



**PLANNING FOR STARTUP:
ANALYSIS OF THE PLANNING MODEL
AND OTHER SUCCESS DRIVERS**

by

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Executive Summary

While CII has conducted much research into incorporating enhanced project planning into the early phases of a project, little previous work has focused on the subject of planning for the startup phase. As a result, CII's Research Team 121 was formed to identify problems with traditional startup planning and to develop a Planning for Startup best practice model and associated tools.

Additional specific research objectives were established to complement these developments. These included the following:

- Validate the best-practice model;
- Investigate optimal levels and timing of planning for startup;
- Establish performance metrics for measuring startup success;
- Acquire an understanding of the relationships between planning for startup, startup success, and overall project success;
- Identify those planning activities that most significantly contribute to startup success; and
- Identify and assess the importance to startup of other factors, such as project type and size, maturity level of manufacturing technology, management's startup experience, among other factors.

This report attempts to address all these issues.

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Chapter 1 Introduction

1.1 MEANING AND IMPORTANCE OF STARTUP

For major capital projects in the process industry, while phase names vary widely from company to company, there is a typical cycle of project phases. Projects begin with business planning and requirements definition followed by conceptual and detailed engineering, procurement, construction, startup, and operation. After a sustained period of commercial operation, facilities may be dismantled or reconfigured by means of another project. The interface points between phases are loosely defined and there is often considerable overlap between the end of one phase and the beginning of the next.

Startup is the transitional phase between construction and commercial operations. CII has previously defined the startup phase as the progressive initiation of systems within a facility, where a system is any assemblage of structural, mechanical, electrical and instrumentation components providing a function or service. This activity can be as simple as opening a new highway or as complex as beginning generation of electrical power at a nuclear power plant.

Industrial plant startups are generally conducted in stages, reflective of the industrial processes and sub-processes involved. While the specific stages and sequencing will vary depending on the project, the general sequence is as follows:

1. Mechanical Completion of Construction
2. Checkout Systems
3. Commission systems
4. Introduce Feedstock
5. Conduct Performance Testing
6. Begin Production or Commercial Operations

The importance of startup planning is evident given the challenging characteristics of today's industrial business environment:

- Pressures to increase profits by reducing costs;
- Reduction in owner project staff and increases in outsourcing of services;
- Demand for shorter project cycle times; and
- General lack of planning capabilities and supportive tools.

Planning for startup is difficult due to the extensive coordination and input needed early in the project. A successful startup requires not only that many disciplines work together, but also that these disciplines view the project from a systems perspective. Converting from a discipline-based construction paradigm to the systems paradigm is not easy. Furthermore, since the early phases of the project have the greatest impact on project success, it is critical that startup planning occur early in the project cycle.

A successful startup is generally considered essential to overall project success for the following reasons:

- Startup costs are significant. Startup costs average approximately 5.5% of construction costs (Meyers, 1986).
- Startup delays can be very expensive. A delayed startup costs between 4% and 8% of the fixed capital cost per month of delay (King, 1977).
- Startup is risk-intensive. Startup often reveals problems overlooked in planning, design, and/or construction. Risks range from contractual risks due to delays in product delivery to human health and environmental risks.
- Aspects of startup are keenly memorable. The startup phase is typically the last phase where both the construction manager and constructor are involved. Therefore, a successful startup will leave a lasting positive impression with the owner and conversely, an unsuccessful startup will remain a difficult memory for many years.

1.2 RESEARCH OBJECTIVES

CII was founded in the early 1980's to improve the cost effectiveness of the construction industry through industry-wide cooperative research. As the ability to influence final total project cost decreases with time, CII has focused its research efforts on improving projects through increased planning early in the project's life cycle. While CII has conducted much research into incorporating

construction planning early in a project, little work has gone into planning for the startup phase. Accordingly, CII's Research Team 121 (RT 121, Planning for Startup Research Team) was formed in the Spring of 1995 to identify problems with traditional startup planning and to develop a Planning for Startup Model and associated tools.

Many objectives were established for this research:

- Develop and validate a best-practice model of planning for startup and provide implementation tools to support thorough, yet efficient startup planning;
- Investigate optimal levels and timing of up-front planning for startup and increase awareness of the importance of such planning;
- Establish performance metrics for measuring startup success and to facilitate benchmarking;
- Understand the relationships between planning for startup, startup success, and overall project success;
- Identify those planning activities that most significantly contribute to startup success;
- Understand the challenges to startup success and the causes of startup failure; and
- Identify and assess the importance to startup of other project factors such as project type and size, maturity of manufacturing technology, management's startup experience, timing of assignment of the startup manager, and startup duration performance, among others.

