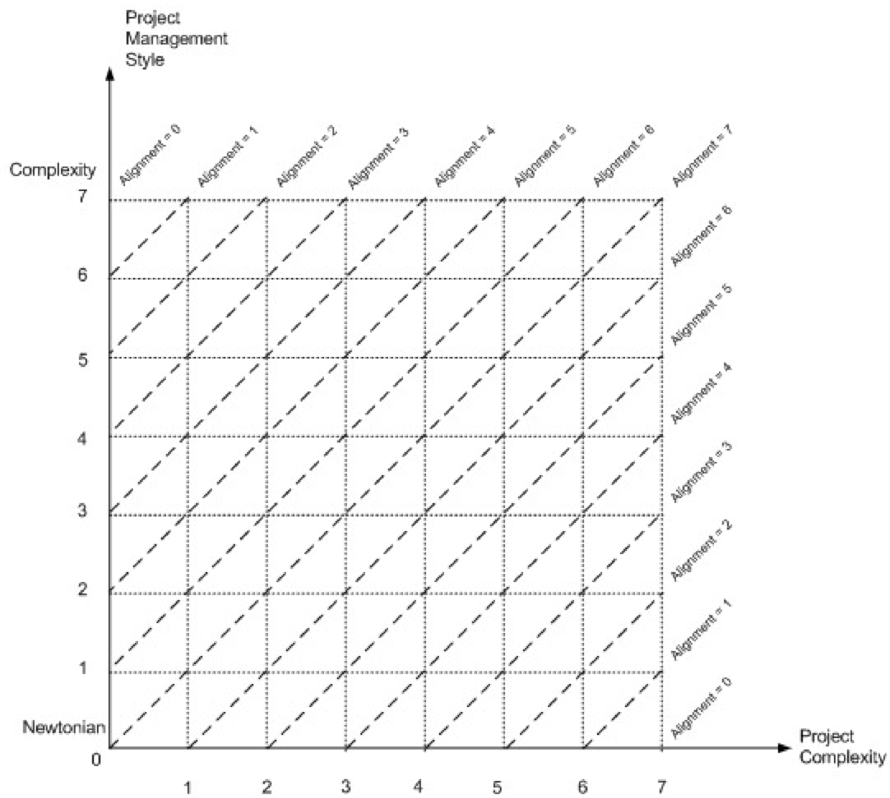


Figure 17: The graphical representation of the alignment as matching between project complexity and project management style.

Table 21: Alignment values for different project complexity (X1) and project management style (X2) combinations.

		X1: Project Complexity						
		1	2	3	4	5	6	7
X2: Project Management Style	1	7	6	5	4	3	2	1
	2	6	7	6	5	4	3	2
	3	5	6	7	6	5	4	3
	4	4	5	6	7	6	5	4
	5	3	4	5	6	7	6	5
	6	2	3	4	5	6	7	6
	7	1	2	3	4	5	6	7

3.4.4 Operatialization of Project Issues (Y1)

The project issues (Y1) construct will be operationalized by soliciting answers for five questions related to four different variables (Table 22). In order to obtain a value for the project issues (Y1) construct, factor score of the construct is used.

Table 22: Operationalization of Project Issues (Y1) construct.

Variable	Q	Items	Scale	Reference
Project Issues	26	Lack of customer commitment to the project and its deliverables	7 point Likert Scale Strongly Disagree → Strongly Agree	(White and Fortune, 2002; Schmidt et al.,2001; Bellasi and Tukel, 1996)
	27	Lack of top management support to the project		
	28	Lack of experience/expertise of project personnel		
	29	Lack of involvement and commitment of functional departments		
	30	Excessive dependence on vendors/ consultants		

3.4.5 Operatialization of Project Management Performance (Y2)

The project management performance (Y2) construct will be operationalized by soliciting answers of questions related to two different variables (Table 23):

a) Achievement of Project Objectives

b) Satisfaction Outcomes

In order to obtain a value for the project management performance (Y2) construct, factor scores of two variables (achievement of project objectives, satisfaction outcomes) will be combined by averaging them.

Table 23: Operationalization of Project management performance (Y2) construct.

Construct	**Q**	**Items**	**Scale**	**Reference**
Achievement of Project Objectives	31	Original technical performance objective met?	7 point Likert Scale Significantly Worse Than Expectations → Significantly Better Than Expectations	Tatikonda (1999)
	32	Original cost objective met?		
	33	Original schedule objective met?		
	34	Original combination of project objectives met?		
Achievement of Project Objectives (Weights)		At the beginning of the project, how important was achieving each objective thought to be for project success:	7 point Likert Scale No Importance → Great Importance	Tatikonda (1999)
	35	Technical performance		
	36	Cost		
	37	Schedule		
Satisfaction Outcomes		To what degree were these groups satisfied with the outcome of the project	7 point Likert Scale Not Satisfied At All → Completely Satisfied	Tatikonda (1999)
	38	Senior Management		
	39	Project Management		
	40	Customers		

3.5 Data Collection

After the research design and instrument are determined and operationalized, researcher can deploy the instrument and collect data. This section covers the data collection model which is the blueprint of the questions and their relationships and the domain in which the data is collected.

3.5.1 Data Collection Model

During data collection, self administered on-line surveys and paper based surveys (in case the respondents can not access the internet) will be used to solicit responses from the project management professionals. There are 40 questions with seven point scale (Likert scale) in the survey. The hierarchy of constructs, variables and questions is given in Figure 18. The explicit model for data collection showing the relationships between the main constructs, variables and the questions as well as the hypotheses is given in Figure 19. The main variables in this model are:

- Project Complexity (X1) with questions Q1 thru Q13
- Project Management Style (X2) with questions Q14 thru Q25
- Project Issues (Y1) with questions Q26 thru Q30
- Project Management Performance (Y2) with questions Q31 thru Q40

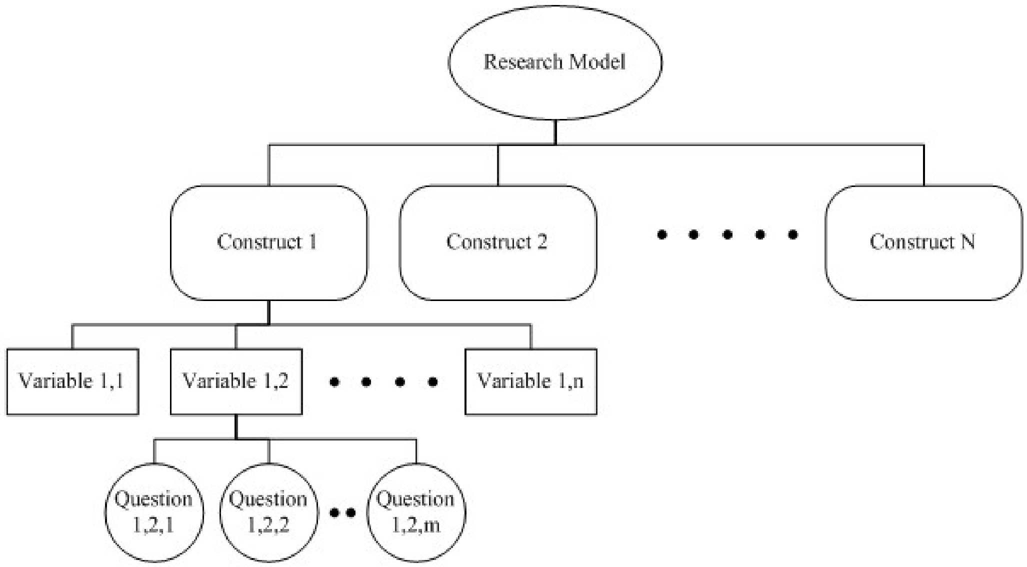


Figure 18: The hierarchy of constructs, variables and questions.

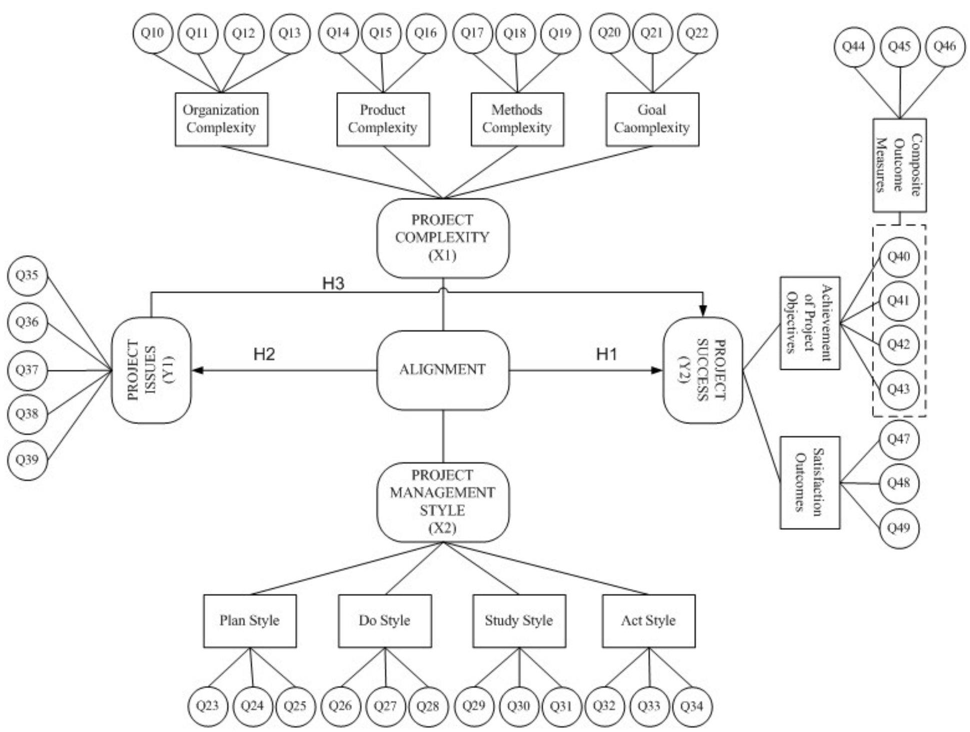


Figure 19: The model for data collection showing the relationships between the main constructs, variables and the questions as well as the hypotheses.

3.5.2 Data Collection Domain

The main characteristics of the domain where the survey data were collected in this research are as follows:

- Unit of analysis: Completed projects in project organizations. Each respondent was asked to answer questions for two different kinds of projects:
    - A successful project which is defined as a specific project where the project team was able to achieve all the project objectives (cost, schedule, technical performance).
    - A challenged project which is defined as a specific project where the project team was unable (or struggled) to achieve one or more project objectives (cost, schedule, technical performance).

  The main reasons for using two different types of questions are as follows:
    - To avoid response bias: When asked for a specific project, respondents are expected to provide data only about successful projects, which is an example of response bias which can be described as the tendency for people's answers to questions to be influenced by things other than their true feelings, beliefs and behavior (Monette et al., 2002). The source of this bias is the social desirability effect (Monette et al., 2002).
    - To increase the size of the sample: Asking each respondent to answer questions for two different kinds of projects will double the size of the sample.
- Data collection instrument: Self administered paper-based and on-line surveys were used to solicit responses from project managers. Paper-based surveys were administered during a formal gathering of the Project Management Institute Central Florida Chapter.

On-line surveys, on the other hand were posted on an Internet web page and respondents were solicited using e-mails. There are 40 questions in the survey with questions with seven point Likert scale and an additional 9 questions about the respondent and his/her organization and project.

- Population: The theoretical or target population for this research was the project managers or project management professionals from multi-project organizations who administered projects from start to finish in the US. But due to the limitations of this research, the sample was selected among the project managers in the Central Florida region.
- Sample: The sampling approach in this dissertation was non-probabilistic. The sample was the project managers from different industries represented in the Central Florida region. In order to achieve higher reliability, the sample was chosen from different organizations from different industries, by soliciting the members of the PMI Central Florida Chapter, as well as the large technical organizations established in the region.
- Desired sample size: According to Gliner and Morgan (2000), the rule of thumb for associational designs is that a study might have as few as 30 participants. Writing about the sample sizes in regression analysis, Green (1991) provides another rule of thumb, which requires at least 50 + 8m (m is the number of independent variables) for testing the multiple correlation. Thus, according to Green (1991), this dissertation with 2 independent variables, should have at least (50 +8*2) 66 respondents.

3.6 Data Analysis

After the data collection instrument is employed and the data from the respondents is collected, the next step is to group, manipulate and validate the data collected. In coming subsections, descriptive statistics and the analyses for reliability and validity of the research instrument are given.

3.6.1 Descriptive Statistics of Sample Questions

The first step in statistical data analysis is to summarize the data collected by the research instrument in a clear and understandable way using descriptive statistics which describe patterns and general trends in the collected data. In this dissertation 4 different types of descriptive statistic are reported:

1) Sample Size: The first descriptive statistic to be reported is sample size, which shows the actual number of participants in the study.
2) Range: This statistic is a measure of the spread of sample values and is determined by the minimum and maximum values of a variable in the data.
3) Mean: This descriptive statistic shows the average score of each question, variable and construct for the sample.
4) Variation: The final descriptive statistic in this study is the variation in the scores for each question, variable and construct. The measure of variation is the standard deviation.

3.6.2 Reliability and Validity of the Data Collection Instrument

The data collected by the survey instrument mentioned above, does not mean much if the method's reliability and validity are not established. The basic definitions for reliability and validity are as follows (Monette et al., 2002):

- Reliability refers to the measure's ability to yield consistent results each time it is applied
- Validity refers to the accuracy of the measure in measuring the variable it is intended to measure.

Reliability and validity are closely related evaluation measures, an instrument can be reliable without being valid but it can not be valid without being reliable (Monette et al., 2002). Figure 20 shows the main processes to determine the validity and the reliability of the research measures. Since this research aims to test hypotheses about the alignment of project complexity and the project management style and project issues and project performance; confirmatory factor analysis for each construct described in the conceptual model is the tool to test the validity in this dissertation. If the hypothesized factor models cannot be supported by the confirmatory analysis, exploratory factor analysis (EFA) is applied to determine new factor structures. After exploratory factor analysis the new factor structure will go through the confirmatory factor analysis process again in order to determine its validity and modify the new factor structure. After the factor structures are established, the reliability analysis is performed to determine the consistency of the measures. And the final step is to establish the factor scores to be used in the subsequent hypothesis tests (correlation analysis).

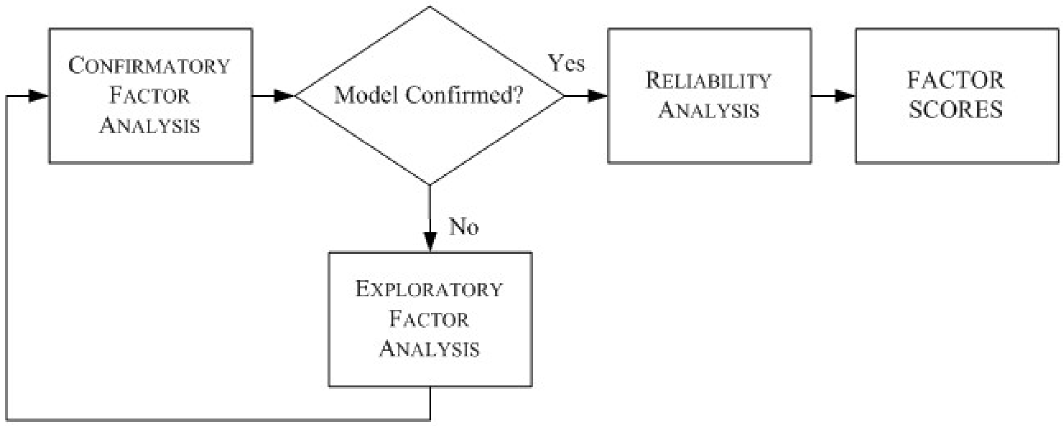


Figure 20: Processes for testing the validity and the reliability of the constructs.

The first criteria to asses the quality of a data collection instrument is validity. According to Babbie (1998), validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration. Construct validation is a process where the investigator attempts to demonstrate that the instrument is measuring a construct (Gliner and Morgan, 2000). Gliner and Morgan (2000) state that when a construct is complex and several of its factors are measured, factor analysis, where the clustering of items in theory-based groups, is the method used by the researcher.

The purpose of factor analysis is to discover simpler patterns among the relationships between the variables and whether the observed variables can be explained in terms of a much smaller number of variables called factors. There are both exploratory and confirmatory approaches used in factor analysis. Exploratory factor analysis (EFA) is especially appropriate for scale development at the initial stages of theory development when there is little evidence for the common factors (Hurley et al., 1997). Confirmatory factor analysis (CFA) is more useful when the investigator has developed specific hypotheses about the factor structure in later stages of research (Swisher et al., 2004). Swisher et al. (2004) outlines the major characteristics of exploratory and confirmatory factor analysis approaches in Table 24.

Table 24: Differences between exploratory and confirmatory factor analysis approaches (Swisher et al., 2004).

	Exploratory Factor Analysis	**Confirmatory Factor Analysis**
Purpose	To identify a factor structure in a set of variables	To test an existing, theoretical or hypothesized model or structure or to determine which of several models is the best fit for the data.
Primary questions	• What are the underlying processes that could have produced correlations among the variables? • What is the factor model?	• Are the covariances (or correlations) among variables consistent with the hypothesized factor structure? • How well does the proposed model explain the responses?
Appropriate uses	• Theory building • Early stages of research on a topic when trying to establish basic concepts and relationships or to simplify an existing instrument by reducing number of items to evaluate the same construct.	• Theory testing • To test a proposed theory underlying an existing instrument used in a different context or population. • To serve as a bridge between theory and instrument development
Factor derivation	• Factors are derived a posteriori or after the fact by inductive reasoning	• A factor model has been developed a priori or in advance.
Statistical analysis	• Evaluation of pattern of factor loadings using rules of thumb for what constitutes strong factor loadings; typical cutoffs range from 0.30 to 0.55. • Quality of solution based n proportion of variance explained or size of discrepancies between observed and reproduced covariances.	• Structural equations modeling evaluates fit of the hypothesized model to data. • Test of significance provided for factor loading coefficients. • Quality of solution based on various fit indexes that summarize discrepancies between observed and reproduced variance-covariance matrix.
Limitations	• Identification of factors requires judgment of the researcher. • Different statistical methods may yield different factors. • Generating factors from correlated items also may result in factors that are not actually relevant. • Requires relatively large sample size.	• Requires extensive knowledge of specific statistical procedures. • Requires relatively large sample size. • Sample size too small or large may present problems. The chi-square statistic requires a larger sample, but a very large sample size may yield differences that cause rejection of the model. However, a very small sample may be in error in suggesting a good fit of the model. • Assumes normal distribution of variables.

The main steps taken to determine the construct validity and reliability of research constructs are confirmatory factor analysis (CFA), exploratory factor analysis (EFA) and reliability analysis (Cronbach's Alpha):

1- Confirmatory factor analysis: The purpose of the confirmatory factor analysis (CFA) is to determine if the number of factors and the loadings of measured variables (questions in the survey) on these factors conform to what is expected on the basis of the hypotheses regarding each of the constructs of this dissertation (Byrne, 2001): project complexity, project management style, project management issues and project performance. In this dissertation, confirmatory factor analysis is performed by analysis of measurement (factor) models using AMOS structural equation modeling (SEM) package. The main steps of confirmatory factor analysis are as follows (Figure 21) (Byrne, 2001):

    a. Build the theoretical factor model (conceptual model): The theoretical SEM models show the factors (variables of a construct), their indicators (questions), covariance between each possible pair of factors and direct effects (straight arrows) between factors and indicators and between indicators and the error terms.

    b. Analyze the model: In the SEM, the model is analyzed through an iterative estimation process which yields parameter values such that the discrepancy (i.e., residual) between the sample covariance matrix and the population covariance matrix implied by the model is minimal (Byrne, 2001). After the model is analyzed by a SEM package (AMOS), the researcher should make decisions based on the outcomes of the analysis.

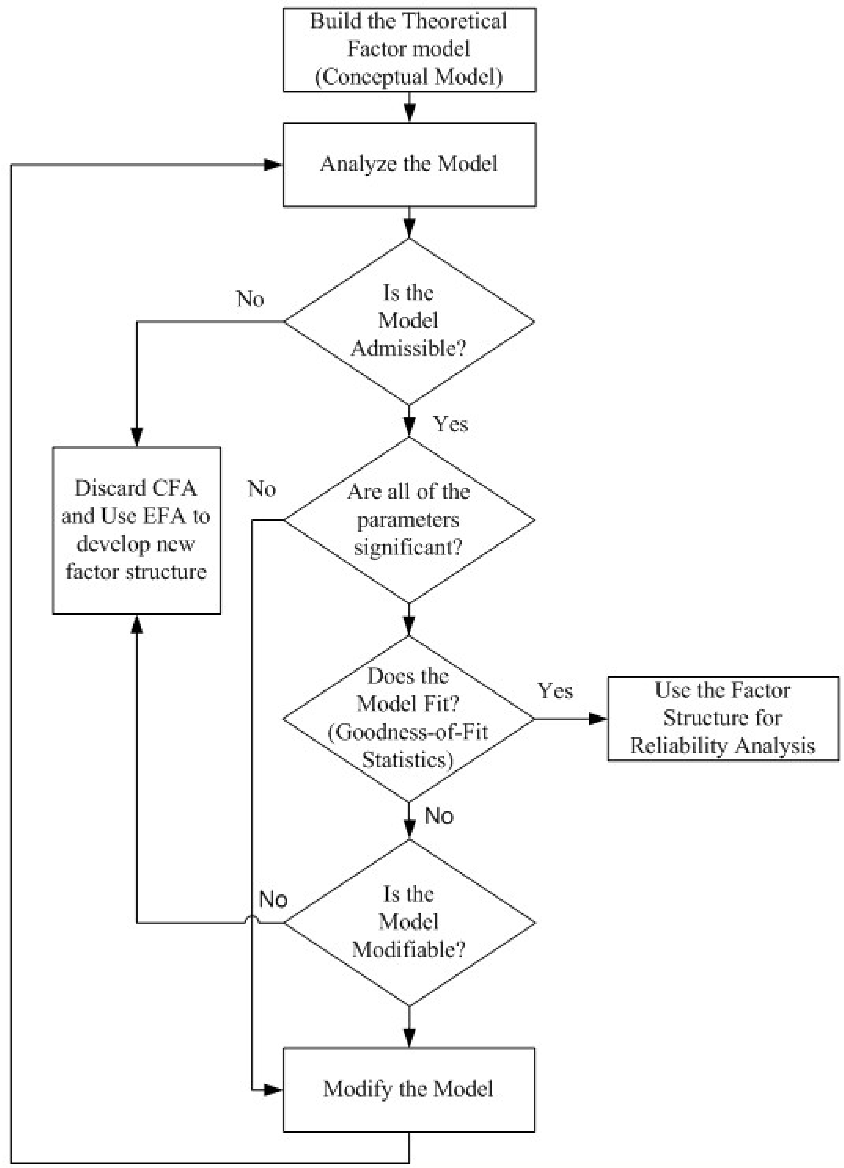


Figure 21: Confirmatory factor analysis process for construct validity of a construct.

c. Is the model admissible? : The first step of SEM analysis is to check the admissibility of the model. The AMOS software warns the researcher when the model is not admissible. In this case, the researcher should abandon CFA and switch to exploratory factor analysis to develop a new factor structure.

d. Are all of the parameters significant? : The next step after determining whether the model is admissible is to determine the statistical significance of parameter estimates. The test statistic for statistical significance is the critical ratio (c.r.), which represents the parameter estimate divided by its standard error. The critical ratio operates as a z-statistic in testing that the estimate is statistically different from zero. For 0.05 significance level, the test statistic needs to be larger than ±1.96 before the hypothesis (the estimate equals 0.0) can be rejected (Byrne, 2001). Non-significant parameters, with the exception of error variances, can be considered unimportant to the model and should be deleted from the model (Byrne, 2001). If there are non-significant parameters, the model is modified using only the significant parameters.

e. Does the model fit? (Goodness-of-fit statistics): Goodness-of-fit statistics are measures that researchers use to determine whether the analyzed model is acceptable. The main goodness-of statistics for SEM are:

   i. Chi-square fit index: The chi-square fit index tests the null hypothesis which postulates that specification of the factor loadings, factor variances/covariances, and error variances for the model under study are valid (Byrne, 2001). The chi-square value should not be significant if there is a good model fit or the probability value associated with the chi-square (P) should be greater than 0.05 significance level.

   ii. $\chi 2$ / DF is the minimum discrepancy divided by its degrees of freedom and its values smaller than 2.00 represents an inadequate fit (Byrne, 1989).

iii. The normed fit index (NFI) has shown a tendency to underestimate fit in small samples (Byrne, 2001) and the value of NFI close to 1.00 indicates very good fit.

iv. The relative fit index (RFI) represents a derivative of the NFI and like NFI, RFI shows a tendency to underestimate fit in small samples (Byrne, 2001). The value of RFI greater than 0.95 indicates very good fit (Byrne, 2001).

v. The incremental index of fit (IFI) addresses sample size issue faced by NFI and RFI (Byrne, 2001). The value of greater than 0.95 indicates very good fit (Byrne, 2001).

vi. The Tucker–Lewis index (TLI) yields values ranging from zero to 1.00 and the value of TLI greater than 0.95 indicates very good fit (Byrne, 2001).

vii. Comparative fit index (CFI) is less sensitive to the sample size than NFI and provides a measure of complete covariation in the data and CFI value close to 0.95 represents a well-fitting model (Byrne, 2001).

viii. The root mean square error of approximation (RMSEA) index takes into account the error of approximation in the population (Byrne, 2001). Values less than 0.05 indicate good fit and values as high as 0.08 represent reasonable errors of approximation in the population (Byrne, 2001).

f. Is the model modifiable? : In case the model does not fit, model modification is required to obtain a better-fitting model. In SEM, modification indices (MI) are used to generate the expected reduction in the overall model fit chi-square for each possible additional path. A modification index shows the minimum decrease in the model's chi-square value when a previously fixed parameter is set free (Diamantopoulos and Siguaw, 2000). Prior to modifying the model, a researcher should check if there are large modification indices, otherwise the model is not modifiable and the researcher should abandon CFA.

g. Modify the model: In order to achieve the maximum fit in the model, the modification indices with the highest values should be set free (Diamantopoulos and Siguaw, 2000). The rule of thumb for modification indices is to allow two error term variables to correlate when their respective modification index (MI) exceeds 4 starting from the greatest MI (Byrne, 2001). But modifying the model based on modification indices might not yield a fitted solution. Diamantopoulos and Siguaw (2000) suggest that allowing correlated error terms should only be done when it makes statistical and theoretical sense to do so. In practice Diamantopoulos and Siguaw (2000) suggest that researchers should change paths or covariances one at a time only if this change makes sense theoretically until an acceptable solution is reached.

h. Use the factor structure for reliability analysis: After analyzing the final modified model and determining that the final model fits, a researcher can proceed to reliability analysis to check the reliability of the model.

2- Exploratory factor analysis: The purpose of exploratory factor analysis (EFA) is to reveal the underlying structure of a set of variables (questions of a survey) with the assumption that any indicator may be associated with any factor. This is the most common form of factor analysis. There is no prior theory and the factor loadings are used to determine the factor structure of the data. The main steps of exploratory factor analysis are as follows (Figure 22) (Thompson, 2004):

   a. Assessment of the appropriateness of the data: Before starting the actual analysis, a researcher should check if the data is appropriate for the exploratory factor analysis. Main issues to be addressed in this assessment are as follows (Pallant, 2001):

      i. High number of correlation coefficients > 0.3: Exploratory factor analysis is not feasible unless a substantial number of correlation coefficients are greater than 0.3.

      ii. Bartlett's test of sphericity should be significant ($p<0.05$).

      iii. The Kaiser-Meyer-Olkin (KMO) measure ranges from 0 to 1, and 0.6 is considered to be the minimum value for an appropriate factor analysis.

   b. Factor Extraction : This step is crucial in exploratory factor analysis (EFA), since the remainder of the analysis depends on the decision on the number of factors that explain the observed variables. Using the statistical software package SPSS and principal axis factoring, an initial set of factors will be extracted. The factor extraction is based on the analysis of the correlation matrix, which is a tabular representation of all possible correlation coefficients between a set of variables. The results of principal component analysis are communalities which are the percent (%) variance of each variable that is accounted for by the solution and component matrix that shows the factor loadings of each of the variables on the factor.

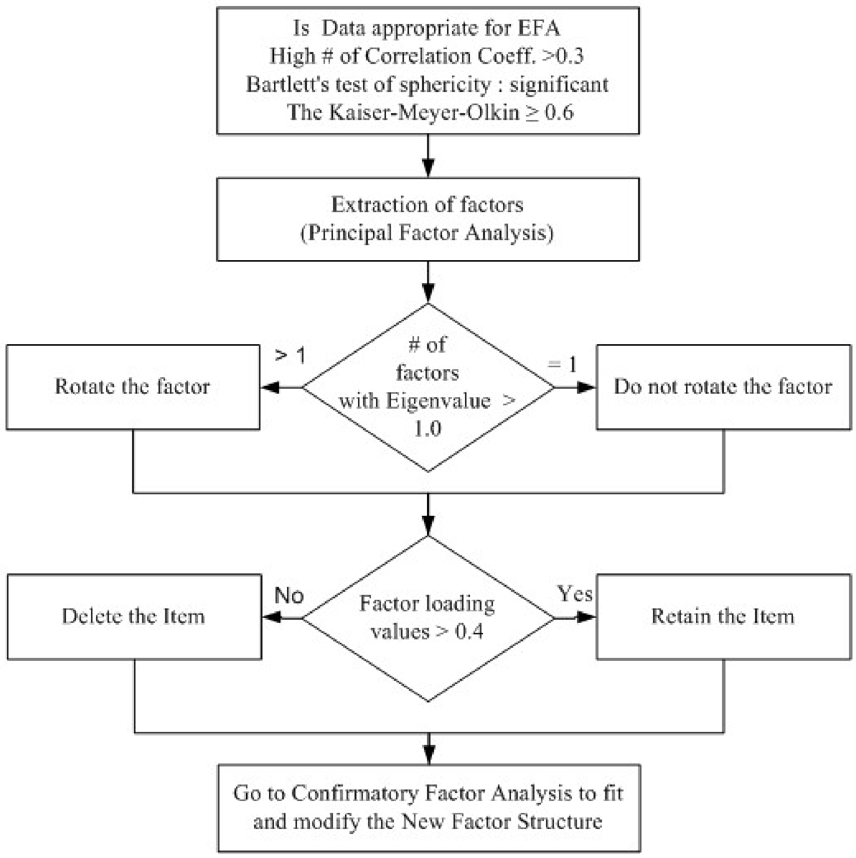


Figure 22: Exploratory factor analysis process for construct validity of a construct.

There are two methods to identify the number of factors to retain in EFA. Both of these methods use eigenvalues obtained after the principal component analysis:

- The first method is the Kaiser or K1 rule, which identifies the number of factors to be retained as the number of factors whose eigenvalues of the correlation matrix are greater than one.

- The second method, scree plot, is used to graphically determine the number of factors. The number of factors is chosen where the plot levels off to a linear decreasing pattern. The scree plot is a useful tool to assess the accuracy of the Kaiser (K1) rule; researcher can change the number of factors after analyzing the scree plot.

c. Factor rotation: Rotation is necessary when extraction suggests there are at least two or more factors. The aim of rotating the factors is to transform the principal factors or components so that each variable is aligned to only one factor in a simple structure for better interpretability of the analysis results. The resulting factors are rotated using the orthogonal, varimax transformation to get a simpler factor structure.

d. Factor loading values : The resulting factor structure is analyzed looking at the individual factor loadings to find out whether they are significant (factor loadings are significant with values greater than 0.4 in a sample size less than 100 and greater than 0.3 for sample size greater than 100). Insignificant variables are excluded from the factor and, if a variable's factor loading is insignificant for any of the factors, this variable is eliminated.

e. Confirmatory factor analysis to fit and modify the new factor structure: In this dissertation, confirmatory factor analysis is used to confirm and further modify the factor structure obtained after exploratory factor analysis. As a result of confirmatory factor analysis process (described in the previous section) a modified final structure is obtained.

3- Reliability analysis: Reliability of the instrument depends on the reliability of each constructs measurement. After determining the final factor structure for each construct, the researcher analyzes the reliability of each factor or variable using Cronbach's alpha criteria. According to Nunnally (1967, 1978), the lower threshold for Cronbach's alpha value is 0.5 for emerging construct scales and 0.7 for established scales. This dissertation aims to develop new constructs of project complexity, project management style and project issues. For these constructs, the lower threshold for Cronbach's alpha is taken as 0.5. The process of reliability analysis is given in Figure 23.

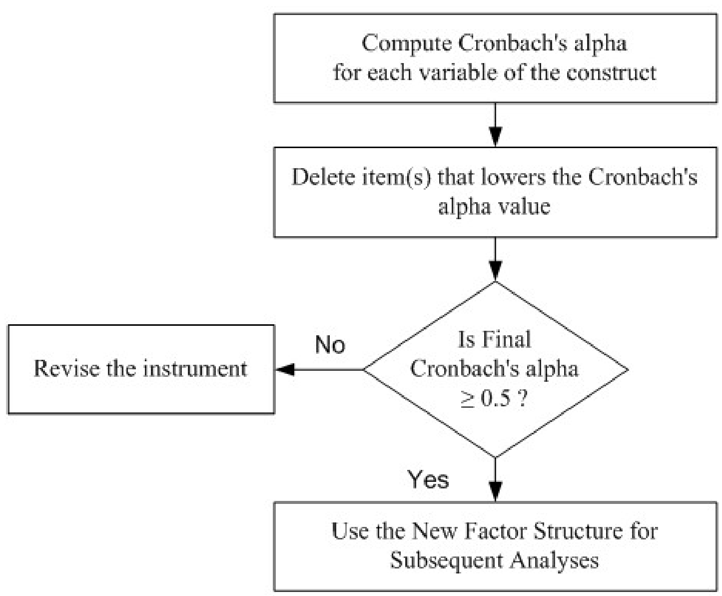


Figure 23: Reliability analysis process of a construct.

4- Factor Scores: After the validity and the reliability of a measure is established, the final step is to determine the factor scores for further analyses, like correlation or regression. In this dissertation, the factor scores for each variable in a construct is calculated using sequential equation modeling software (AMOS). The SEM analysis yields a matrix of factor score weights, which are multiplied by the values of questions (research data) to determine the factor scores of variables. Factor scores for constructs with more than two variables are established using principal components analysis, otherwise the factor scores of variables are simply averaged to determine the factor scores for constructs.

3.6.3 Issues Affecting Validity and Reliability

During the execution of the research instrument, several issues that would deteriorate the reliability and the validity of the research instrument might surface:

- The number of respondents: As the number of respondents in a sample increases so does the validity and reliability. In order to ensure that the number of respondents is sufficient, the survey instrument will be easy to access and a large number of participants will be solicited. But since the participants are project management professionals from a particular geographical region (Central Florida), the final number of respondents is expected to be relatively low.
- Projects might not represent the full complexity spectrum. There is a possibility that the respondents are only from low complexity or high complexity projects. In order to solve this issue, respondents from many different industries and organization will be solicited, instead of picking respondents from limited number of organizations. Similar to the issue with the number of respondents mentioned above, the projects in this survey represents

the projects from a particular region, thus the project complexity of the respondents' projects might not cover the whole complexity spectrum due to similarities of industries of the respondents.

3.7 Testing the Hypotheses

After determining the data collected by the research instrument is reliable and valid, the researchers can test their hypotheses. According to Gliner and Morgan(2000), the methods used to test associational hypotheses which investigate relationships between continuous variables are multiple regression analysis and correlation. The method used in this dissertation to test the three hypotheses is correlation between two variables:

These variables are:

Independent Variables:

X1 = Project Complexity

X2 = Project Management Style

Dependent Variables:

Y1 = Project issues

Y2 = Project Performance

Alignment in the hypothesis testing will be addressed using "the alignment as matching" approach as prescribed by Vankatraman (1989). In this case alignment is calculated as:

$$A = 7 - (|X1-X2|).$$

In this equation 7 is the maximum value that the alignment score can get.

Hypothesis 1

H1: Alignment of project management style to project complexity leads to increased project performance

The hypothesis seeks a positive correlation between the alignment (7 – (|X1-X2|)) and project performance (Y2).

The null hypothesis in this case is

$H1_0$ = There is no correlation between alignment and project performance (Y2),

$H1_0$: $\rho 1 = 0$.

The research or alternative hypothesis for this case is

$H1_a$: There is positive correlation between alignment and project performance (Y2).

$H1_a$: $\rho 1 > 0$ (positive correlation).

Hypothesis 2

H2: Alignment of project management styles to project complexity leads to decrease in project management issues.

The hypothesis seeks a negative correlation between the alignment: (7 – (|X1-X2|)) and project issues (Y1).

The null hypothesis in this case is

$H2_0$: There is no correlation between alignment and project issues (Y1).

$H2_0$: $\rho 2 = 0$.

The research or alternative hypothesis for this case is

$H2_a$ = There is negative correlation between alignment and project issues (Y1).

$H2_a$: $\rho 2 < 0$ (negative correlation).

Hypothesis 3

H3: Increase in project management issues leads to decreased project performance. The hypothesis seeks a negative correlation between the project issues (Y1) and project performance (Y2).

The null hypothesis in this case is

$H3_0$: There is no correlation between project issues (Y1) and project performance (Y2).

$H3_0$: $\rho 3 = 0$.

The research or alternative hypothesis for this case is

$H3_a$: There is negative correlation between project issues (Y1) and project performance (Y2)

$H3_a$: $\rho 3 < 0$ (negative correlation).

$\rho 1$ (rho), $\rho 2$, $\rho 3$ are the correlation coefficients for Hypotheses 1, 2 and 3. To test the hypotheses, t-test is performed with significance level of 0.05.

3.8 Theory Development and Further Research

If the null hypotheses are not rejected, the researcher should decide whether to modify the research model and instrument or abandon the research altogether. But when the null hypotheses are rejected, the researcher should determine how this knowledge will contribute for the further development of a theory. According to Kerlinger (1986) "a theory is a set of interrelated construct (concepts), definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena" (p.9). In order to develop a theory, a researcher should develop and test a series of hypotheses. This dissertation is an exploratory study to determine the relationships between project complexity and project management styles and, at this point, it is not able to develop a theory, but it can be used as a starting point for developing a theory of project management contingent upon the further, wider research.

3.9 Prediction and Implications

Since this research will not develop a theory, the attempt to predict actual phenomena is not possible. But the results of this research will have several impacts:

- Impacts on the academic research and teaching on project management.
- Impacts on project management practitioners.

3.10 Conclusions

The final step of the dissertation is to demonstrate the lessons learned during the research process. The lessons learned are the weaknesses or strengths in the research methodology and design, what the researcher might do differently and implications for future research.

CHAPTER FOUR: DATA COLLECTION AND ANALYSIS

4.1 Introduction

The purpose of this dissertation is to answer the following research question:

How does the alignment of the project management style and the complexity of a project affect the issues faced during the project's life and overall project performance?

In order to answer this research question a self-administered survey instrument (paper-based and on-line) with 40 questions (seven point Likert scale) is used. This survey also includes 9 demographic questions regarding the background of the respondents and their projects.

This section describes the data sources, characteristics of the collected data, validity and reliability of the research model with respect to the collected data as well as the outputs of research analyses.

4.2 Data Collection

During this research, self-administered paper based and on-line surveys were used to solicit responses from project managers. Prior to administrating the survey a pilot test survey given to a small number of people knowledgeable in project management and survey methods.

4.2.1 Pilot Test

After drafting the survey, a pilot test was conducted to further check and refine the survey and especially to make sure that it is easy to understand and it provides appropriate data. Pilot testing was done with a group of five respondents, four of whom represent the academic and professional side of the project management discipline and one English language major who works at Writing Services of the University of Central Florida. Participants in the pilot test were asked to evaluate the survey and to identify unclear questions, missing topics and needs for improvements and to provide written comments on these topics. Using the information obtained through the pilot test, the following modifications were made on the survey:

- In the test survey, respondents were asked to answer questions for two different kinds of projects: A "successful" and a "routine" project. The pilot test respondents mentioned that they found it difficult to think of both projects using those terms. Thus, in the final survey, instead of a "routine" project, respondents were asked to answer questions for a "challenging" project in addition to a "successful" project.
- In the test survey, for questions 14 thru 25, the mid point in the Likert scale between "Strongly Disagree" and "Strongly Agree" was given as "Agree". The pilot test respondents mentioned that it is more pertinent to name the mid point "Neutral", so in the

final survey the term “Neutral” was used for the midpoint of the Likert scale for questions 14 to 25.

4.2.2 Administration of Survey

After suggested modifications were made after the pilot test, the final survey was administered using paper and online questionnaires. Paper-based surveys were administered during a Project Management Institute Central Florida Chapter meeting. On-line surveys were posted on an Internet web page (Surveymonkey.com) and respondents were solicited using e-mails. The unit of analysis in this research is a completed project. Each respondent was asked to answer questions for two different kinds of projects. The first type is a successful project which is defined as a specific project where the project team was able to achieve all the project objectives (cost, schedule, technical performance). The second type is a challenged project which is defined as a specific project where the project team was unable (or struggled) to achieve one or more project objectives (cost, schedule, technical performance). The main reasons for using two different types of questions are as follows:

- To avoid response bias: When asked for a specific project, respondents are expected to provide data only about successful projects, which is an example of response bias which can be described as the tendency for people’s answers to questions to be influenced by things other than their true feelings, beliefs and behavior (Monette et al., 2002). The source of this bias is the social desirability effect (Monette et al., 2002).
- To increase the size of the sample: Asking each respondent to answer questions for two different kinds of projects will double the size of the sample.

The theoretical or target population for this research is the project managers or project management professionals from multi-project organizations who administered projects from start to finish in the US. But due to the limitations of this research, the sample was selected among the project managers in the Central Florida region. The sampling approach in this dissertation was non-probabilistic. The sample was made up of the project management professionals from different industries represented in the Central Florida region. In order to achieve higher reliability, sample was chosen from different organizations from different industries and by soliciting the members of PMI Central Florida Chapter.