It should be noted that this research focuses on the startup of industrial facilities, such as process plants, since these types of projects are more likely to experience startup difficulties. In accomplishing these objectives, the research team studied a diversity of industrial project types and sizes. No constraining assumptions have been made regarding project organization structure or contractual approach.

1.3 REPORT ORGANIZATION

The remainder of this report is organized as follows:

Chapter Two examines the research methodology and presents the process that RT 121 followed in developing the Planning for Startup Model and associated tools.

Chapter Three presents an overview of the Planning for Startup Model and provides a detailed description of the Model's purpose and general structure. This chapter also presents an overview of the supportive tools, startup personnel assignments, and common startup challenges. Readers are referred to CII Publication 121-2 for a complete view of the Planning for Startup Model (including activity profiles and tools).

Chapters Four and Five present the findings from analysis of data pertaining to actual startups.

Chapter Six presents the overall conclusions and recommendations from this research.

Chapter 2 Study Methodology

2.1 Methodology Overview

The research proposal helped establish a common understanding of research objectives and scope (previously discussed in Chapter One). The six basic steps included the following:

1. Review of literature and corporate best practices;
2. Development of the Planning for Startup Model;
3. Development of startup planning tools;
4. Analysis of the Planning Model and tools;
5. Demonstration projects implementing the Planning for Startup Model and tools;
6. Analysis of actual projects and startups;

Each of these steps is addressed below in a separate section of this chapter.

2.2 REVIEW OF LITERATURE AND CORPORATE BEST PRACTICES

Research activities began with a review of the few previous publications that existed on the subject of Startup planning. While CII Research Summary 6-9, *Planning Construction Activity to Support the Startup Process* was found to be the most in-depth document on the subject, it was also found to be insufficient in a variety of ways. The Research team used such insights to better understand its own objectives.

In addition to reviewing the few publications on the subject in the public domain, several proprietary corporate planning procedural documents were obtained and reviewed for content and format. These were useful in both identifying critical planning activities and later in creating supportive planning tools.

2.3 DEVELOPMENT OF THE PLANNING FOR STARTUP MODEL

One of RT 121's key objectives was to develop a model for startup planning that incorporates industry's best practices. As a result, the initial research focused on creating the Planning for Startup Model and involved three primary steps:

1. Identification of fundamental planning activities and respective activity sequences;
2. Characterization of planning activities with activity profile sheets; and
3. Identification of needed startup planning tools.

The first step was to break startup planning into manageable pieces and to link planning activities to widely understood project milestones. In order to accomplish this, and given that there was no industry-wide standard on the subject, the Research Team decomposed the overall project delivery process into eight clearly defined project phases. The research team then identified best practices in the form of individual startup planning activities that project teams

should accomplish during each of the respective project phases. This establishment of phases and planning activities was intended to facilitate timely and rigorous startup planning. This point, that startup planning is a logical sequence of steps or activities is the very essence of the Planning for Startup Model.

Once RT 121 established the Model's flow chart of activities, they developed a plan to further develop implementation guidance for each planning activity. The team structured and standardized the activity profile format as a way to present useful information in an orderly, concise, and useful manner. Each team member contributed to the write-ups of activities that related to their own personal experience and knowledge. Additional information was collected from existing corporate startup planning documentation.

Each activity profile contains nine fields of descriptive and useful information:

- A. Phase
- B. Key Concepts
- C. Deliverables
- D. Motive/Rationale
- E. Assignments for Responsibility/Accountability/Consult/Inform (RACI)
- F. Quality Gate/Sequencing Constraints
- G. Basic Steps
- H. Tools Needed/Provided

I. Challenges to Successful Implementation

The Research Team conducted an activity-by-activity review. In order to improve the Model's clarity, some activities were combined while others were further broken down into separate activities. Concurrent to this refinement, the activities were organized into sequential order to form the final Planning for Startup Model (which is presented in CII Pub. 121-2). At this point, the research team shifted focus to the development of supportive tools, the needs for which were listed in Section H. of each activity profile.