The number of respondents was 76 with 22 respondents to the paper-based survey and 54 respondents to the online survey. Ten (10) respondents to the online survey were eliminated due to incomplete responses. Even though participants were asked to answer survey questions for two different projects, 3 respondents of the paper survey and 1 respondent of the online survey provided information only on successful projects. Thus, in the sample there are 66 successful and 62 challenged projects with a total of 128 projects. According to Green (1991), in order to test multiple correlation between variables, a researcher needs a sample size of at least 50 + 8m (m is the number of independent variables) which corresponds to 66 projects for this dissertation. Thus, the number of projects (128 > 66) satisfies the rule of thumb suggested by Green (1991).

4.3 Demographics

At the beginning of the questionnaire, respondents were informed that their collaboration was voluntary and that they could skip any question that they deemed proprietary information. Of the 66 respondents, 62 provided information about the primary industry of their organization (Table 25). Five major industries represented in this research are government, financial/ insurance, and telecommunications, consulting/business services and entertainment/ hospitality/recreation with two thirds of the respondents (66.2 %).

Table 25: Primary industries of respondents' organizations.

Type of Organization	Qty	Percentage
Government	12	19.4%
Financial/Insurance	9	14.5%
Telecommunications	8	12.9%
Consulting/Business Services	6	9.7%
Entertainment/Hospitality/Recreation	6	9.7%
Higher Education	4	6.5%
Aerospace	3	4.8%
Manufacturing	3	4.8%
Electronics	2	3.2%
Transportation (Automotive, Aerospace and Rail)	2	3.2%
Wholesale/Retail	2	3.2%
Hospitals	1	1.6%
Industrial Machinery and Computer Equipment	1	1.6%
Medical and Dental Laboratories	1	1.6%
Transportation/Logistics Services	1	1.6%
Other	1	1.6%
Total	62	

Of the 66 respondents, 64 provided information about the annual revenues of their organizations (Table 26). The majority of the organizations (51.6 %) have revenues over $1 billion. On the other hand, 36% of the organizations have revenues of $200 million and less.

Table 26: Annual revenues of respondents' organizations.

Organization's Annual Revenue	Qty	Percentage
Less than $50 million	14	21.9%
$50-200 million	9	14.1%
$201-500 million	5	7.8%
$501 million to $1 billion	3	4.7%
More than $1 billion	33	51.6%
Total	64	

All of the 66 respondents provided information about the number of employees in their organizations (Table 27). The majority of the organizations (56.1 %) have more than 10,000 employees in their organizations. On the other hand, 25.8 % of the organizations have less more than 1,000 employees in their organizations.

Table 27: Number of employees in respondents' organizations.

Number of Employees in the Organization	Qty	Percentage
Less than 100	4	6.1%
100-999	13	19.7%
1,000-4,999	6	9.1%
5,000-9,999	6	9.1%
10,000 or more	38	56.1%
Total	66	

Respondents provided information about their positions in 103 projects that they participated in (Table 28). More than half (56.3 %) of the respondents were project (43.7%) or program (12.6%) managers and 31.1% of the respondents participated in the projects as a leader (14.6%) or a member (16.5%) of a project team.

Table 28: Respondents' positions in their projects.

Position in the Project	Qty	Percentage
Program Manager	13	12.6%
Project Manager	45	43.7%
Project Team Leader	15	14.6%
Project Team Member	17	16.5%
Consultant/Vendor	6	5.8%
Other	7	6.8%
Total	103	

Respondents also provided information that their experience in project management (Table 29). More than one third (34.8%) of the respondents have 2-5 years of project management experience while 53.1% have over 5 years of experience. Only 12.1% of respondents have experience of 2 years or less.

Table 29: Respondents' project management experience.

Project Management Experience	Qty	Percentage
Less than 1 years	2	3.0%
1-2 years	6	9.1%
2-5 years	23	34.8%
5-10 years	12	18.2%
10-15 years	13	19.7%
more than 15 years	10	15.2%
Total	66	

The final group of demographic data is on respondents' projects. First, respondents provided information about the type of the projects that they completed (Table 30). Information system projects are the largest group (46.1%) of projects, with 19.5% software development projects and 26.6% information technology projects. The other large group of projects is engineering projects (15.6%). Technology projects (information systems, engineering, R&D, manufacturing, defense and construction) made up of 79% of all the projects in the sample.

Table 30: Type of projects in the sample.

Type of Project	Qty	Percentage
Staff development / training	9	7.0%
Software development	25	19.5%
Risk management	3	2.3%
Research and Development	6	4.7%
Public sector reorganization	2	1.6%
Manufacturing	6	4.7%
Information technology	34	26.6%
Engineering	20	15.6%
Defense	6	4.7%
Construction	4	3.1%
Business change / reorganization	9	7.0%
Other	4	3.1%
Total	128	

Respondents provided information about the approximate dollar value of their projects (Table 31). More than a quarter (25.5%) of the projects are valued at $100,000 to $500,000, while projects valued over $10 million represented 23.5% of all the projects in the sample.

Table 31: The approximate dollar value of respondents' projects.

Monetary Value of Project	Qty	Percentage
less than $10,000	4	3.9%
$10,000 to $100,000	17	16.7%
$100,000 to $500,000	26	25.5%
$500,000 to $1 Million	11	10.8%
$1M to $5M	14	13.7%
$5M to $10M	6	5.9%
more than $10M	24	23.5%
Total	102	

Respondents provided information about the number of employees for 98 projects (Table 32). The majority of the projects (52.0 %) have 10 to 99 team members while 22.4% of the projects have relatively small team size (less than 10).

Table 32: Number of employees involved in the projects.

Number of Employees in the Project	Qty	Percentage
Less than 10	22	22.4%
10-99	51	52.0%
100-499	16	16.3%
500-999	5	5.1%
1,000 or more	4	4.1%
Total	98	

Final demographic data collected from the respondents is the time span of the projects in the sample (Table 33). More than half of the projects (52.5%) lasted more than 1 year with 31.7% lasting between 1 to 2 years 17.8% lasting between 2 and 5 years. The projects with time spans less than a year are 47.5% of all projects in the sample with 25.4% lasting 6 moths to 1 year and 21.8% lasting less than 6 months.

Table 33: The time span of respondents' projects.

Time Span of the Project	Qty	Percentage
Less than 2 months	4	4.0%
2-6 months	18	17.8%
6 months to 1 year	26	25.7%
1-2 years	32	31.7%
2-5 years	18	17.8%
more than 5 years	3	3.0%
Total	101	

4.4 Validity and Reliability of the Data Collection Instrument

Construct validation is a process where the investigator attempts to demonstrate that the instrument is measuring a construct (Gliner and Morgan, 2000). In order to determine the construct validity of a research instrument, factor analysis, where the clustering of items in the theory-based groups is the method used by the researchers (Gliner and Morgan, 2000). There are both exploratory and confirmatory approaches used in factor analysis. Exploratory factor analysis (EFA) is especially appropriate for scale development at the initial stages of theory development when there is little evidence for the common factors (Hurley et al., 1997). Confirmatory factor analysis (CFA) is more useful when the investigator has developed specific hypotheses about the factor structure in later stages of research (Swisher et al., 2004). In this dissertation, confirmatory factor analysis for each construct described in the conceptual model is the tool to test the construct validity. If the hypothesized factor model cannot be supported by the confirmatory analysis, exploratory factor analysis (EFA) is applied to determine a new factor structure. After a new factor structure is determined, this structure is further analyzed by CFA to test the construct validity. Figure 24 shows the factor analyses performed on the constructs of the conceptual model.

For all four constructs in the model shown in Figure 24, the initial process to assess the construct validity was confirmatory factor analysis. Except for the project management style (X2) construct, this initial confirmatory factor analysis was sufficient to obtain an acceptable fit model. The initial confirmatory analysis for the theoretical project management style (X2) construct could not be accepted, thus requiring an exploratory factor analysis process for a new model development. Later this model was subjected to the confirmatory factor analysis to obtain a final fit model. The analysis steps for each research constructs and the outcomes are shown in Table 34.

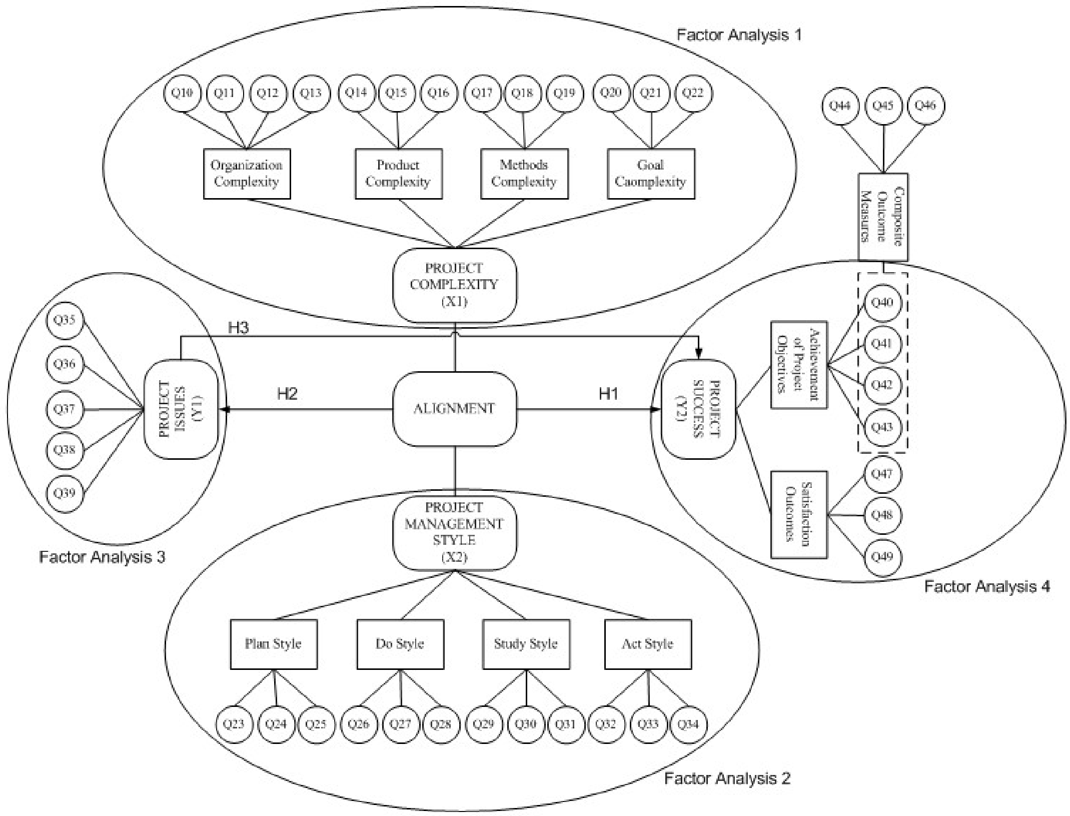


Figure 24: Factor analyses performed on the constructs of the conceptual model.

After determining the final factor structure for each construct using factor analysis techniques, the reliability of each factor or variable in a construct was determined using Cronbach’s alpha criteria. For these constructs developed during this research (project complexity, project management style and project issues) the lower threshold for Cronbach’s alpha was taken as 0.5 Nunnally (1967, 1978). And for the project performance construct, which is based on previous research by Tatikonda (1999), the lower threshold for Cronbach’s alpha value was 0.7.

Table 34: The analysis steps for research constructs.

Constructs	Project Complexity (X1) Construct	Project Management Style (X2) Construct	Project Issues (Y1) Construct	Project Performance (Y2) Construct
Theoretical Model **Factors** **Questions**	Organization Complexity: Q1, Q2, Q3, Q4 Product Complexity: Q5, Q6, Q7 Methods Complexity: Q8, Q9, Q10 Goal Complexity: Q11, Q12, Q13	Plan Style: Q14, Q15, Q16 Do Style: Q17, Q18, Q19 Study Style: Q20, Q21, Q22 Act Style: Q23, Q24, Q25	Issues: Q26, Q27, Q28, Q29, Q30	Project Objectives: Q31, Q32, Q33, Q34 Project Satisfaction: Q38, Q39, Q40
Analysis Step	Confirmatory Factor Analysis Reliability Analysis	Confirmatory Factor Analysis Exploratory Factor Analysis Confirmatory Factor Analysis Reliability Analysis	Confirmatory Factor Analysis Reliability Analysis	Confirmatory Factor Analysis Reliability Analysis
Final Model **Factors** **Questions**	UNCHANGED	Plan Style: Q14, Q15, Q16 Do Style: Q17, Q19, Q20 Study Style: Q18, Q21, Q22 Act Style: Q23, Q24, Q25	UNCHANGED	UNCHANGED

4.4.1 Missing Values

Before starting the confirmatory factor analysis using a sequential equation modeling program (AMOS), researchers should check the data for missing values for some of the critical aspects of SEM packages like modification indices can not be determined with incomplete data (Byrne, 2001). Missing values or partial nonresponse is commonplace in survey research (Govindarajulu, 1999). There are several approaches that a researcher can take to deal with the missing value problem (Roth, 1994):

- Listwise or casewise data deletion: Researcher omits the entire record from the analysis, when a record has missing data for any one variable used in a particular analysis.
- Pairwise data deletion: Cases are deleted when they have missing data on the variables after the researcher computes statistics based upon the available pairwise data for bivariate correlations or covariances.
- Mean substitution: In order to fill in missing data values, the researcher substitutes a variable's mean value computed from available cases.
- Regression methods: Using the complete case data for a given variable as the outcome and using all other relevant variables as predictors, the researcher develops a regression equation and substitutes the regression equation's predicted value for the missing values.
- Hot deck imputation: Researcher identifies the most similar case to the case with a missing value and substitutes the most similar case's value for respective values in the missing case.
- Expectation maximization (EM) approach: A two step iterative process: First, researcher computes the expected value of the complete data log likelihood. Second, researcher

substitutes the expected values for the missing values obtained and maximizes the likelihood function as if no data were missing to obtain new parameter estimates.

- Raw maximum likelihood methods: This method uses all available data to generate maximum likelihood-based sufficient statistics which usually consist of a covariance matrix of the variables and a vector of means.
- Multiple imputation: Multiple imputation method generates five to ten databases of actual raw data values suitable for filling in gaps in an existing database. Then, the researcher analyzes these data matrices using an appropriate statistical analysis method and then combines the results into a single summary finding.

Roth (1994) suggests that when missing data points are less than 10% of the data, using mean imputation gives satisfactory results. As shown in Table 35, all the missing data values are less than 10% for variables with missing values, thus in this dissertation mean substitution will be used as the method to fill in missing values.

Table 35: Missing data points.

Variable	Number of Missing Values	Available Data Points	Percentage Missing
Q1	2	126	1.59%
Q6	5	122	4.10%
Q7	4	124	3.23%
Q9	1	127	0.79%
Q10	2	126	1.59%
Q11	3	125	2.40%
Q12	3	125	2.40%
Q13	2	126	1.59%
Q15	1	127	0.79%
Q17	1	127	0.79%
Q29	1	127	0.79%
Q30	1	127	0.79%
Q31	1	127	0.79%
Q40	3	124	2.42%

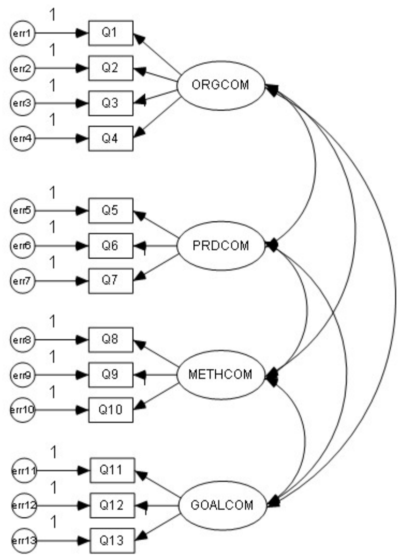
4.4.2 Factor Analysis 1: Project Complexity Construct (X1)

After the data is collected by the survey instrument and the missing values are substituted by the average scores, the validity of the data using confirmatory and exploratory (in case the confirmatory approach does not support the model) factor analysis methods can be determined. The factor analysis used in this dissertation is an iterative process where the researcher starts with a theoretical model and modifies it through the iterations in the process. The number of the steps is determined by the number of analyses needed to achieve a confirmed model. The steps in the factor analysis process for the project complexity construct (X1) are given in Figure 25.

Step 1 - Building the Theoretical Model:

In Figure 25 (Step 1), the theoretical model for project complexity construct (X1) is shown. In this model, the measured variables are the questions of the survey related to project performance (Q1, Q2,…, Q13). The latent variables are the dependent variables or the theorized factors (organizational complexity (ORGCOM), product complexity (PRDCOM), methods complexity (METHCOM) and goal complexity (GOALCOM)) and the measurement errors associated with each observed variable (err1, err2,…, err13).

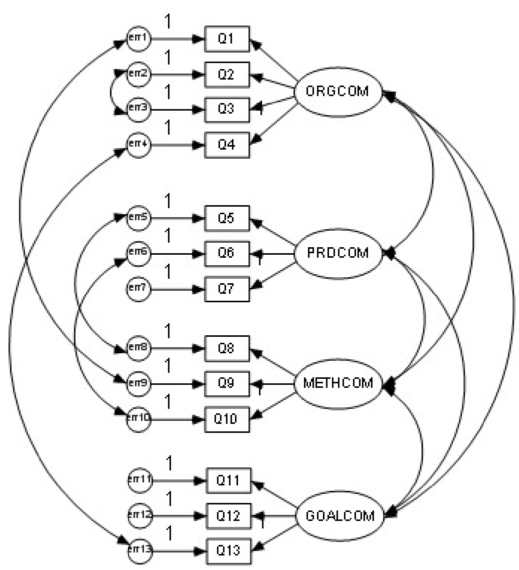
Step 1 – Building the Theoretical Model



Step 2 – Analysis Results of the Theoretical Model

Fit Index	Model Result	Test	Comment
P	.000	>0.05	Not acceptable
χ2 / DF	2.334	< 2	Not acceptable
NFI	.807	>0.90	Not acceptable
RFI	.745	>0.90	Not acceptable
IFI	.880	>0.90	Not acceptable
TLI	.836	>0.90	Not acceptable
CFI	.876	>0.90	Not acceptable
RMSEA	.102	< 0.08	Not acceptable

Step 3 – Modifying the Model



Step 4 – Analysis Results of the Modified Model

Fit Index	Model Result	Test	Comment
P	.059	>0.05	Good Fit
χ2 / DF	1.317	< 2	Good Fit
NFI	.900	>0.90	Acceptable Fit
RFI	.856	>0.90	Not acceptable (Small sample size affect RFI)
IFI	.974	>0.90	Very Good Fit
TLI	.961	>0.90	Very Good Fit
CFI	.973	>0.90	Very Good Fit
RMSEA	.050	< 0.08	Very Good Fit

Figure 25: The steps of factor analysis for Project Complexity (X1) construct.

Step 2 – Analysis Results of the Theoretical Model:

After the model is specified, the model is analyzed by AMOS using the data file collected during the survey process. The first test is the significance test for parameter estimates. The test statistic for significance of parameter estimates is the critical ratio, which represents the parameter estimate divided by its standard error and it operates as a z-statistic which tests the estimate is statistically different from zero (Byrne, 2001). Since all test statistics are larger than ±1.96 for 0.05 significance level, these parameters are included in the model (Appendix B, Table 58).

The AMOS output of goodness-of-fit Statistics for project complexity construct (X1) is shown in Table 59 in Appendix B. The test of our H_0—that project complexity is a four-factor construct as depicted in Figure 25 (as shown in Step 1)— yielded a $\chi 2$ (CMIN) value of 140.186, with 59 degrees of freedom and a probability of less than .0001 ($p < .05$), thus suggesting that the fit of the data to the hypothesized model is not entirely adequate. In other words, this test statistic shows that, with the data available, the hypothesis related to project complexity relations represents an unlikely event (occurring less than one time in a thousand under the null hypothesis) and should be rejected. At this point of the analysis, it is redundant to check other goodness-of-fit statistics. Since the model does not fit, the next step is to check the modification indices to see if the model can be modified.

Step 3 – Modifying the Model:

When a model does not fit at first try; model modification is required to obtain a better-fitting model. In sequential equation modeling (SEM), modification indices are used to generate expected reduction in the overall model fit chi-square ($\chi 2$) for each path that can be added to the model. The rule of thumb for modification indices is to allow two error term variables to correlate when their respective modification index (MI) exceeds 4 starting from the greatest MI (Byrne, 2001). But modifying the model based on modification indices might not yield a fitted solution. Diamantopoulos and Siguaw (2000) suggest that, correlating error terms should only be allowed when it makes statistical and theoretical sense to do so. In practice Diamantopoulos and Siguaw (2000) suggest that researchers should change paths or covariances one at a time only if this change makes sense theoretically until an acceptable solution is reached. Table 36 shows the necessary iterations to achieve an adequate modified model and if these modifications make theoretical sense. After these iterations error terms of Q5 and Q8, Q6 and Q10, Q2 and Q3, Q4 and Q13, Q1 and Q9 are correlated. Allowing correlations between the error terms of Q2-Q3, Q5-Q8, Q7-Q10 and Q4-Q13 yields the modified model given in Figure 25 (Step 3). From this point forward, project complexity construct will be analyzed using this model.

Table 36: The AMOS output of modification indices for project complexity construct (X1).

Iteration	Items with the highest MI	MI	Variables (Questions)	P value of the Modified Model	Theoretical Sense
1	Err5 - Err8	**18.118**	Q5 - The novelty/newness of the product Q8 - The newness of the technologies to deliver the final product	.000 (not adequate)	Both questions ask about the novelty/newness of either product or process.
2	Err6- Err10	**13.759**	Q6 - The number of the product sub assemblies Q10- The impact of a change in one process on to other processes needed to deliver the final product	.000 (not adequate)	Number of the product sub assemblies affects the impact of a change in one process on to other processes.
3	Err2 - Err3	**9.487**	Q2 - The number of vendors/ subcontractors Q3 - The number of departments involved in the project	.010 (not adequate)	Vendors/subcontractors and functional departments are stakeholders outside the project who contribute to the project externally.
4	Err4 - Err13	**6.213**	Q4 - The number of projects dependent on this project Q13 - The impact of not realizing the goals of the project on the organization	.025 (not adequate)	Both questions ask about the external effects of the project on other projects and overall organization.
5	Err1 - Err9	**5.166**	Q1 - The size of the project Q9 - Number of the processes needed to deliver the final product	.059 (adequate)	Number or processes needed to deliver the final product is related to the project size

Step 4 – Analysis Results of the Modified Model

The AMOS output of goodness-of-fit statistics for project complexity construct (X1) is shown in Table 60 of Appendix B. The test of our H_0—that project complexity is a four-factor construct as depicted in Figure 24— yielded a $\chi2$ (CMIN) value of 69.850, with 54 degrees of freedom and a probability of 0.059 ($p > 0.05$), thus suggesting that the fit of the data to the hypothesized model is adequate. The other goodness of it statistics for the model yields following results:

- $\chi2$ / DF (the minimum discrepancy divided by its degrees of freedom) is 1.317 < 2, thus represents an adequate fit.

- The normed fit index (NFI) has shown a tendency to underestimate fit in small samples (Byrne, 2001) and the value of NFI=0.900 (>0.90) indicates good fit.
- The relative fit index (RFI) represents a derivative of the NFI and like NFI, RFI shows a tendency to underestimate fit in small samples (Byrne, 2001). The value of RFI= 0.856 (<0.90) indicates inadequate fit but due to the small sample size, this result can be overlooked (Byrne, 2001).
- The incremental index of fit (IFI) was to address sample size, the issue faced by NFI and RFI (Byrne, 2001). The value of IFI= 0.974 (> 0.95) indicates a very good fit.
- The Tucker–Lewis index (TLI) yields values ranging from zero to 1.00 and the value of TLI= 0.961 (> 0.95) indicates a very good fit (Byrne, 2001).
- The comparative fit index (CFI) is less sensitive to the sample size than NFI and the value of CFI = 0.973 (>0.90) indicates a very good fit.
- The root mean square error of approximation (RMSEA) index takes into account the error of approximation in the population (Byrne, 2001). The value of RMSAE = 0.050 (< 0.05) indicate a very good fit.

After comparing the fit indices to their accepted levels, it can be concluded that the project complexity (X1) construct has a four factor structure as shown in Figure 25 (Step 3).

4.4.3 Factor Analysis of Project Management Style construct (X2)

The second construct to be analyzed using factor analysis processes is the project management style (X2) construct. Since the number of the steps is determined by the number of analyses needed to achieve a confirmed model, unlike the project management style construct (X1), the project management style (X2) needed a 6 step factor analysis process as shown in Figure 26 (Step 1).

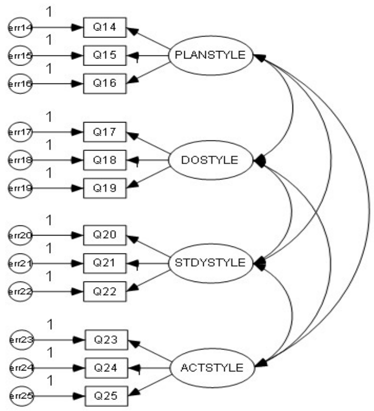
Step 1 - Building the Theoretical Model:

In Figure 26, the theoretical model for project management style (X2) construct is shown. In this model, the measured variables are the questions of the surveys (Q14, Q15,.., Q25). The latent variables are the dependent variables or the theorized factors (planning style (PLANSTYLE), execution style (DOSTYLE) monitoring style (STDYSTYLE) and control and action style (ACTSTYLE)) and the measurement errors associated with each observed variable (err14, err15,…err25).

Step 2 – Analysis Results of the Theoretical Model:

After the model is specified, the model is analyzed by AMOS using the data file collected during the survey process. Before scrutinizing the significance of parameter of estimates and goodness-of-fit statistics, AMOS analysis concludes that "The solution is not admissible", which suggests that either the model is wrong or the sample is too small (Jöreskog & Sörbom, 1984). Since the same sample gave an acceptable solution for the project complexity construct (X1), it can be concluded that the factor structure is likely to be wrong and a new factor structure should be developed using exploratory factor analysis.

Step 1 - Building the Theoretical Model:

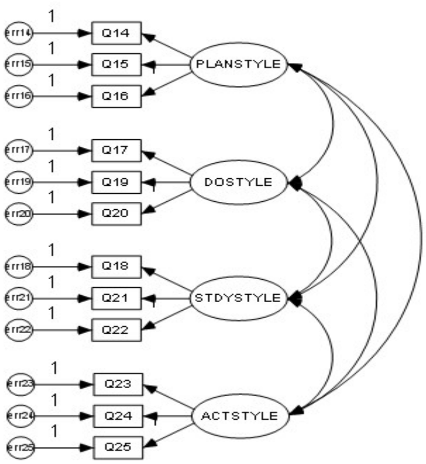


Step 2 – Analysis Results of the Theoretical Model

The solution is not admissible.

(A new model should be developed by using Exploratory Factor Analysis)

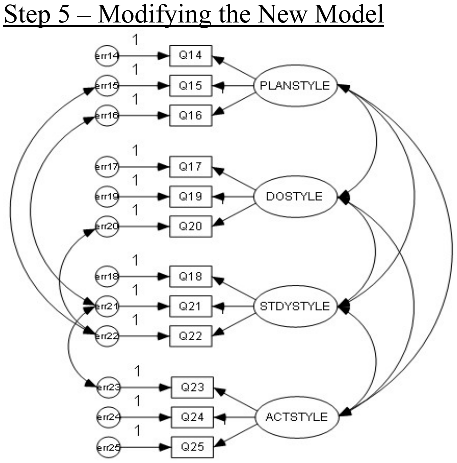
Step 3- Exploratory Factor Analysis to Develop a New Model



Step 4 – Analysis Results of the New Model

Fit Index	Model Result	Test	Comment
P	.001	>0.05	Not acceptable
χ2 / DF	1.740	< 2	Acceptable
NFI	.846	>0.90	Not acceptable
RFI	.789	>0.90	Not acceptable
IFI	.928	>0.90	Acceptable
TLI	.898	>0.90	Not acceptable
CFI	.926	>0.90	Acceptable
RMSEA	.076	< 0.08	Marginally acceptable

Step 5 – Modifying the New Model



Step 6 – Analysis Results of the Modified New Model

Fit Index	Model Result	Test	Comment
P	.061	>0.05	Good Fit
χ2 / DF	1.350	< 2	Very Good Fit
NFI (Small sample size affect NFI)	.891	>0.90	Not acceptable (Overlooked)
RFI (Small sample size affect RFI)	.836	>0.90	Not acceptable (Overlooked)
IFI	.969	>0.90	Very Good Fit
TLI	.952	>0.90	Very Good Fit
CFI	.968	>0.90	Very Good Fit
RMSEA	.052	< 0.08	Very Good Fit

Figure 26: The steps of factor analysis for Project Management Style (X2) construct.

Step 3- Exploratory Factor Analysis to Develop a New Model:

a) Assessment of the appropriateness of the data: Before starting the actual analysis, a researcher should check if the data is appropriate for the exploratory factor analysis. Main issues to be addressed in this assessment are as follows (Pallant, 2001):

- Correlations among items: In order for to be exploratory factor analysis feasible, there should be substantial number of correlation coefficients greater than 0.3 in the correlation matrix of questions of the construct. As shown in Table 37, there is a substantial number of correlation coefficients (41 of 66 or 62%) greater than 0.3.

Table 37: Correlation coefficients of the questions of project style construct.

	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25
Q14	1.000	.165	.314	.167	.050	.041	.098	-.041	.119	.162	.038	.105
Q15	.165	1.000	.520	.351	.428	.253	.382	.309	.532	.314	.257	.329
Q16	.314	.520	1.000	.302	.440	.272	.372	.262	.480	.471	.372	.373
Q17	.167	.351	.302	1.000	.228	.307	.335	.242	.296	.397	.332	.287
Q18	.050	.428	.440	.228	1.000	.259	.278	.545	.543	.400	.423	.498
Q19	.041	.253	.272	.307	.259	1.000	.243	.354	.207	.326	.282	.264
Q20	.098	.382	.372	.335	.278	.243	1.000	.435	.485	.463	.256	.303
Q21	-.041	.309	.262	.242	.545	.354	.435	1.000	.485	.329	.451	.439
Q22	.119	.532	.480	.296	.543	.207	.485	.485	1.000	.437	.455	.500
Q23	.162	.314	.471	.397	.400	.326	.463	.329	.437	1.000	.514	.628
Q24	.038	.257	.372	.332	.423	.282	.256	.451	.455	.514	1.000	.436
Q25	.105	.329	.373	.287	.498	.264	.303	.439	.500	.628	.436	1.000

- Bartlett's test of sphericity should be significant ($p<0.05$). As shown in Table 38, Bartlett's test of sphericity is significant ($0.00<0.05$).

- The Kaiser-Meyer-Olkin measure (KMO) ranges from 0 to 1, and 0.6 is considered to be the minimum value for an appropriate factor analysis. Table 38 shows that, the Kaiser-Meyer-Olkin measure (KMO) is $0.847 >0.6$.

Table 38: Bartlett's test of sphericity and the Kaiser-Meyer-Olkin measure (KMO).

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	**Bartlett's Test of Sphericity**		
	Approx. Chi-Square	df	Sig.
.847	519.718	66	.000

All three appropriateness tests suggest that the data is appropriate for factor analysis.

b) Factor extraction: Using the statistical software package SPSS and principal axis factoring, an initial set of factors is extracted. Table 39 shows the extracted factors of the project management style construct (X2).

Table 39: The extracted factors of the project management style construct (X2).

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	4.851	40.421	40.421
2	1.237	10.307	50.728
3	.971	8.089	58.816
4	.893	7.438	66.255
5	.776	6.468	72.723
6	.684	5.702	78.425
7	.627	5.224	83.648
8	.571	4.762	88.410
9	.442	3.683	92.093
10	.365	3.044	95.136
11	.339	2.825	97.962
12	.245	2.038	100.000

At this point, the researcher should determine the number of factors to be used in the analysis. The first method to determine the number of factors is the Kaiser or K1 rule, which identifies the number of factors to be retained as the number of factors whose eigenvalues of the correlation matrix are greater than one. Table 39 shows that only 2 factors are greater than one. The second method to determine the number of factors is the scree plot (Figure 27), which is used to graphically determine the number of factors. As seen in Figure 26, there are also 2 factors where the plot levels off to a linear decreasing pattern. Both Kaiser (K1) rule and scree plot (Figure 27) suggest a two-factor structure. But first two factors explain only 50.49 % of the total variance of the factor. Also the facts that the third factor is very close to the Kaiser criterion (0.973) and the fourth factor is relatively close (0.893) suggest that the factor structure can have more than two factors (Rummel, 1970). Also, a four factor structure explains 66.2 % of the total variance and fits with the original four factor theoretical model. Thus, the subsequent factor rotation is based on a four factor structure.

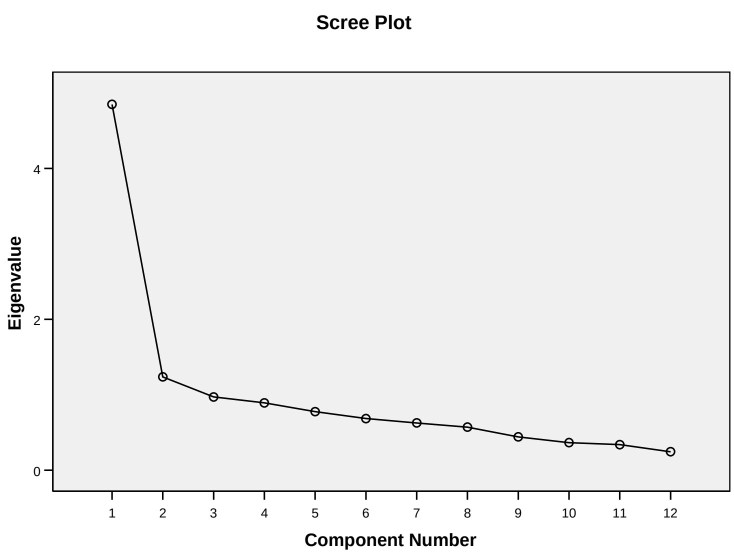


Figure 27: Scree Plot for project management style construct (X2).

c) Factor rotation: Rotation is a necessary step after the extraction suggests there are four factors. The rotation technique used in this dissertation is rotated using orthogonal, varimax transformation. Table 40 shows the unrotated and rotated factor matrices.

Table 40: The unrotated and rotated factor loadings of the project management style construct (X2).

Unrotated Factor Matrix

	Factor			
	1	2	3	4
Q14	.180	.368	.072	-.029
Q15	.628	.176	.369	.048
Q16	.652	.329	.181	-.090
Q17	.500	.173	-.069	.297
Q18	.671	-.224	.137	-.231
Q19	.416	-.032	-.076	.253
Q20	.565	.040	.053	.210
Q21	.650	-.529	.060	.161
Q22	.731	-.049	.218	-.120
Q23	.748	.210	-.495	-.054
Q24	.603	-.109	-.161	-.026
Q25	.680	-.072	-.219	-.214

Rotated Factor Matrix

	Factor			
	1	2	3	4
Q14	-.024	.069	.047	**.408**
Q15	.475	.007	.314	**.488**
Q16	.369	.230	.219	**.581**
Q17	.100	.205	**.505**	.257
Q18	**.682**	.281	.127	.112
Q19	.159	.170	**.433**	.055
Q20	.295	.160	**.455**	.219
Q21	**.652**	.168	.471	-.235
Q22	**.635**	.221	.240	.298
Q23	.147	**.792**	.362	.269
Q24	.368	**.421**	.293	.057
Q25	.432	**.575**	.174	.120

d) Analysis of factor structure : The resulting factor structure is analyzed looking at the individual factor loadings to find out whether they are significant (factor loadings are significant with values greater than 0.4 in a sample size less than 100 and greater than 0.3 for sample size greater than 100). This analysis yields no insignificant variables to be excluded from the factor structure. Table 41 shows the final structure of the factors for the project management style construct. The final structure is similar to the hypothesized factor structure except that DO STYLE variable consists of Q17, Q19, Q20 (instead of Q17, Q18, Q19) and STUDY STYLE variable consists of Q18, Q21, Q22 (instead of Q20, Q21, Q22). The final representation of the project style construct is given in Figure 28. This model is again subjected to confirmatory factor analysis for a further model fit.

Table 41: The final structure of the factors for the project management style construct.

	Factor			
	PLAN STYLE (4)	DO STYLE (3)	STUDY STYLE (1)	ACT STYLE (2)
Q14	**<u>0.408</u>**	0.047	-0.024	0.069
Q15	**<u>0.488</u>**	0.314	0.475	0.007
Q16	**<u>0.581</u>**	0.219	0.369	0.23
Q17	0.257	**<u>0.505</u>**	0.1	0.205
Q19	0.055	**<u>0.433</u>**	0.159	0.17
Q20	0.219	**<u>0.455</u>**	0.295	0.16
Q18	0.112	0.127	**<u>0.682</u>**	0.281
Q21	-0.235	0.471	**<u>0.652</u>**	0.168
Q22	0.298	0.24	**<u>0.635</u>**	0.221
Q23	0.269	0.362	0.147	**<u>0.792</u>**
Q24	0.057	0.293	0.368	**<u>0.421</u>**
Q25	0.12	0.174	0.432	**<u>0.575</u>**

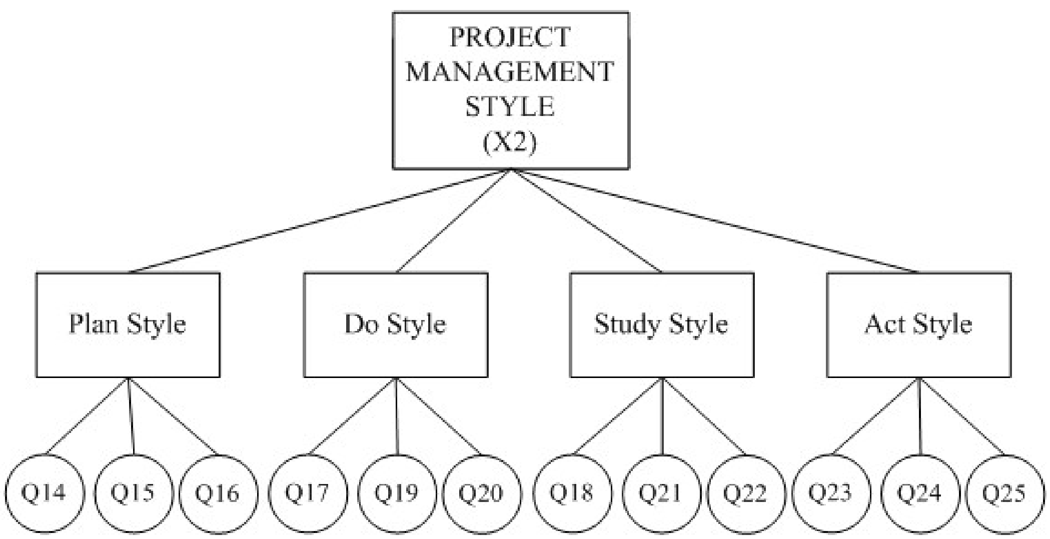


Figure 28: The final representation of the project style construct.

The exploratory factor analysis suggests that Q18 which is originally conceptualized as a variable of “do” style belongs to “act” style and Q20 which is originally conceptualized as a variable of Act Style belongs to Do Style. These questions are:

Q18- Team members continuously reported the status of their tasks to the team leaders or the project manager.

Q20 - Project management received just-in-time information about the progress of the project.

Both of these questions deal with the feedback processes related to the progress of the project. Q18 involves information flow initiated from the bottom, thus “study” style which deals with the monitoring of the project is appropriate factor for Q18. Q20 involves information flow initiated from the top, thus “do” style which deals with the execution of the project is appropriate factor for Q20. In Figure 26, the measurement models for new project management styles (X2) construct after the exploratory factor analysis and confirmatory factor analysis are shown (Step 3).

In order to confirm the new structure determined by the exploratory factor analysis and to determine the factor scores, the project management style (X2) construct is further analyzed using AMOS SEM software package.

Step 4 – Analysis Results of the New Model

After the model is constructed as specified by the exploratory factor analysis, the model is analyzed by AMOS using the data file collected during the survey process. The first test is the significance test for parameter estimates. Since all test statistics are larger than ±1.96 for 0.05 significance level, these parameters are included in the model (Appendix B, Table 61).

The AMOS output of goodness-of-fit statistics for project complexity construct (X1) is shown in Table 62 in Appendix B. The test of our H_0—that new project management style construct is a four-factor construct as depicted in Figure 26 (Step 3) — yielded a $\chi 2$ (CMIN) value of 140.186, with 59 degrees of freedom and a probability of less than .0001 ($p < .05$), thus suggesting that the fit of the data to the hypothesized model is not entirely adequate. In other words, this test statistic shows that the hypothesis related to project management style relations represents an unlikely event (occurring less than one time in a thousand under the null hypothesis) and should be rejected. At this point of the analysis, it is redundant to check other goodness-of-fit statistics. Since the model does not fit, the next step is to check the modification indices.

Step 5 – Modifying the New Model:

Table 42 shows the necessary iterations to achieve an adequate modified model and if these modifications make theoretical sense. After these iterations error terms of Q15 and Q22, Q16 and Q21, Q21 and Q23, Q20 and Q22 are correlated. Allowing correlations between the error terms of Q15-Q22, Q16-Q21, Q21-Q23 and Q20-Q22 yields the modified model given in

Figure 26 (Step 5). From this point forward, project management style construct will be analyzed using this model.

Table 42: The AMOS output of modification indices for project management style construct (X2).

Iteration	Items with the highest MI	MI	Variables (Questions)	P value of the Modified Model	Theoretical Sense
1	Err15 – Err22	**5.433**	Q15 - The customer was involved in the decision making process from start of the project. Q22 - The project team regularly presented the progress of the project to the management of the organization and the customer.	.004 (not adequate)	Both questions ask about involvement of the customer into the project management process.
2	Err16-Err21	**6.104**	Q16 - Project plans were revised periodically in short intervals. Q21- Project team members investigated and reported the causes for non-realization of their assigned tasks.	.004 (not adequate)	Revision of project plans is based on the investigation and reports on the causes for non-realization of assigned tasks.
3-a	Err21 - Err23	**4.747**	Q21- Project team members investigated and reported the causes for non-realization of their assigned tasks Q23 - Project plans were revised regularly using the lessons learned during the project.	.014 (not adequate)	Revision of project plans is based on the investigation and reports on the causes for non-realization of assigned tasks which are the lessons learned in the project.
3-b	Err20 - Err22	**4.051**	Q20 - Project management received just-in-time information about the progress of the project. Q22 - The project team regularly presented the progress of the project to the management of the organization and the customer	.014 (not adequate)	Both questions ask about how regularly information is shared with in the project.

Step 6 – Analysis Results of the Modified New Model:

The AMOS output of goodness-of-fit statistics for project management style construct (X2) is shown in Table 63 of Appendix B. The test of our H_0—that project complexity is a four-factor construct as depicted in Figure 28— yielded a $\chi 2$ (CMIN) value of 69.850, with 54 degrees of freedom and a probability of 0.059 ($p > 0.05$), thus suggesting that the fit of the data to the hypothesized model is adequate. The other goodness-of-fit statistics for the model yields following results:

- $\chi2$ / DF (the minimum discrepancy divided by its degrees of freedom) is 1.350 < 2, thus representing an adequate fit.
- The normed fit index (NFI) =0.891 (>0.90) indicates inadequate fit but due to the small sample size, this result can be overlooked (Byrne, 2001).
- The relative fit index (RFI) = 0.836 (<0.90) indicates inadequate fit but, due to the small sample size, this result can be overlooked (Byrne, 2001).
- The incremental index of fit (IFI) = 0.969 (> 0.95) indicates a very good fit.
- The Tucker–Lewis index (TLI) = 0.952(> 0.95) indicates a very good fit (Byrne, 2001).
- The comparative fit index (CFI) = 0.968 (>0.90) indicates a very good fit.
- The root mean square error of approximation (RMSEA) = 0.052 (< 0.05) indicate a good fit.

After comparing the fit indices to their accepted levels, it can be concluded that the project management style (X2) construct has a four-factor structure (Figure 26, Step 5) as determined by the previous exploratory factor analysis.

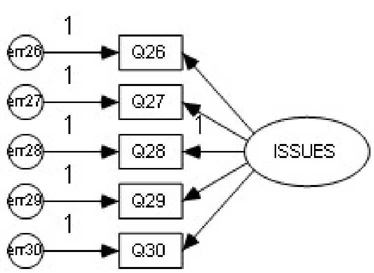
4.4.4 Factor Analysis of Project Issues Construct (Y1)

The next construct to be analyzed using factor analysis processes is the project issues (Y1) construct. Since the number of the steps is determined by the number of analyses needed to achieve a confirmed model, like the project management style construct (X1), the project issues (Y1) needed a 4 step factor analysis process as shown in Figure 29.

Step 1 – Building the Theoretical Model:

In Figure 29 (Step 1), the measurement model for the project issues (Y1) construct is shown. In this model, the measured variables are the survey questions Q26, Q27,.., Q30. Project issues is a single-factor construct. The only latent variables are the measurement errors associated with each observed variable (err26, err27,…err30).

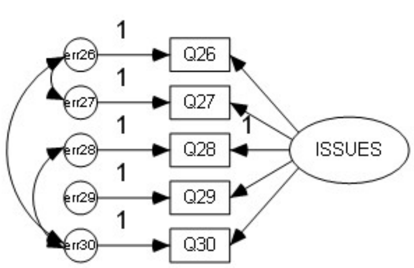
Step 1 – Building the Theoretical Model



Step 2 – Analysis Results of the Theoretical Model

Fit Index	Model Result	Test	Comment
P	.000	>0.05	Not acceptable
χ2 / DF	5.571	< 2	Not acceptable
NFI	.867	>0.90	Not acceptable
RFI	.733	>0.90	Not acceptable
IFI	.888	>0.90	Not acceptable
TLI	.770	>0.90	Not acceptable
CFI	.885	>0.90	Not acceptable
RMSEA	.190	< 0.05	Not acceptable

Step 3 – Modifying the Model



Step 4 – Analysis Results of the Modified Model

Fit Index	Model Result	Test	Comment
P	.562	>0.05	Very Good Fit
χ2 / DF	.576	< 2	Very Good Fit
NFI	.994	>0.90	Very Good Fit
RFI	.972	>0.90	Very Good Fit
IFI	1.004	>0.90	Very Good Fit
TLI	1.021	>0.90	Very Good Fit
CFI	1.000	>0.90	Very Good Fit
RMSEA	.000	< 0.05	Very Good Fit

Figure 29: The steps of factor analysis for Project Issues (Y1) construct.

Step 2 – Analysis Results of the Theoretical Model:

After the model is specified, the model is analyzed by AMOS using the data file collected during the survey process. The first test is the significance test for parameter estimates. The test statistic for significance of parameter estimates is the critical ratio, which represent s the parameter estimate divided by its standard error and it operates as a z-statistic which tests whether the estimate is statistically different from zero (Byrne, 2001). Since all test statistics are larger than ±1.96 for 0.05 significance level, these parameters are included in the model (Appendix B, Table 64).

The AMOS output of goodness-of-fit statistics for project issues construct (Y1) is shown in Table 65 of Appendix B. The test of our H_0—that project issues is a single-factor construct as depicted in Figure 29, yielded a $\chi 2$ (CMIN) value of 29.541, with 5 degrees of freedom and a probability of less than .0001 ($p < .05$), thus suggesting that the fit of the data to the hypothesized model is not entirely adequate. In other words, this test statistic shows that the hypothesis related to project issues relations represents an unlikely event (occurring less than one time in a thousand under the null hypothesis) and should be rejected. At this point of the analysis, it is redundant to check other goodness-of-fit statistics. Since the model does not fit, the next step is to check the modification indices.

Step 3 – Modifying the Model:

The AMOS output of modification indices for the project issues construct (Y1) is shown in Table 43. In this model only covariances have significant (greater than 4) modification indices. In this case the highest MIs are between the error terms of Q28 and Q30, Q26 and Q30, Q26 and Q27. Allowing correlations between the error terms of Q28-Q30, Q26-Q30 and Q26-Q27 yields the modified model given in Figure 28 (Step 3). From this point forward, project issues construct will be analyzed using this model.

Table 43: The AMOS output of modification indices for project issues construct (Y1)

Iteration	**Items with the highest MI**	**MI**	**Variables (Questions)**	**P value of the Modified Model**	**Theoretical Sense**
1	Err28 – Err30	**11.733**	Q28 - Lack of experience/ expertise of project personnel. Q30 - Excessive dependence on vendors/consultants	.005 (not adequate)	It can be assumed that as the experience/ expertise of project personnel decreases dependence on vendors/consultants might increases.
2	Err26-Err30	**8.806**	Q26 - Lack of customer commitment to the project and its deliverables.. Q30 - Excessive dependence on vendors/consultants.	.025 (not adequate)	Customers and vendors/subcontractors represent the opposite end of the stakeholder continuum.
3	Err26 - Err27	**7.110**	Q28 - Lack of customer commitment to the project and its deliverables. Q27 -Lack of top management support to the project.	.562 (adequate)	For a project manager's perspective, customers and senior management are two stakeholders whose satisfaction is very important.

Step 3 – Modifying the Model:

The AMOS output of goodness-of-fit statistics for project issues (Y1) is shown in Table 66 (Appendix B). The test of our H_0—that project issues is a single-factor construct as depicted in Figure 30— yielded a $\chi 2$ (CMIN) value of 0.682, with 2 degrees of freedom and a probability of 0.562 ($p > 0.05$), thus suggesting that the fit of the data to the hypothesized model is adequate. The other goodness of it statistics for the model yields following results:

- $\chi 2$ / DF (the minimum discrepancy divided by its degrees of freedom) is 0.576 < 2, thus representing an adequate fit.
- The normed fit index (NFI) =0.994 (>0.90) indicates a very good fit.
- The relative fit index (RFI) = 0.972 (>0.90) indicates a very good fit.
- The incremental index of fit (IFI) = 1.004 (> 0.95) indicates a very good fit.
- The Tucker–Lewis index (TLI) = 1.021 (> 0.95) indicates a very good fit (Byrne, 2001).
- The comparative fit index (CFI) = 1.000 (>0.90) indicates a very good fit.
- The root mean square error of approximation (RMSEA) = 0.00 (< 0.05) indicates a very good fit.

4.4.5 Factor Analysis of Project Performance Construct (Y2)

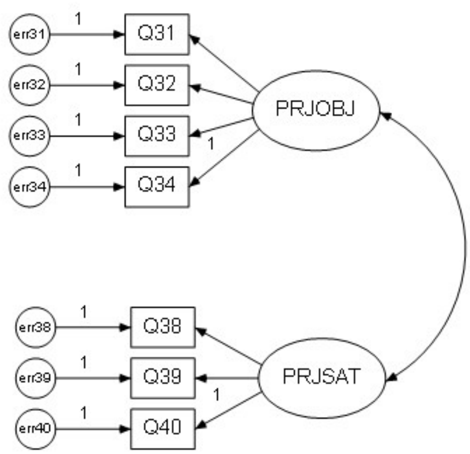
The final construct to be analyzed using factor analysis processes is the project performance (Y2) construct. Like the previous project management style (X1) and the project issues (Y1) constructs, the project performance (Y2) construct needed a 4-step factor analysis process as shown in Figure 30.

a) Model Development: In Figure 30 (step 1), the measurement model for the project performance (Y2) construct is shown. In this model, the measured variables are the questions of the survey related to project performance (Q31, Q32, Q33, Q34, Q38, Q39, Q40). Questions Q35, Q36, Q37 are used to determine the weights for questions Q31, Q32, Q33 as follows:

- For Q31, weight, W31 = [(Q35 * 0.75) / (Q35+Q36+Q37)]. Using this weight score, the Q31 becomes Q31' = [(W31 * Q31) / 0.25]
- For Q32, weight, W32 = [(Q36 * 0.75) / (Q35+Q36+Q37)]. Using this weight score, the Q32 becomes Q32' = [(W32 * Q32) / 0.25]
- For Q33, weight, W33 = [(Q37 * 0.75) / (Q35+Q36+Q37)]. Using this weight score, the Q33 becomes Q33' = [(W33 * Q33) / 0.25]

The latent variables are the dependent variables or the theorized factors (project objectives (PRJOBJ) and project satisfaction (PRJSAT)) and the measurement errors associated with each observed variable (err31, err32, err33, err34, err38, err39, err40).

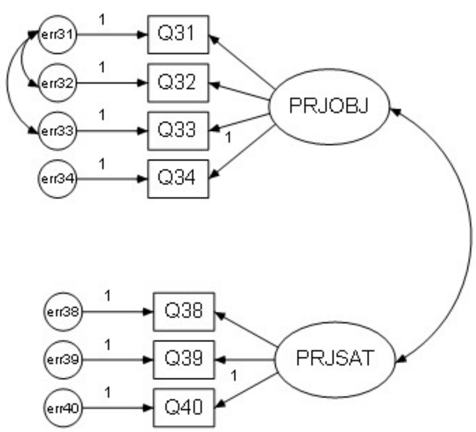
Step 1 – Building the Theoretical Model



Step 2 – Analysis Results of the Theoretical Model

Fit Index	Model Result	Test	Comment
P	.000	>0.05	Not acceptable
χ2 / DF	3.311	< 2	Not acceptable
NFI	.938	>0.90	Very Good Fit
RFI	.900	>0.90	Very Good Fit
IFI	.956	>0.90	Very Good Fit
TLI	.928	>0.90	Very Good Fit
CFI	.955	>0.90	Very Good Fit
RMSEA	.135	<0.08	Not Acceptable

Step 3 – Modifying the Model



Step 4 – Analysis Results of the Modified Model

Fit Index	Model Result	Test	Comment
P	.622	>0.05	Very Good Fit
χ2 / DF	.818	< 2	Very Good Fit
NFI	.987	>0.90	Very Good Fit
RFI	.975	>0.90	Very Good Fit
IFI	1.003	>0.90	Very Good Fit
TLI	1.006	>0.90	Very Good Fit
CFI	1.000	>0.90	Very Good Fit
RMSEA	.000	< 0.05	Very Good Fit

Figure 30: The steps of factor analysis for Project Performance (Y2) construct.

Step 2 – Analysis Results of the Theoretical Model

After the model is specified, the model is analyzed by AMOS using the data file collected during the survey process. The first test is the significance test for parameter estimates. Since all the critical ratio statistics are larger than ±1.96 for 0.05 significance level, these parameters are included in the model (Table 67 in Appendix B).

The AMOS output of goodness-of-fit statistics for the project performance construct (Y2) is shown in Table 68 (in Appendix B). The test of our H_0—that project performance is a two-factor construct as depicted in Figure 24— yielded a $\chi 2$ (CMIN) value of 22.490, with 13 degrees of freedom and a probability of less than .048 ($p < .05$), thus suggesting that the fit of the data to the hypothesized model is not entirely adequate. At this point of the analysis, it is redundant to check other goodness-of-fit statistics. Since the model does not fit, the next step is to check the modification indices.

Step 3 – Modifying the Model:

- Since the model does not fit at first try, model modification is required to obtain a better-fitting model. The AMOS output of modification indices (MIs) for project issues construct (Y1) is shown in Table 44. In this case the highest MIs are between the error terms of Q31 and Q33, Q31 and Q32. Allowing correlations between the error terms of Q31-Q33 and Q31-Q32 yields the modified model given in Figure 30 (Step 3). From this point forward, the project issues construct will be analyzed using this model.

Table 44: The AMOS output of modification indices for project complexity construct (X1).

Iteration	Items with the highest MI	MI	Variables (Questions)	P value of the Modified Model	Theoretical Sense
1	Err31 – Err33	**12.073**	Q28 - To what degree was the original technical performance objective met? Q30 - To what degree was the original schedule objective met?	.0017 (not adequate)	Both questions ask about the degree by which an objective is met.
2	Err31-Err32	**9.646**	Q28 - To what degree was the original technical performance objective met? Q29- To what degree was the original cost objective met?	.622 (adequate)	Both questions ask about the degree by which an objective is met.

Step 4 – Analysis Results of the Modified Model:

The AMOS output of goodness-of-fit statistics for modified project performance (Y2) construct is shown in Table 69 in Appendix B. The test of our H_0—that project performance is a two-factor construct as depicted in Figure 30— yielded a $\chi 2$ (CMIN) value of 8.995, with 11 degrees of freedom and a probability of 0.622 ($p > .05$), thus suggesting that the fit of the data to the hypothesized model is adequate.

- $\chi 2$ / DF is 0.818 < 2, thus represents an adequate fit.
- The normed fit index (NFI) =0.987 (>0.90) indicates a very good fit.
- The relative fit index (RFI = 0.975 (>0.90) indicates a very good fit.
- The incremental index of fit (IFI) = 1.003 (> 0.95) indicates a very good fit.
- The Tucker–Lewis index (TLI) = 1.006 (> 0.95) indicates a very good fit (Byrne, 2001).
- The comparative fit index (CFI) = 1.000 (>0.90) indicates a very good fit.
- The root mean square error of approximation (RMSEA) = 0.00 (< 0.05) indicates a very good fit.

4.4.6 Reliability Analysis

After determining the construct validity of the factor structure for each construct using confirmatory or exploratory factor analysis techniques, the reliability of each factor or variable in a construct is determined using Cronbach's alpha criteria. According to Nunnally (1967, 1978), the lower threshold for Cronbach's alpha value is 0.5 for emerging construct scales and 0.7 for established scales. This dissertation aims to develop new constructs of project complexity, project management style and project issues. For these constructs, the lower threshold for Cronbach's alpha is taken as 0.5. As seen from the results of reliability analysis given in Table 45, all the factors or theoretical variables have adequate reliability.

Table 45: The results of reliability analysis of factors.

Construct	Factor	Cronbach's Alpha	Reliability Threshold
Project Complexity	Organizational Complexity	0.715	0.5
	Product Complexity	0.757	0.5
	Methods Complexity	0.750	0.5
	Goal Complexity	0.731	0.5
Project Management Style	Planning Style	0.603	0.5
	Execution Style	0.557	0.5
	Monitoring Style	0.766	0.5
	Control and Act style	0.770	0.5
Issues	Issues	0.796	0.5
Project Performance	Project Objectives	0.899	0.7
	Project Satisfaction	0.936	0.7

4.4.7 Factor Scores

The final step for a factor analysis is to determine the factor scores for further analyses like correlation or regression.

Project Complexity Construct (X1)

Table 46 shows the factor score weights obtained by analyzing the final model of project complexity (X1) construct using AMOS.

Table 46: The factor score weights for the factors of project complexity (X1) construct.

	ORGCOM	PRDCOM	METHCOM	GOALCOM
Q1	0.227	0.086	-0.043	0.02
Q2	0.027	0.013	0.001	0.004
Q3	0.08	0.04	0.004	0.011
Q4	0.055	0.028	0	-0.005
Q5	0.03	0.074	0.002	-0.005
Q6	0.089	0.297	0.21	0.033
Q7	0.061	0.172	0.063	0.003
Q8	-0.01	0.002	0.067	0.017
Q9	-0.065	0.057	0.182	0.031
Q10	0.07	0.296	0.329	0.064
Q11	0.029	0.006	0.047	0.185
Q12	0.036	0.007	0.058	0.229
Q13	-0.005	-0.005	0.015	0.06

The factor scores of organization complexity (ORGCOM), product complexity (PRDCOM), methods complexity (METHCOM) and goal complexity (GOALCOM) determined using the factor score weights shown in Table 46, are further subjected to principal components analysis (SPSS) in order to determine the factor score weights for the project complexity (X1).Table 47 shows the factor score weights for project complexity (X1) construct using SPSS.

Table 47: The factor score weights for the project complexity (X1) construct.

	Project Complexity
ORGCOM	0.262801
PRDCOM	0.280401
METHCOM	0.277323
GOALCOM	0.255235

Project Management Styles Construct (X2)

Table 48 shows the factor score weights obtained by analyzing the final model of project management style (X2) construct using AMOS.

Table 48: The factor score weights for the factors of project complexity (X1) construct.

	PLANSTYLE	**DOSTYLE**	**STDYSTYLE**	**ACTSTYLE**
Q14	0.041	0.013	0.007	-0.001
Q15	0.161	0.059	-0.014	-0.016
Q16	0.412	0.145	0.164	0.066
Q17	0.041	0.099	0.009	0.035
Q18	0.048	0.018	0.153	0.055
Q19	0.035	0.085	0.008	0.031
Q20	0.062	0.144	-0.013	0.041
Q21	0.213	0.105	0.241	0.161
Q22	-0.031	-0.039	0.139	0.043
Q23	0.064	0.119	0.143	0.291
Q24	-0.003	0.048	0.036	0.133
Q25	-0.004	0.058	0.044	0.163

The factor scores of planning style (PLANSTYLE), execution (do) style (DOSTYLE), monitoring (study) Style (STDYSTYLE) and control (act) Style (ACTSTYLE), determined using the factor score weights shown in Table 48, are further subjected to principal components analysis (SPSS) in order to determine the factor score weights for the project management style (X2). Table 49 shows the factor score weights for the project management styles (X2) construct using SPSS.

Table 49: The factor score weights for the project management style (X2) construct.

	Project Management Style
PLANSTYLE	0.255184
DOSTYLE	0.264511
STDYSTYLE	0.263541
ACTSTYLE	0.259076

Project Issues Construct (Y1)

Table 50 shows the factor score weights obtained by analyzing the final model of project issues (Y1) construct using AMOS.

Table 50: The factor score weights for the project issues (Y1) construct.

	ISSUES
Q26	0.088
Q27	0.093
Q28	0.096
Q29	0.354
Q30	0.043

Project Performance Construct (Y2)

Table 51 shows the factor score weights obtained by analyzing the final model of project performance (Y2) construct using AMOS.

Table 51: The factor score weights for the factors of project performance (Y2) construct.

	PRJOBJ	**PRJSAT**
Q31	0.407	0.067
Q32	0.187	0.031
Q33	0.278	0.046
Q34	0.037	0.006
Q38	0.006	0.237
Q39	0.008	0.293
Q40	0.009	0.322

The factor scores of project objectives (PRJOBJ) and project satisfaction (PRJSAT) are determined using the factor score weights shown in Table 51. The factor scores of project performance (Y2) construct are calculated by averaging the factors project objectives (PRJOBJ) and project satisfaction (PRJSAT).

4.5 Descriptive Statistics

The first step in statistical data analysis is to summarize the data collected by the research instrument in a clear and understandable way using descriptive statistics. In this dissertation, four different types of descriptive statistic will be reported:

1) Sample Size: The first descriptive statistic to be reported is sample size, which shows the actual number of participants in the study.
2) Range: This statistic is a measure of the spread of sample values and is determine by the minimum and maximum values of a variable in the data.
3) Mean: This descriptive statistic show the average score of each question, variable and construct for the sample.
4) Variation: The final descriptive statistic in this study is the variation in the scores for each question, variable and construct. The measure of variation is the standard deviation.

The descriptive statistics for research constructs and variables are shown in Table 52. The descriptive statistics for each question, variable and construct is shown in Table 70 in Appendix C. Since values of variables (factors) and constructs are based on factor score matrices, maximum values of product complexity (7.511) and plan style (7.074) exceed the maximum theoretical value of 7, but none of the values of the constructs which are also determined by the factor scores of variables exceed 7.

The results of the descriptive statistics indicate that the usage of two different types of projects (successful and challenged) as data collection domain, instead of a single project, has increased the range and the variability of the data. These results justify the data collection on two different projects.

For the project complexity (X1) construct and its variables (organizational, product, methods and goal complexities), the successful projects have lower mean complexity scores than those for the challenged projects. A study based only on the successful projects would only yield results in the lower end of the complexity spectrum.

For the project management style (X2) construct and its variables (plan, do, study and act styles), the successful projects have higher mean style scores than those for the challenged projects. The management style of the successful projects are more affected by the complexity paradigm than the Newtonian, thus a study based only on the successful projects would only yield results in the complexity side of the management style spectrum.

Similarly, for the project issues (Y1) construct, the successful projects have lower mean issue scores than those for the challenged projects. A study based only on the successful projects would only yield results in the lower end of the project issues spectrum.

And finally, for the project performance (Y2) construct and its variables (project objectives and project satisfaction), the successful projects have higher mean performance scores than those for the challenged projects. A study based only on the successful projects would only yield results in the higher end of the project performance spectrum.

Table 52: Descriptive Statistics for research constructs and variables.

Construct, Variable	**Project Type**	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Project Complexity	All Projects	128	1.661	6.225	4.246	0.832
	Successful Projects	66	1.836	5.961	3.958	0.783
	Challenged Projects	62	1.661	6.225	4.551	0.776
Organizational Complexity	All Projects	128	1.084	4.368	2.958	0.591
	Successful Projects	66	1.290	4.140	2.835	0.553
	Challenged Projects	62	1.084	4.368	3.090	0.606
Product Complexity	All Projects	128	2.162	7.511	5.121	1.056
	Successful Projects	66	2.162	7.386	4.813	1.030
	Challenged Projects	62	2.219	7.511	5.449	0.991
Methods Complexity	All Projects	128	1.902	6.545	4.490	0.941
	Successful Projects	66	1.902	6.371	4.167	0.874
	Challenged Projects	62	1.936	6.545	4.835	0.892
Goal Complexity	All Projects	128	0.852	4.536	3.085	0.679
	Successful Projects	66	1.130	4.120	2.776	0.598
	Challenged Projects	62	0.852	4.536	3.415	0.607
Legend : 0= No Complexity → 7= Much Higher Than Average Complexity						
Project Management Style	All Projects	128	1.039	6.812	4.346	1.166
	Successful Projects	66	2.678	6.812	4.879	0.908
	Challenged Projects	62	1.039	6.003	3.779	1.148
Plan Style	All Projects	128	1.162	7.074	4.613	1.266
	Successful Projects	66	2.775	7.074	5.086	1.036
	Challenged Projects	62	1.162	6.405	4.109	1.300
Do Style	All Projects	128	0.893	5.815	3.796	0.988
	Successful Projects	66	2.561	5.815	4.262	0.738
	Challenged Projects	62	0.893	5.140	3.300	0.983
Study Style	All Projects	128	0.938	6.369	3.964	1.106
	Successful Projects	66	2.042	6.369	4.470	0.876
	Challenged Projects	62	0.938	5.598	3.426	1.076
Act Style	All Projects	128	0.999	6.989	4.323	1.298
	Successful Projects	66	1.720	6.989	4.924	1.009
	Challenged Projects	62	0.999	6.260	3.685	1.273
Legend : 0= Newtonian Management Style → 7= Complexity Management Style						

Table 52 (continued): Descriptive Statistics for research constructs and variables.

Construct, Variable	**Project Type**	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Alignment	All Projects	128	2.564	6.977	5.889	0.849
	Successful Projects	66	2.564	6.977	5.939	0.773
	Challenged Projects	62	3.529	6.953	5.835	0.927
Legend : 0= No Alignment → 7= Perfect Alignment						
Project Issues	All Projects	128	0.674	4.491	2.330	1.065
	Successful Projects	66	0.674	4.257	1.873	0.916
	Challenged Projects	62	0.866	4.491	2.816	1.000
Legend : 0= No Issue Experienced → 7= Maximum extent of the Issue Experienced						
Project Performance	All Projects	128	0.955	6.769	4.063	1.439
	Successful Projects	66	3.836	6.769	5.078	0.660
	Challenged Projects	62	0.955	6.226	2.982	1.244
Project Objectives	All Projects	128	0.910	6.524	3.459	1.338
	Successful Projects	66	2.943	6.524	4.318	0.861
	Challenged Projects	62	0.910	6.069	2.545	1.136
Project Satisfaction	All Projects	128	0.999	7.014	4.667	1.665
	Successful Projects	66	4.056	7.014	5.838	0.647
	Challenged Projects	62	0.999	6.382	3.420	1.504
Legend : 0= No Success → 7= Significantly Better than Expected Success						

4.6 Testing the Hypotheses

After determining the data collected by the research instrument is reliable and valid, the researchers can test their hypotheses. Three hypotheses are tested in this dissertation:

Hypothesis 1: Alignment of Project Management Style to Project Complexity leads to increased project performance.

Hypothesis 2: Alignment of Project Management Styles to Project Complexity leads to decrease in project management issues.

Hypothesis 3: Increase in project management issues leads to decreased project performance.

The results of the hypothesis tests are given in Table 53.

Table 53: The results of the hypothesis tests.

	Test Method	Correlation	Significance	Implication
Hypothesis 1	Correlation (positive)	0.211	$0.008 < 0.05$	Hypothesis 1 is supported
Hypothesis 2	Correlation (negative)	-0.162	$0.034 < 0.05$	Hypothesis 2 is supported
Hypothesis 3	Correlation (negative)	-0.497	$0.000 < 0.05$	Hypothesis 3 is supported

4.6.1 Hypothesis 1

"Alignment of project management style to project complexity leads to increased project performance ".

The hypothesis seeks a positive correlation between the independent variable alignment (7 – (|X1-X2|)) and the dependent variable project performance (Y2).

The null hypothesis in this case is:

$H1_0$ = There is no correlation between alignment and project performance (Y2),

$H1_0$: $\rho 1 = 0$.

The research or alternative hypothesis for this case is:

$H1_a$: There is positive correlation between alignment and project performance (Y2).

$H1_a$: $\rho 1 > 0$ (positive correlation).

In order to test this hypothesis, factor scores associated with each variable are calculated using the factor score weights given by confirmatory factor analysis. In this case factor scores of project complexity(X1), project management style (X2) and project performance (Y2) constructs are calculated using the factor score weights. Alignment construct is calculated using the formula 7 – (|X1-X2|), where X1 and X2 are the factor scores of Project Complexity(X1) and Project Management Style (X2). After the factor scores are determined, a Pearson's correlation analysis between the factor scores of alignment (7 – (|X1-X2|)) construct and project performance (Y2) construct were conducted using a one-tailed significance test. Table 54 represents the correlation matrix between the factor scores of alignment and project performance constructs.

Table 54: Correlation matrix between the variables alignment and project performance.

		ALIGNMENT	PROJPER
ALIGNMENT	Pearson Correlation	1	.211(**)
	Sig. (1-tailed)		.008
	N	126	128
PROJPER	Pearson Correlation	.211(**)	1
	Sig. (1-tailed)	.008	
	N	128	126

** Correlation is significant at the 0.01 level (1-tailed).

The results of the correlation analysis demonstrate that there is a significant one-tailed correlation between the alignment and the project performance constructs at 0.01 significance level. Thus the null hypothesis $H1_0$ can be rejected.

4.6.2 Hypothesis 2

"Alignment of project management styles to project complexity leads to decreased project management issues."

The hypothesis seeks a negative correlation between the independent variable alignment: (7 – (|X1-X2|)) and the dependent variable project issues (Y1).

The null hypothesis in this case is:

$H2_0$: There is no correlation between Alignment and Project Issues (Y1).

$H2_0$: $\rho 2 = 0$.

The research or alternative hypothesis for this case is:

$H2_a$ = There is negative correlation between Alignment and Project Issues (Y1).

$H2_a$: $\rho 2 < 0$ (negative correlation).

In order to test this hypothesis, factor scores associated with each variable is calculated using the factor scores weights given by confirmatory factor analysis. In this case factor scores of project complexity(X1), project management style (X2) and project issues (Y1) constructs are calculated using the factor score weighs. Alignment construct is calculated using the formula 7 – (|X1-X2|), where X1 and X2 are the factor scores of project complexity(X1) and project management style (X2). After the factor scores are determined, a Pearson's correlation analysis between the factor scores of alignment (7 – (|X1-X2|)) construct and project issues (Y1) construct were conducted using a one-tailed significance test. Table 55 represents the correlation matrix between the factor scores of alignment and project issues constructs.

Table 55: Correlation matrix between the variables alignment and project issues.

		ALIGNMENT	ISSUES
ALIGNMENT	Pearson Correlation	1	-.162
	Sig. (1-tailed)		.034
	N	128	128
ISSUES	Pearson Correlation	-.162	1
	Sig. (1-tailed)	.034	
	N	128	128

The results of the correlation analysis demonstrate that there is significant one-tailed correlation between the alignment and the project issues constructs at 0.05 significance level. Thus the null hypothesis $H2_0$ can be rejected.

4.6.3 Hypothesis 3

"Increase in project management issues leads to decreased project performance."

The hypothesis seeks a negative correlation between the independent variable project issues (Y2) and the dependent variable project performance (Y2).

The null hypothesis in this case is:

$H3_0$: There is no correlation between project issues (Y1) and project performance (Y2)

$H3_0$: $\rho 3 = 0$.

The research or alternative hypothesis for this case is:

$H3_a$: There is negative correlation between project issues (Y1) and project performance (Y2)

$H3_a$: $\rho 3 < 0$ (negative correlation).

In order to test this hypothesis, factor scores associated with each variable is calculated using the factor scores weights given by confirmatory factor analysis. In this case factor scores of project issues (Y1) and project performance (Y2) constructs are calculated using the factor score weights. After the factor scores are determined, a Pearson's correlation analysis between the factor scores of project issues (Y1) and project performance (Y2) constructs were conducted using a one-tailed significance test. Table 56 represents the correlation matrix between the factor scores of project issues and project performance constructs.

Table 56: Correlation matrix between the variables of the Project Issues and Project Performance.

		ISSUES	PROJPER
ISSUES	Pearson Correlation	1	-.497(**)
	Sig. (1-tailed)		.000
	N	128	128
PROJPER	Pearson Correlation	-.497(**)	1
	Sig. (1-tailed)	.000	
	N	128	128

** Correlation is significant at the 0.01 level (1-tailed).

The results of the correlation analysis demonstrate that there is a significant one-tailed correlation between the project issues and the project performance constructs at 0.01 significance level. Thus the null hypothesis $H3_0$ can be rejected.

CHAPTER FIVE: RESULTS AND CONCLUSIONS

5.1 Introduction

The final section of this dissertation discusses the outcomes of this research. The dissertation process is a long, arduous journey, during which the graduate students, using all the resources at their disposal, should explore and internalize the previous body of knowledge of their research areas as well as the pertinent research methods. Thus, outputs of a dissertation include the major findings related to the research question and the lessons learned during the research process.

During this research a set of constructs has been developed through the literature review in order to establish theoretical foundations for relationships between the alignment of project complexity and project management style, project issues and project management performance. After identifying the causal relationships between the constructs as described by the research hypotheses, upcoming sections discuss the findings of the research, implications of the findings for project management practitioners and academicians and future research directions.

In addition to the findings of the research, the lessons learned during the main phases of the long research process are outlined. The main phases of this research are, finding the research topic, literature review, preparing the research instrument, data collection and data analysis.

5.2 Major Findings

The purpose of this dissertation is to answer the following research question:

How does the alignment of the project management style and the complexity of a project affect the issues faced during the project's life and overall project performance?

The purpose of scientific research, based on the hypothetico-deductive approach, is to gather evidence and data to support and test hypotheses (Babbie, 1998, Lawson, 2000). In order to test a hypothesis, researchers should develop models representing the constructs in the hypotheses. How well a model represents reality is crucial to the validity and the reliability of the research findings. In the following sections, the outcomes of this research are discussed by the results of the three research hypotheses.

5.2.1 Hypothesis 1

"Alignment of project management style to project complexity leads to increased project performance".

This first hypothesis seeks a correlation between alignment, which is calculated as a function of project management style and project complexity and project performance. Before discussing the results of the hypothesis test, it is pertinent to look at the validity and the reliability of the constructs used in the model to test the hypothesis:

- Project complexity construct (X1): The results of the confirmatory data analysis suggest that the 13-item, 4-factor measure of project complexity construct developed in this research exhibited adequate levels of measurement properties. In addition, the confirmatory factor analysis results suggest that the hypothesized measurement model of project complexity after modifications had adequate levels of goodness of fit.

- Project management style (X2) construct: The results of the confirmatory data analysis suggest that the hypothesized project management style construct with 12 items and 4 factors is not appropriate. But subsequent exploratory factor analysis produced a factor structure very similar to the 12-item, 4-factor structure of the hypothesized model with one exception of an exchange of two questions between two factors. In addition, the confirmatory factor analysis results on the revised model suggest that the revised model of project management styles after modifications has adequate levels of goodness of fit.
- Project performance (Y2) construct: The results of the confirmatory data analysis suggest that the 7-item, 2 factor measure of project performance construct developed by Tatikonda (1999) exhibited adequate levels of measurement properties. In addition, the confirmatory factor analysis results suggest that the hypothesized measurement model of project performance after modifications had adequate levels of goodness of fit.

After concluding that the constructs the model uses to test the hypothesis are valid and reliable, the results of the data analysis demonstrate a positive significant correlation between alignment of project management style to project complexity and project performance at the 0.05 significance level. This empirical finding supports the following four related conclusions:

Conclusion 1a: With increased project complexity, project management style with the complexity paradigm characteristics leads to increased project performance.

Conclusion 1b: With increased project complexity, project management style with the Newtonian paradigm characteristics leads to decreased project performance.

Conclusion 1c: With decreased project complexity, project management style with the complexity paradigm characteristics leads to decreased project performance.

Conclusion 1d: With decreased project complexity, project management style with the Newtonian paradigm characteristics leads to increased project performance.

5.2.2 Hypothesis 2

"Alignment of project management styles to project complexity leads to decreased project management issues."

The second research hypothesis seeks a correlation between alignment, which is calculated as a function of project management style and project complexity and project management issues. Before discussing the results of the hypothesis test, it is pertinent to look at the validity and the reliability of the constructs used in the model to test the hypothesis:

- Project complexity (X1) and project management style (X2) constructs are discussed at the previous section (Hypothesis 1).
- Project issues construct (Y1): The results of the confirmatory data analysis suggest that the 5-item single factor measure of project issues construct developed in this research exhibited adequate levels of measurement properties. In addition, the confirmatory factor analysis results suggest that the hypothesized measurement model of project issues after modifications had adequate levels of goodness of fit.

The results of the data analysis demonstrate that there is significant negative correlation between alignment of project management style to project complexity and project issues at the 0.05 significance level. This empirical finding supports the following four related conclusions:

Conclusion 2a: With increased project complexity, project management style with the complexity paradigm characteristics leads to decreased project issues.

Conclusion 2b: With increased project complexity, project management style with the Newtonian paradigm characteristics leads to increased project issues.

Conclusion 2c: With decreased project complexity, project management style with the complexity paradigm characteristics leads to increased project issues.

Conclusion 2d: With decreased project complexity, project management style with the Newtonian paradigm characteristics leads to decreased project issues.

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5.2.3 Hypothesis 3

"Increase in project management issues leads to decreased project performance."

The third research hypothesis seeks a correlation between project management issues and project performance. The validity and the reliability of the project issues (Y1) and project performance (Y2) constructs used in the model to test the hypothesis are discussed in the previous sections (Hypothesis 1 and 2).

The results of the data analysis demonstrate that there is significant negative correlation between project issues and project performance at the 0.05 significance level. This empirical finding supports the following conclusion:

Conclusion 3: Increased project issues lead to decreased project performance.

5.3 Implications of the Results

In this section, theoretical and practical implications of this dissertation on the project management discipline are discussed. The theoretical implications will likely affect the future academic research in the field, whereas the practical implications can be utilized by the practicing project management professionals.

5.3.1 Theoretical Implications

This dissertation has utilized mainly two tracks of literature; firstly, the literature related to project management and secondly, the literature related to the scientific paradigms. In relation to both of these tracks, different subtopics have been discussed. The main area of research to which this study has aimed at contributing is the research on project management. Literature on scientific paradigms has thus been used to bring its concepts and viewpoints into the project management discussion. In the following sections, the most important theoretical contributions that this study has made to the project management research are summarized.

In terms of the knowledge and new insights that this research has generated to the project management discipline, one of the most important contributions concerns the entire purpose of this study: to develop concepts to describe, conceptualize and analyze the alignment between project complexity and project management styles and the effects of this alignment on project performance and project issues from the project management perspective. By studying project management complexity, project management style and project issues this study provides quite valuable insights into the wider project management body of knowledge on these topics.

Most important contribution of this study has been to the knowledge of the influences of the main scientific paradigms (the complexity and the Newtonian) on project management styles. As discussed in Chapter 2, the current project management research has not paid enough attention to the influences of the main scientific paradigms (the complexity and the Newtonian) on project management styles. Although the scientific paradigms constitute the foundation for managers' decision making process, the discussion on project management style based on scientific paradigms has been an untouched topic.

In this study, the new measure developed for project management style based on the Newtonian and complexity paradigms combines the research areas of different disciplines (e.g. chaos theory, complex adaptive systems, nonlinear dynamics) and relates this knowledge to widely accepted plan-do-study (PDSA). This gives project management researchers a more familiar and organized view of the project management style concept with 12 variables (questions). The project management style construct developed during this research will enable researchers to test theories on recent project management methodologies like Scrum and Agile Project Management.

Another contribution of this dissertation is the project complexity construct, which gathers a body of knowledge from previous research and classifies the complexity of a project in a straightforward manner. By combining the previous research on project complexity

(McFArlan, 1981, Clark and Wheelwright, 1993, Turner and Cochrane, 1993, Baccarini, 1996, Williams, 1999, Shenhar and Dvir, 2004), this research has attempted to develop a wider perspective by which the complexity of a project can be assessed by 13 variables (questions) and 4 factors. This perspective will enable researcher to use the measure in related future research on project complexity related research.

The final contribution of this research to the academic community is the discussion of the project issues. After an extensive literature review on project management issues, risks and success factors, this dissertation classified these issues into four main groups as shown in Table 10 (Chapter 2). Academic researchers can use either the raw list or the classified lists for further research on project management issues. The four main groups of the issues were further analyzed and the project issues construct was developed. This construct represents the most critical issues which affect all other issues and shows that the main issues are all related to the main stakeholders (customer, senior management, project management team, vendors/contractors and functional departments).

5.3.2 Managerial implications

In addition to the theoretical contributions described, this dissertation has provided new insights for practical project management. Since this study was conducted from the project management professional's perspective, the insights provided by this study have contributed to the wider project management discipline which covers topics like systems engineering, portfolio/program management, project management offices and reorganization of project organizations as well as management of projects.

From the perspective of project management, the conclusions of this study have illustrated the importance of aligning the complexity of a project to the management style that its management adopted. It has been shown that the increased alignment leads to decreased project issues and increased project performance, thus emphasizing the importance of the techniques to analyze project complexity and project management styles. Using the alignment perspective proposed in this dissertation, project management practitioners will be able to assess the complexity and the management style of their projects and take necessary actions to increase the alignment, either by attempting to change the complexity of the project (systems engineering) or management style (organizational change).

This dissertation provides methodologies for the project management professionals to assess project complexity and project management style:

- The first methodology is based on the project complexity taxonomy, which is the combination of four distinct types of complexities: organizational, product, methods and goal. This methodology enables the organizations to assess the overall complexity of a project with 13 variables. Either by using the factor scores given in Chapter 4 or developing organization-specific scores, organizations will be able to come up with project complexity score which is used to the compute the alignment score.
- The second methodology is based on the project management style taxonomy, which is based on the plan-do-study-act (PDSA) cycle with plan, do, study and act styles. Similar to the methodology to assess the project complexity, project management style score can be computed either by using the factor scores given in Chapter 4 or developing

organization-specific scores. After the score for management style of a project is computed, project management organizations can determine whether their project management style is aligned to the project's complexity. Project management style methodology also helps project managers to evaluate the appropriateness of different types of off-the-shelf project management methodologies like Scrum and Agile Project Management.

Finally, this dissertation illustrated that 5 issues represented by the project issues construct are the main issues that a project management professional should always monitor. These issues affect all other issues and are all related to the main stakeholders (customer, senior management, project management team, vendors/contractors and functional departments). Since this dissertation demonstrated that the increase in these issues result in a decrease in the project performance, project management professionals should pay extra attention to keep these issues as low as possible.

5.4 Lessons Learned

The purpose of this section is to share lessons learned from the dissertation process. These lessons can be a valuable for future researchers who may choose a similar path of developing their own original theories as done in this dissertation. The lessons learned of this dissertation will be discussed using the steps of the dissertation process as subtopics.

5.4.1 Research Topic and Question

- Determining the research topic and research questions takes an enormous amount of the graduate student's time, unless the research topic is given to the researcher by the advisor or the sponsor of the research. This uncertain period can be even longer if the graduate student chooses to develop his/her own original theory. Graduate students tend to tackle the issue of a dissertation after their course load begins to decrease, usually at the second or third year in graduate school. In order to use the time more productively, graduate students with the encouragement of their advisors, should start the dissertation process as soon as they start graduate school by choosing the area or discipline that they will be comfortable to study. This way, by the end of the coursework, they will have the necessary depth in the field that they study and will be able to generate the research questions.

5.4.2 Literature Review

- Another time consuming phase in the dissertation process is the literature review. The first lesson for future researchers is to identify the main sources in the literature for a given topic and collect the articles or book chapters related to those sources. Some of the cutting edge research is published in conference proceedings, so the researcher should attend and read the proceedings of the recent conferences.

- Unlike the researcher of the pre-internet era, today's graduate students have enormous resources in terms of electronic databases and academic web pages at their disposal. Graduate students should take advantage of this resource to develop and improve their literature review.

5.4.3 Developing the Research Instrument

- In order to conduct a scientific research, the graduate student should review many resources in order to develop a valid and reliable research instrument. Reviewing literature and dissertations using similar research techniques even in other disciplines will enable the researcher to better understand how a research instrument is developed.
- In addition to gathering literature in their subject areas, the graduate students should learn about the methodologies that they will likely use in their research. Having an in-depth knowledge about the research methodologies and analytical methods will give insight to the researcher in determining the research questions, for these methodologies are used to find the answers to these research questions.

5.4.4 Data Collection

- In order to have a large number of respondents, researchers should utilize online surveys. Researchers should actively seek assistance from their advisors, industry contacts and even fellow researchers to get access to the key managers in the organizations. For a nationwide sample, head quarters of national professional organizations should be contacted.
- The data collection process should be planned well in advance and contingencies and risks should be identified. Key contacts should be identified and strategies to gain access to their organizations should be developed.

5.5 Future research

This section outlines suggestions for future research including ideas about new research questions and potential methodologies based on the outputs and lessons learned of this research. The suggestions for topics for future investigations are as follows:

- What competencies should project management professionals possess in order to deal with change brought by alignment between project complexity and project management style?
- What are the organizational implications of changing management style in a project?
- What are the tools and processes that organizations can use to monitor and reduce the complexity of a project?
- What are the critical factors for a successful alignment between project complexity and project management style?
- What are cause-effect relationships between the project issues?
- What is the relationship between the maturity of a project organization and the success of the alignment between project complexity and project management style?

Suggestions for potential methodologies instead of surveys for similar research:

- Controlled organizational experiments where different levels of management style are applied to similar tasks for similar complexities.
- Participative action research where the researcher is involved in the execution of several projects and writes case studies about them.

5.6 Conclusions

In this dissertation, the topics: complexity of projects; main scientific paradigms (the Newtonian and the complexity) and their influences on project management styles; alignment between project complexity and project management style; project issues and project performance, were investigated, conceptualized and operationalized. The gaps in the literature regarding these topics were identified. Three hypotheses based on these topics were developed and tested. A self-administered survey was designed and administered in order to data.

The analytical results of this investigation demonstrate that the increased alignment between project complexity and project management style leads to increased project performance and to decreased project issues. The results also revealed that increased project issues leads to decreased project performance. These results suggest that project or program managers can improve the performance of their projects by any attempt to increase the alignment between project complexity and project management style.

APPENDIX A – UNDERSTANDING RESEARCH PROCESS

What is Research?

Research is the cornerstone of scientific development in today's world. Thomas Kuhn (1962) describes research as a strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education. According to Leedy (1974) research is simply the manner in which humans solve the complex problems in their attempt to push back the frontiers of human ignorance. Mauch and Birch (1998) states that research can produce facts and ideas, which can trigger thought process of the researcher, but research does not produce solutions, it is the human thought process that solves the problems ultimately.

Smith (1981) suggests that the term scientific research be substituted by disciplined inquiry, which "must be conducted and reported so that its logical argument can be carefully examined; it does not depend on surface plausibility or the eloquence, status, or authority of its author; error is avoided; evidential test and verification are valued; the dispassionate search for truth is valued over ideology. Every piece of research or evaluation, whether naturalistic, experimental, survey, or historical must meet these standards to be considered disciplined." (p. 585)

Leedy (1974) also discusses the characteristics of research by looking at what research is and what research is not. Thus characteristics of research are (Leedy, 1974):

1. Research originates with a question in the mind of the researcher
2. Research requires a specific plan.
3. Research demands a clear articulation of the problem
4. Research approaches the main problem by dividing it into sub problems.

5. Research is guided by appropriate hypotheses.
6. Research deals with facts, measurable data, and their meaning.
7. Research is circular, by nature.
8. Research is not just information gathering.
9. Research is not transportation of facts from one location to another.
10. Research is not rummaging for information.

Writing about doctorate research, Remenyi and Money (2002) claims that a doctorate degree is awarded to those who demonstrate that they have added something of value to the body of knowledge through their research with significant theoretical contribution and liken the doctorate degree process to an apprenticeship, and the degree candidate to an apprentice, thus describe the primary objective of doctorate degree for the candidate as to be able to demonstrate that they can undertake independent academic research. Remenyi and Money (2002) stresses that good research, and good doctoral research does not necessarily arrive at the answers to problems, especially when testing theory, but research often produces the next layer of good questions rather than good answers.

Characteristics of good research

Denscombe (2002) outlines the characteristics of good research in a 10-point classification:

1) Purpose: The purpose of the research should be stated clearly and explicitly in a format appropriate for the style of investigation and the outcomes from the research should be linked to its purpose.
2) Relevance: The research should relate to existing knowledge and address specific practical needs.
3) Resources: Research should recognize the constraints imposed by the resources available to the research. These resources are time, money and access to data.
4) Originality: Research should contribute something new to body of knowledge and extend the existing knowledge boundaries.
5) Accuracy: Research should produce valid data using reliable methods. The accuracy of data should be checked using appropriate tests of validity and the impact of the research process on data should be assessed using suitable measures of reliability.
6) Accountability: Research should include an explicit account of its methodology so that judgments can be made about the quality of the procedures and checks can be made on the validity of the research.
7) Generalizations. Research should produce findings from which generalizations can be made.
8) Objectivity: Researcher should be open minded and self-reflective. And the research should be designed, conducted and reported in a true sprit of exploration.
9) Ethics: Research should recognize the rights and the interests of participants and avoid any deception or misrepresentation in its dealings with them.

10) Proof: Researchers should be cautious about claims based on their findings. Evidence, which is suitably substantial and has been collected in a systematic fashion, should be provided to support the arguments put forward by the research.

Mauch and Birch (1998) stresses that in a thesis or dissertation the most important characteristics are the integrity (ethics) and objectivity of the investigator and these criteria prevail regardless of the form of investigation or analysis used.

McCurdy and Cleary (1984) and Adams and White (1994) identified the criteria to test the capability of research projects:

- Research Purpose: Did the researcher set out to conduct basic research and report on the findings? Denscombe (2002) states the purpose of the research should be stated clearly and explicitly in a format appropriate for the style of investigation and the outcomes from the research should be linked to its purpose.
- Methodological Validity: Did the research have a rigorous design so that readers could have confidence in the findings and applicability to the similar situations? This criterion is includes the concepts of reliability and validity. According to Babbie (1998) reliability is the ability of a particular technique to come up with the same result each time this particular technique is applied. On the other hand, according to Singleton et al. (1993) validity refers to the extent of matching, congruence or goodness of fit between an operational definition and the concept it is supposed to measure.
- Impact - Theory Testing: and Casual Relationships: Did the research test an existing theory and did the dissertation conclude with a causal statement? In order to contribute

significantly to knowledge development in a given field, a research should have theoretical relevance (Adams and White, 1994). Mccurdy and Cleary (1984) states that for most fields testing theory is synonymous with testing a casual relationship.

- Important Topic: Was the topic research topic an important one in that particular field? This is a very subjective criteria and it is up to researchers to determine whether their research is important.
- Cutting Edge: Did the research involve the development of new questions or the creation of new experience? A research can be cutting edge but that does not mean that it is also important. McCurdy and Cleary, 1984)
- Theoretical or conceptual framework: Dissertation research should be guided by explicit theoretical and conceptual framework (Adams & White 1994).
- Obvious flaws: Adams and White (1994) gives some examples of obvious flaws in research: To small a sample size to draw reasonable conclusions, generalization based on findings from a single case study, use of inappropriate statistic, inappropriate research design, etc.
- Overall Quality: Adams and White (1994) give this criterion as a combination of other criteria.

Characteristics of good research in Engineering Management

Mavor (1997) describes engineering management as an activity devoted to the timely deployment of resources needed to satisfy the operational requirement of an enterprise within an organizational framework, leading to the delivery of its mission and claims that the management element of engineering enterprises must evolve along with the business and introduce and deliver on appropriate approaches.

Kocaoglu (1990) outlines the scope of engineering management discipline into two dimensions:

1) Life Cycle Dimension covers the management of technological life cycle. The sub-dimensions of life cycle management are:
    a. Innovation Subsystem
    b. Basic Research Subsystem
    c. Applied Research Subsystem
    d. Development Subsystem
    e. Design Subsystem
    f. Implementation Subsystem
    g. Marketing Subsystem
    h. Maintenance Subsystem
    i. Transfer Subsystem
2) The System Dimension covers the interrelated components of engineering management systems. The sub-dimensions for the system dimensions are:
    a. Human Subsystem
    b. Projects Subsystem

c. Organizational Subsystem

d. Resource Subsystem

e. Technology Subsystem

f. Strategy Subsystem

According to Ahire and Devaraj (2001), during the last decade, the research landscape of engineering management has gradually changed from traditional problem-solving or algorithmic flavor to empirical research on complex interactions of macro-level organization of business functions and processes

Using the characteristics that Schmenner and Swink (1998) determined for a very similar discipline, operations management theory, we can deduce these similar characteristics for engineering management research:

1) The engineering management phenomenon for which explanation is sought should be clearly defined. This clarity is enhanced by unambiguous measures of the phenomenon.
2) The description of the phenomenon will likely center on some observed regularities that have been derived either logically or empirically.
3) There should be one or more precise statements of these regularities (laws). Mathematical statements of the laws will naturally help the precision.
4) The theory should indicate a mechanism or tell a story that explains why the laws work as they do and how, and in which ways, the laws may be subject to limitations. The theory may include some special terms or concepts that aid the explanation.

5) The more powerful the theory, the more likely it will unify various laws and also generate predictions or implications that can be tested with data. Furthermore, the power of the theory does not necessarily rest with the methodological choice of the tests made.

Research paradigms

Gliner and Morgan (2000) define research paradigm as a way of thinking about and conducting research and also state that rather than being a methodology, research paradigm is a philosophy that guides how the research is to be conducted and determines the types of questions that are legitimate, how they will be answered, and in what context they will be interpreted. In empirical research, there are three research philosophies in the scientific world (Amaratunga et al., 2002, Gliner and Morgan, 2000). These are positivist (Quantitative) and constructivist (Qualitative) Research and the combination of these two:

- Positivistic (Quantitative) Research uses quantitative and experimental methods to test hypotheses and come up with generalizations and searches for causal explanations and fundamental laws, and generally reduces the whole to simplest possible elements in order to facilitate analysis. Positivism believes that the world is external and objective, and observer is independent. Operationalizing concepts in order to measure them and taking large samples are preferred methods in the positivist research.
- Constructivist (Qualitative) Research uses qualitative and naturalistic approaches to inductively and holistically understand human experience in context-specific settings. This approach tries to understand and explain a phenomenon, rather than search for external causes or fundamental laws. The basic beliefs for constructivist research are that the world is socially constructed and subjective and the observer is part of what is observed. Using multiple methods and small samples are the preferred research methods for constructivist research paradigm.

The differences between these two paradigms (Lincoln and Guba,1985, Gliner and Morgan, 2000), are given in Table 57.

Table 57: The differences between these two main research paradigms.

	Positivists	**Constructivists**
The nature of reality	A single reality.	Multiple constructed realities.
The relationship of knower to known	Investigator is totally objective.	Investigator cannot be totally objective; in fact, participant and researcher interact.
The possibility of generalization	Truth statements are free from both time and context.	Best that can be accomplished is a working hypothesis; everything is contextually bound.
The possibility of causal linkages	Cause and effect can be determined at least as a probability.	We are in a constant state of mutual shaping and it is impossible to distinguish cause and effect.
The role of values in inquiry	Inquiry is value free and objective.	Inquiry is value bound by inquiry, choice, theory, values, and conflict.

Validity of Research Process

Brinberg and McGrath (1985) offer a framework, which they call validity network schema (WNS) to offer a systematic description of the research process and of the multiple types of validity that a researcher should pursue. The assumptions that the WNS starts with are (Brinberg and McGrath, 1985):

1) Research involves three interrelated but analytically distinct domains;
    a. The conceptual,
    b. The methodological, and
    c. The substantive.
2) Research involves elements and relations between elements, from each of those three domains.
3) The complete research process comprises three major stages, with several steps and alternative paths for fulfilling these steps and the idea of validity is different for each of these stages.

The WNS (Brinberg and McGrath, 1985) describes the research process as the identification, selection, combination, and use of elements and relations from the conceptual, methodological, and substantive domains:

a. The conceptual domain contains elements that are concepts, and relations between elements that are essentially conceptual models about patters of concepts.
b. The methodological domain contains elements that are methods, instruments or techniques for making observations or manipulating variables, and relations that are structures or comparison model sets of observations.

c. The substantive domain contains elements that are events, concepts, and relations between elements that are essentially conceptual models about patters of concepts.

Brinberg and McGrath (1985) conceptualize a research process being made up of three distinct stages each made up of several steps and with different validity requirements. The stages of the research process are (Brinberg and McGrath, 1985):

1) Prestudy Stage: This first preparatory stage, which builds the necessary groundwork for further research, involves development, clarification and selection of the elements and relations within each of the three domains mentioned above. The key determinant of validity in this stage is value, which Brinberg and McGrath (1985) describe as the importance/ relevance/ truth of concepts, methods, and substance selected for the research. For each domain there are different values (Brinberg and McGrath, 1985):
    a. For conceptual domain, the values are testable, quantifiable, and internally consistent.
    b. For methodological domain, the values generally used are significance testing, accuracy, repeatable and quantifiable.
    c. For the substantive domain, the values are observable, real.
2) Study Stage: The second stage of the research process is when the research study is conducted. This stage involves two main steps different for each one of three research 'paths' (experimental, theoretical or empirical). Result of this stage for each path is a set of empirical findings. For the theoretical path, which is utilized in this dissertation, two main steps are hypotheses and testing. The main forms of validities for these steps are:

   a. For hypotheses step, the main validities are the construct validity for the elements and the nomological validity for the relations.
   b. For test step, the main validities are the operational validity for the elements and the predictive validity for the relations.
3) Post-study Stage: In this final stage, empirical findings from study stage are assessed for external validity, by replication and by a systematic search for both the range and the limits of these findings.

Below is the summary of types of validities for each stage of the research process for a quantitative research involving hypothesis testing (Brinberg and McGrath, 1985):

1) Prestudy Stage: Validity as value;
   a. Conceptual domain: testable, quantifiable, and internally consistent.
   b. Methodological: significance testing, accuracy, repeatable and quantifiable.
   c. Substantive domain: observable, real.
2) Study Stage: Validity as correspondence or fit;
   a. Hypotheses: construct validity (elements) and nomological validity (relations).
   b. Test: operational validity (elements) and predictive validity (relations).
3) Post-study Stage: Validity as Robustness (External Validity):
   a. Replication of the findings of stage.
   b. Robustness analysis
   c. Boundary analysis

Research Process

While conducting scientific research, a researcher reaches conclusions using a research process which is dominated by one of the two widely used basic reasoning approaches. These are inductive and hypothetico-deductive approaches:

- Induction is often described as 'going from the specific to the general'. The Inductive approach is based on the assumption that explanations about the phenomena should be based on facts gained from observation, rather than on predetermined concepts. Thus, inductive approach begins with a number of observations and using these observations the researcher can reach empirical verification of a general conclusion. Inductive approach is strongly based on the reductionism of the Newtonian Paradigm, where general or universal propositions can be made based on singular or particular statements.
- Hypothetico-deductive approach is the opposite of the Inductive approach. "Hypothetico" means "based on hypotheses", deductive logic is a way of making authoritative statements about what is not known by a thorough analysis of what is known. Karl Popper (1962) stated that it is impossible to prove a scientific theory true by means of induction, because no amount of evidence assures us that contrary evidence will not be found. Instead, Popper (1962) proposed that proper science is accomplished by deduction which involves the process of falsification. Falsification involves stating an assertion from a theory and then finding contrary cases using experiments or observations.

The Hypothetico-deductive approach is based on one or more hypothetical assumptions that would form a theory to provide an explanation for a phenomenon. Thus, starting point for this approach is the observation of phenomena then researcher proceeds to use these initial observations to develop research questions and hypotheses. These hypotheses are tested using data obtained through systemic observation methods. Figure 13 in Chapter 3 summarizes the Hypothtico deductive method (Popper, 1962, Lawson, 2000, Babbie, 1998).

Phenomena

Phenomena are the starting-point for all scientific research and, they simply refer to the research topic that catches our attention and which we want to describe, analyze and / or explain. This first stage of the research process is when the researcher chooses the field in which he/she wants to investigate. During this stage the researcher gather information and develop ideas necessary to narrow the research down into something more specific.

In this research the phenomena refers to the project management discipline and how it is affected by the scientific paradigms.

Observation and Idea Generation

As the researcher gains information and insight into the phenomena, he/she starts to generate ideas to be further investigated. These ideas can be formulated in the form of problem statements and/or research questions.

As mentioned as the problem statement in chapter 1 of this research, the purpose of this research is to investigate (characterize, conceptualize, demonstrate, and generalize) how the project management tool characteristics based on the Newtonian and the complexity paradigms used in project management process, in different project management complexity levels affect project management issues and overall project performance. Subsequently, guidelines for project management tools will be developed and presented.

Data Collection Methods

There are many types of techniques and instruments used to collect data. Gliner and Morgan (2000) conceptualize the research approaches and designs as being approximately orthogonal to the data collection techniques, and thus theoretically any type of data collection technique could be used with any research approach and design. Table 17 in Chapter 3 summarizes how commonly the data collection techniques are used within quantitative and qualitative research approaches (adapted from Gliner and Morgan , 2000).

1) Structured Observation: Structured observation is a direct observation technique in which an observer observes and records events using written protocols and codes that have been developed prior to the study (Martinko and Gardner, 1990). The observer is not a participant in the activities being observed and records them with minimum possible involvement in the phenomena. In order to transform observations into a standardized format for data analysis and classify observations relevant to the research, researcher must methodically develop a coding system. Coding is the process of recording the occurrence of different observations into pre-selected categories (Wiersma, 1986). The coding scheme acts as a lens for the researcher throughout the data collection. The limitations of structured observations are (Martinko and Gardner, 1990, Wiersma, 1986):

- Small sample size precludes formal hypothesis testing with inferential statistics.
- Reliability and validity is low.

- Coding Systems can not capture the whole phenomena.
- In order to overcome observer's bias regarding events being observed, an observer must be trained to be neutral and non-judgmental.

2) Narrative Analysis: Elbaz-Luwisch (1997) describes narrative analysis as a research in the narrative mode, in which the researcher studies particular cases, either of individuals or of systems, by collecting material, usually descriptions of events, and from them producing storied accounts which render the data meaningful. Narrative research is usually qualitative (Gliner and Howard, 2000) and uses oral, first-person accounts of experience derived from interviews (Riessman, 1993). In narrative analysis the desired outcome is not a generalization but a narrative which renders clear the meanings inherent in or generated by a particular subject (Elbaz-Luwisch, 1997). According to Riessman (1993), the concepts of reliability and validity do not apply to narrative studies. Instead, narrative studies substitute the concept of trustworthiness, which can be evaluated in four ways (Riessman, 1993):

- Persuasiveness: the degree to which the investigator's interpretation is credible and convincing.
- Correspondence: the degree to which informants agree with and affirm the researcher's interpretations.
- Coherence: the degree to which the investigator's interpretation of meaning is consistent with the text.
- Pragmatic use: the degree which a study is the basis of the work of other researchers.

3) Participant Observation: According to Fine (2004), in participant observation research, the researcher actively engages with the members the community that he or she wishes to study, typically as an equal member of the group in a single case study. The advantages of this research methodology are (Fine, 2004):

- Richness: This methodology, in contrast to most methods that do not involve personal witnessing, provides for rich and detailed data.
- Validity: A second benefit is analytical validity. Because the observations are of behavior in situ, the researcher can rely upon the claim that the findings are close to the 'proper' depiction of the scene.
- Interpretive Understanding: Participant observation with its emphasis on both participation and observation adds to research knowledge. By directly involving the researcher in the activity, one can understand on an immediate level the dynamics and motivations of behavior.
- Economy: Participant observation research is typically inexpensive. In many cases the researcher is the only member of the project, and can set the terms of his or her own involvement.

Similarly, the disadvantages of participation observation are (Fine, 2004):

- Proof: Participant observation relies upon a single case study and this raises questions about the nature of proof, or, reliability.
- Generalizability: The legitimacy of generalizing after analysis of a single case is problematic in participant observation. Researchers need to present a theoretical model

that helps readers to judge the legitimacy of their broader claims in light of the audience's own experiences.

- Bias: Even though the researcher's insight and perspective is an advantage for participant observation methodology, it is hard to distinguish between perspective and bias. The background of the researcher can be distinctively different from other researchers, thus the understanding of a particular situation may be systematically biased.
- Time: Participant observation research is relatively inexpensive but it is also highly labor intensive and requires the researcher be present in the observed social scene.

4) Questionnaires : Questionnaires and the interviews are parts of a larger research method called survey research. Gliner and Morgan (2000) describes questionnaires as any group of written questions to which participants are asked to respond in writing, often by checking or circling responses. With interviews, questionnaires are usually called survey research methods, but questionnaires and interviews are used in many studies that would not meet the definition of survey research (Gliner and Morgan 2000). There are two basic ways to gather information with a questionnaire: mailed questionnaires (including e-mail or internet access) and directly administered questionnaires.

5) Interviews : Interviews are a series of questions presented orally by an interviewer and are usually responded to orally by the participant (Gliner and Morgan, 1993). Two main types of interviews are telephone and face-to-face. The questions are often close-ended so that the interviewer only needs to circle the chosen response or fill in a brief blank.

Advantages and disadvantages of questionnaires and interviews will be discussed under survey research. According to Hart (1987) the survey research is the most usual form of primary research undertaken and attributes its popularity to the following factors:

- Survey research provides the researcher with the means of collecting both qualitative and quantitative data required to meet the objectives of majority of research studies which require factual, attitudinal and/or behavioral data.
- The fact that a great deal of information can be collected economically from a large population is one of the greatest advantages of survey research
- Survey research is logical, deterministic, general, parsimonious and specific and conforms to the specifications of scientific research.

Hart (1987) also cites the disadvantages of the survey research:

- Respondents may be unwilling to provide the desired data and non-response error can invalidate research findings.
- Respondents may not be able of to provide data.
- Respondents may give the answers they think the researcher will want to hear, thus distorting the accuracy of the data.

6) Focus Groups: Focus groups are like interviews, but relatively small groups of 8 to 10 people are interviewed together (Gliner and Morgan, 1993). Focus groups can provide an initial idea about what responses people will give to a certain type of question, which can be used in developing more structured questionnaires or interviews.

7) Historical Archive Analysis: Historical archive analysis uses unobtrusive measures, including physical traces and archives (Gliner and Morgan, 2001), often in conjunction with a single or multiple case study design. In historical archival analysis researcher does not control the environment, therefore it may be impossible to obtain the type of data desired and to gather historical factual data from respondents archival data is sometimes used in conjunction with a survey or panel study (Gliner and Morgan, 2001).

8) Content Analysis: Holsti (1969) defines content analysis as, "any technique for making inferences by objectively and systematically identifying specified characteristics of messages" (p. 14). Content analysis is a technique where researchers are able to sort through large amount of data and to discover and describe the focus of individual, group, institutional, or social attention (Weber, 1990).

APPENDIX B – AMOS OUTPUTS FOR CONFIRMATORY FACTOR ANALYSES

A) Project Complexity Construct (X1)

Table 58: The Amos output of parameter estimates for the theoretical project complexity construct (X1).

Regression Weights			Estimate	S.E.	C.R.	P	Label
Q3	<---	ORGCOM	1.413	.306	4.624	***	
Q2	<---	ORGCOM	1.188	.285	4.173	***	
Q1	<---	ORGCOM	1.167	.269	4.342	***	
Q7	<---	PRDCOM	1.000				
Q6	<---	PRDCOM	.902	.119	7.600	***	
Q5	<---	PRDCOM	.767	.121	6.327	***	
Q4	<---	ORGCOM	1.000				
Q10	<---	METHCOM	1.000				
Q9	<---	METHCOM	1.123	.129	8.684	***	
Q8	<---	METHCOM	.853	.137	6.209	***	
Q13	<---	GOALCOM	1.000				
Q12	<---	GOALCOM	1.496	.273	5.476	***	
Q11	<---	GOALCOM	1.472	.277	5.312	***	

Covariances:			Estimate	S.E.	C.R.	P	Label
ORGCOM	<-->	PRDCOM	.608	.159	3.818	***	
GOALCOM	<-->	ORGCOM	.304	.102	2.994	.003	
ORGCOM	<-->	METHCOM	.425	.119	3.584	***	
PRDCOM	<-->	METHCOM	.893	.168	5.327	***	
GOALCOM	<-->	PRDCOM	.536	.143	3.740	***	
GOALCOM	<-->	METHCOM	.495	.125	3.964	***	

Variances:			Estimate	S.E.	C.R.	P	Label
		ORGCOM	.544	.212	2.563	.010	
		PRDCOM	1.223	.256	4.772	***	
		METHCOM	.846	.184	4.604	***	
		GOALCOM	.555	.194	2.858	.004	
		err4	1.773	.244	7.267	***	
		err3	1.038	.221	4.696	***	
		err2	1.494	.242	6.162	***	
		err1	.764	.156	4.904	***	
		err7	.822	.145	5.662	***	
		err6	.878	.145	6.036	***	
		err5	1.256	.179	7.004	***	
		err10	.652	.109	5.993	***	
		err9	.522	.107	4.877	***	
		err8	1.095	.154	7.122	***	
		err13	1.510	.206	7.337	***	
		err12	.565	.137	4.139	***	
		err11	.712	.145	4.900	***	
			.544	.212	2.563	.010	>0.001)

Table 59: The Amos output of Goodness-of-Fit Statistics for theoretical project complexity construct (X1).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	45	137.688	59	.000	2.334
Saturated model	104	.000	0		
Independence model	26	713.036	78	.000	9.141

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.807	.745	.880	.836	.876
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.756	.610	.663
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	78.688	48.261	116.830
Saturated model	.000	.000	.000
Independence model	635.036	553.319	724.211

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	1.084	.620	.380	.920
Saturated model	.000	.000	.000	.000
Independence model	5.614	5.000	4.357	5.702

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.102	.080	.125	.000
Independence model	.253	.236	.270	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	227.688	238.838		
Saturated model	208.000	233.770		
Independence model	765.036	771.478		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.793	1.553	2.093	1.881
Saturated model	1.638	1.638	1.638	1.841
Independence model	6.024	5.380	6.726	6.075

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	72	81
Independence model	18	20

Table 60: The Amos output of Goodness-of-Fit Statistics for modified project complexity construct (X1).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	37	71.105	54	.059	1.317
Saturated model	91	.000	0		
Independence model	13	713.036	78	.000	9.141

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.900	.856	.974	.961	.973
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.692	.623	.674
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	17.105	.000	43.078
Saturated model	.000	.000	.000
Independence model	635.036	553.319	724.211

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.560	.135	.000	.339
Saturated model	.000	.000	.000	.000
Independence model	5.614	5.000	4.357	5.702

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.050	.000	.079	.477
Independence model	.253	.236	.270	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	145.105	154.273		
Saturated model	182.000	204.549		
Independence model	739.036	742.257		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.143	1.008	1.347	1.215
Saturated model	1.433	1.433	1.433	1.611
Independence model	5.819	5.176	6.521	5.845

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	129	145
Independence model	18	20

B) Project Management Style Construct (X2)

Table 61: The Amos output of parameter estimates for the new project management style construct (X2).

Regression Weights			Estimate	S.E.	C.R.	P	Label
Q20	<---	DOSTYLE	1.000			***	
Q19	<---	DOSTYLE	.716	.173	4.143	***	
Q17	<---	DOSTYLE	.864	.183	4.721	***	
Q22	<---	STDYSTYLE	1.000				
Q21	<---	STDYSTYLE	.811	.119	6.845	***	
Q18	<---	STDYSTYLE	.856	.112	7.638	***	
Q25	<---	ACTSTYLE	1.000				
Q24	<---	ACTSTYLE	.748	.111	6.745	***	
Q23	<---	ACTSTYLE	1.050	.129	8.121	***	
Q16	<---	PLANSTYLE	1.000				
Q15	<---	PLANSTYLE	.942	.146	6.455	***	
Q14	<---	PLANSTYLE	.337	.129	2.616	.009	

Covariances:			Estimate	S.E.	C.R.	P	Label
PLANSTYLE	<-->	DOSTYLE	1.151	.265	4.340	***	
DOSTYLE	<-->	STDYSTYLE	1.144	.259	4.421	***	
STDYSTYLE	<-->	ACTSTYLE	1.517	.296	5.132	***	
PLANSTYLE	<-->	STDYSTYLE	1.362	.275	4.946	***	
PLANSTYLE	<-->	ACTSTYLE	1.232	.278	4.438	***	
DOSTYLE	<-->	ACTSTYLE	1.271	.283	4.496	***	

Variances:			Estimate	S.E.	C.R.	P	Label
		DOSTYLE	1.221	.376	3.248	.001	
		STDYSTYLE	1.767	.378	4.673	***	
		ACTSTYLE	2.041	.443	4.608	***	
		PLANSTYLE	1.728	.407	4.242	***	
		err20	1.924	.320	6.018	***	
		err19	2.343	.322	7.268	***	
		err17	2.207	.324	6.816	***	
		err22	1.243	.221	5.619	***	
		err21	1.563	.231	6.778	***	
		err18	1.122	.185	6.083	***	
		err25	1.529	.263	5.812	***	
		err24	1.587	.232	6.838	***	
		err23	1.266	.249	5.092	***	
		err16	1.321	.273	4.837	***	
		err15	1.520	.272	5.589	***	
		err14	2.628	.337	7.806	***	

(*** <0.001)

Table 62: The Amos output of Goodness-of-Fit Statistics for the new project management style construct (X2).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	42	83.499	48	.001	1.740
Saturated model	90	.000	0		
Independence model	24	543.095	66	.000	8.229

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.846	.789	.928	.898	.926
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.727	.615	.673
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	35.499	13.970	64.886
Saturated model	.000	.000	.000
Independence model	477.095	406.489	555.170

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.657	.280	.110	.511
Saturated model	.000	.000	.000	.000
Independence model	4.276	3.757	3.201	4.371

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.076	.048	.103	.062
Independence model	.239	.220	.257	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	167.499	177.078		
Saturated model	180.000	200.526		
Independence model	591.095	596.569		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.319	1.149	1.550	1.394
Saturated model	1.417	1.417	1.417	1.579
Independence model	4.654	4.098	5.269	4.697

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	100	113
Independence model	21	23

Table 63: The Amos output of Goodness-of-Fit Statistics for the modified new project management style construct (X2).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	46	59.380	44	.061	1.350
Saturated model	90	.000	0		
Independence model	24	543.095	66	.000	8.229

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.891	.836	.969	.952	.968
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.667	.594	.645
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	15.380	.000	39.614
Saturated model	.000	.000	.000
Independence model	477.095	406.489	555.170

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	468	.121	.000	.312
Saturated model	.000	.000	.000	.000
Independence model	4.276	3.757	3.201	4.371

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.052	.000	.084	.456
Independence model	.239	.220	.257	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	151.380	161.872		
Saturated model	180.000	200.526		
Independence model	591.095	596.569		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.192	1.071	1.383	1.275
Saturated model	1.417	1.417	1.417	1.579
Independence model	4.654	4.098	5.269	4.697

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	130	147
Independence model	21	23

C) Project Issues Construct (Y1)

Table 64: The Amos output of parameter estimates for project issues construct (Y1)

Regression Weights			Estimate	S.E.	C.R.	P	Label
Q28	<---	ISSUES	1.000				
Q27	<---	ISSUES	1.344	.212	6.327	***	
Q26	<---	ISSUES	1.102	.183	6.023	***	
Q29	<---	ISSUES	1.282	.202	6.336	***	
Q30	<---	ISSUES	.764	.185	4.124	***	

Variances:		Estimate	S.E.	C.R.	P	Label
	ISSUES	1.353	.388	3.487	***	
	err28	2.257	.325	6.939	***	
	err27	1.677	.311	5.388	***	
	err26	1.650	.265	6.226	***	
	err29	1.504	.281	5.353	***	
	err30	3.420	.451	7.578	***	

(*** < 0.001)

Table 65: The Amos output of Goodness-of-Fit Statistics for project issues construct (Y1).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	15	27.855	5	.000	5.571
Saturated model	20	.000	0		
Independence model	10	208.694	10	.000	20.869

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.867	.733	.888	.770	.885
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.500	.433	.442
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	22.855	9.885	43.326
Saturated model	.000	.000	.000
Independence model	198.694	155.402	249.420

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.219	.180	.078	.341
Saturated model	.000	.000	.000	.000
Independence model	1.643	1.565	1.224	1.964

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.190	.125	.261	.000
Independence model	.396	.350	.443	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	57.855	59.343		
Saturated model	40.000	41.983		
Independence model	228.694	229.686		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.456	.353	.617	.467
Saturated model	.315	.315	.315	.331
Independence model	1.801	1.460	2.200	1.809

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	51	69
Independence model	12	15

Table 66: The Amos output of Goodness-of-Fit Statistics for modified project issues construct (Y1).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	18	.747	2	.562	.373
Saturated model	20	.000	0		
Independence model	10	208.694	10	.000	20.869

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.994	.972	1.004	1.021	1.000
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.200	.199	.200
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	.000	.000	4.386
Saturated model	.000	.000	.000
Independence model	198.694	155.402	249.420

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.009	.000	.000	.045
Saturated model	.000	.000	.000	.000
Independence model	1.643	1.565	1.224	1.964

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.150	.760
Independence model	.396	.350	.443	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	37.153	38.938		
Saturated model	40.000	41.983		
Independence model	228.694	229.686		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.293	.299	.344	.307
Saturated model	.315	.315	.315	.331
Independence model	1.801	1.460	2.200	1.809

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	661	1015
Independence model	12	15

D) Project Performance Construct (Y2)

Table 67: The Amos output of parameter estimates for project performance construct (Y2).

Regression Weights			Estimate	S.E.	C.R.	P	Label
Q34	<---	PRJOBJ	1.000				
Q33	<---	PRJOBJ	.919	.095	9.637	***	
Q32	<---	PRJOBJ	.746	.093	8.046	***	
Q31	<---	PRJOBJ	.965	.091	10.647	***	
Q40	<---	PRJSAT	1.000				
Q39	<---	PRJSAT	1.032	.060	17.218	***	
Q38	<---	PRJSAT	.931	.058	15.973	***	

Covariances:			Estimate	S.E.	C.R.	P	Label
PRJSAT	<-->	PRJOBJ	2.018	.310	6.515	***	

Variances:			Estimate	S.E.	C.R.	P	Label
		PRJOBJ	2.059	.329	6.252	***	
		PRJSAT	2.902	.433	6.701	***	
		err34	.468	.122	3.844	***	
		err33	1.479	.218	6.797	***	
		err32	1.652	.226	7.309	***	
		err31	1.325	.201	6.596	***	
		err40	.533	.103	5.155	***	
		err39	.566	.111	5.120	***	
		err38	.633	.108	5.869	***	

(*** < 0.001)

Table 68: The Amos output of Goodness-of-Fit Statistics for project performance construct (Y2).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	22	43.043	13	.000	3.311
Saturated model	35	.000	0		
Independence model	14	693.363	21	.000	33.017

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.938	.900	.956	.928	.955
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.619	.581	.591
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	30.043	13.832	53.852
Saturated model	.000	.000	.000
Independence model	672.363	590.062	762.072

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.339	.237	.109	.424
Saturated model	.000	.000	.000	.000
Independence model	5.460	5.294	4.646	6.001

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.135	.092	.181	.001
Independence model	.502	.470	.535	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	87.043	90.001		
Saturated model	70.000	74.706		
Independence model	721.363	723.245		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.685	.558	.873	.709
Saturated model	.551	.551	.551	.588
Independence model	5.680	5.032	6.386	5.695

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	66	82
Independence model	6	7

Table 69: The Amos output of Goodness-of-Fit Statistics for modified project performance construct (Y2).

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	24	8.995	11	.622	.818
Saturated model	35	.000	0		
Independence model	14	693.363	21	.000	33.017

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.987	.975	1.003	1.006	1.000
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.524	.517	.524
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	.000	.000	8.745
Saturated model	.000	.000	.000
Independence model	672.363	590.062	762.072

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.076	.000	.000	.069
Saturated model	.000	.000	.000	.000
Independence model	5.460	5.294	4.646	6.001

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.079	.821
Independence model	.502	.470	.535	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	56.995	60.222		
Saturated model	70.000	74.706		
Independence model	721.363	723.245		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.449	.465	.533	.474
Saturated model	.551	.551	.551	.588
Independence model	5.680	5.032	6.386	5.696

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	278	350
Independence model	6	8

APPENDIX C – DESCRIPTIVE STATISTICS

Table 70: Descriptive Statistics for research constructs, variables and questions.

	Construct, Variable, Question	N	Minimum	Maximum	Mean	Std. Deviation
Project Complexity		128	1.661	6.225	4.246	0.832
Organizational Complexity		128	1.084	4.368	2.958	0.591
Q1	What was your perception on the size of the project?	126	2	7	4.944	1.241
Q2	What was your perception on the number of vendors/ subcontractors?	128	1	7	4.242	1.510
Q3	What was your perception on the number of departments involved in the project?	128	1	7	4.633	1.463
Q4	What was your perception on the number of projects dependent on this project?	128	1	7	4.258	1.528
Product Complexity		128	2.162	7.511	5.121	1.056
Q5	What was your perception on the novelty/newness of the product?	128	2	7	4.906	1.411
Q6	What was your perception on the number of the product sub assemblies?	123	1	7	4.659	1.402
Q7	What was your perception on the impact of a design change of one sub assembly on another sub assembly?	124	1	7	4.661	1.459
Methods Complexity		128	1.902	6.545	4.490	0.941
Q8	What was your perception on the newness of the technologies to deliver the final product?	128	2	7	4.844	1.313
Q9	What was your perception on the number of the processes needed to deliver the final product?	127	2	7	4.811	1.271
Q10	What was your perception on the impact of a change in one process on to other processes needed to deliver the final product?	126	2	7	4.952	1.238
Goal Complexity		128	0.852	4.536	3.085	0.679
Q11	What was your perception on the number of the requirement changes?	125	1	7	4.632	1.406
Q12	What was your perception on the potential impact of a change in one requirement on the other requirements?	125	1	7	4.832	1.366
Q13	What was your perception on the impact of not realizing the goals of the project on the organization?	126	1	7	4.738	1.454

Table 70 (Continued): Descriptive Statistics for research constructs, variables and questions.

Construct, Variable, Question		**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Project Management Style		128	1.039	6.812	4.346	1.166
Plan Style		128	1.162	7.074	4.613	1.266
Q14	A simple basic solution was designed and later modified during the project's life.	128	1	7	4.438	1.687
Q15	The customer was involved in the decision making process from start of the project.	127	1	7	5.094	1.761
Q16	Project plans were revised periodically in short intervals.	128	1	7	4.289	1.753
Do Style		128	0.893	5.815	3.796	0.988
Q17	Through interaction with the project manager, team members decided which tasks they would complete	127	1	7	4.575	1.780
Q19	Instead of directing the team members, the main role of the project manager was to work with the customer, the management of the organization and the project team in order to remove any obstacles to the progress of the project.	128	1	7	4.250	1.730
Q20	Project management received just-in-time information about the progress of the project.	128	1	7	3.945	1.781
Study Style		128	0.938	6.369	3.964	1.106
Q18	Team members continuously reported the status of their tasks to the team leaders or the project manager.	128	1	7	5.063	1.561
Q21	Project team members investigated and reported the causes for non-realization of their assigned tasks.	128	1	7	4.266	1.658
Q22	The project team regularly presented the progress of the project to the management of the organization and the customer.	128	1	7	4.789	1.742
Act Style		128	0.999	6.989	4.323	1.298
Q23	Project plans were revised regularly using the lessons learned during the project.	128	1	7	4.227	1.883
Q24	The structure and the roles of the project team changed to adapt to the changing project conditions.	128	1	7	4.430	1.659
Q25	The lessons learned during the project were kept, documented and shared within the organization	128	1	7	4.234	1.897
Alignment		128	2.564	6.977	5.889	0.849

Table 70 (Continued): Descriptive Statistics for research constructs, variables and questions.

Construct, Variable, Question		N	Minimum	Maximum	Mean	Std. Deviation
Project Issues		128	0.674	4.491	2.330	1.065
Q26	Lack of customer commitment to the project and its deliverables.	128	1	7	3.445	1.822
Q27	Lack of top management support to the project.	128	1	7	3.359	2.038
Q28	Lack of experience/expertise of project personnel.	128	1	7	3.805	1.908
Q29	Lack of involvement and commitment of functional departments.	127	1	7	3.354	1.946
Q30	Excessive dependence on vendors/consultants.	127	1	7	3.764	2.068
Project Performance		128	0.955	6.769	4.063	1.439
Project Objectives		128	0.910	6.524	3.459	1.338
Q31	To what degree was the original technical performance objective met?	127	1	7	3.906	1.625
Q32	To what degree was the original cost objective met?	128	1	7	3.406	1.585
Q33	To what degree was the original schedule objective met?	128	1	7	3.398	1.671
Q34	To what degree was the combination of original project objectives (technical objectives, cost, schedule) met?	128	1	7	3.570	1.596
Composite Outcome Measures (Weights)						
Q35	Technical Performance	128	2	7	5.828	1.305
Q36	Cost	128	1	7	5.344	1.394
Q37	Schedule	128	1	7	5.688	1.489
Project Satisfaction		128	0.999	7.014	4.667	1.665
Q38	Senior Management	128	1	7	4.961	1.781
Q39	Project Management	128	1	7	4.781	1.919
Q40	Customer(s)	125	1	7	4.776	1.883

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