2.4 DEVELOPMENT OF STARTUP PLANNING TOOLS

Startup planning tools were developed to support the Startup Planning Model by providing detailed examples of key activity deliverables or procedural approaches, such as the Startup Execution Plan, the Operator Training Plan, and the System Turnover Plan. The tools evolved from information contained in corporate startup manuals and from Research Team members' own personal experiences. The final step in the development of the tools was a final review to insure that they were either useful (or beneficial) and implementable. Some tools underwent a final revision. After the Model and tools were completed, a series of validation exercises and analyses were conducted.

2.5 ANALYSIS OF THE PLANNING MODEL AND TOOLS

The Research Team created several documents to assist in the analysis of the Model. Some of these were developed into separate tools, such as the RACI chart, identification of key startup personnel, and the listing of recommended Quality Gates. Additional analyses included a comparison of the activity and tools distributions by phase; the Research Team's assessment of planning activity significance and ease of implementation; a summary of tools types; and a detailed analysis of challenges to Startup planning. These are presented and summarized in Chapter Three of this report.

The Model also underwent an outside review by a national team of startup experts. This team consisted of representatives from two owner companies, two EPC firms, and two startup consultants.

2.6 DEMONSTRATION PROJECTS

Shortly after the Model was completed, two Research team members volunteered actual projects for testing or demonstration the Model and supportive tools. Beyond showcasing the development and presenting the opportunity for future documented case studies, the proposes of these demonstration projects were to answer the following questions:

- How useful or beneficial will the Model be to startup planners?
- How can the Model be improved upon? Are any key elements currently missing?

The results of these demonstration projects are documented in other CII publications (see Research Summary 121-1 *Planning for Startup: Overview of Research* and Implementation Resource 121-2 *Planning for Startup* and have been showcased in both the 1997 and 1998 CII Annual conferences.

2.7 ANALYSIS OF PROJECTS: OBJECTIVES

Beyond development of the Planning for Startup Model and associated tools, this research incorporated a variety of analyses pertaining to the startups of actual projects. The objectives associated with these analysis are perhaps best communicate by way of the variety of questions answered:

- Is the Planning for Startup Model valid?
- How can startup success be measured?
- Is there any relationship between degree of startup success and degree of startup planning?
- Is there any relationship between degree of project success and degree of startup success?
- What is the relationship between startup success and the timing of implementation for startup planning activities?
- What additional project variables influence or in some way are related startup success?

The remainder of this chapter addresses five detailed study methodology issues:

- Tools for data collection;
- Data collection;
- Data set development;
- Data analysis; and
- Characteristics of projects studied.

2.8 TOOLS FOR GATHERING DATA

Three survey instruments, the Interview Guide, the Project Success Questionnaire, and the Startup Success Questionnaire were developed and served as the mechanisms for gathering project data. The Interview Guide was developed for use in personal interviews; the Project Success and Startup Success Questionnaires were developed for use either in personal interviews or in mail/fax surveys.

2.8.1 Interview Guide

The Interview Guide was the primary data gathering instrument in the study. It captured the startup planning data for model validation, as well as project facts and startup conditions. The guide was initially developed, pilot-tested, and then revised.

The guide consisted of nine sections, each containing a combination of explicit fill-in-the-blank type questions, Likert response questions, and open-ended short-answer questions. The guide is divided into the following sections:

- I. Interviewee Information
- II. Identification of Best and Worst Startups
- III. Success Ratings, Percentiles, & Factors
- IV. Duration and Schedule Analysis
- V. Assessment of SU Planning Activities
- VI. Project Organization Issues
- VII. O&M Participation
- VIII. SU System Identification
- IX. Lessons Learned

The complete Interview Guide is presented in Appendix A.

Sections I through IV and VI through IX were used to collect contextual information such as interviewee experience, project costs, and startup duration. Section V: "Assessment of SU Planning Activities" was fundamental to the model validation process and was specifically devoted to capturing startup planning data. The questions in this section were developed on the premise that the startup was planned using the activities described in the model. In the interview, the

interviewee scored each activity based on the level of effort applied and the project phase when it was initiated. If the activity was not done, it was given a zero score. Once startup success indices were assessed, Model validation then involved the process of determining the degree of agreement between planning activities actually done and planning activities recommended in the model.

The major advantage of this approach was that the interview data was collected in the vocabulary of the Planning for Startup Model, and not in the (likely unique) vocabulary of the interviewee's company. A major disadvantage was that it required the interviewee to have a clear understanding of the terminology and approach used in the Model. By collecting the data in personal interviews, this disadvantage was minimized.

To elaborate, the section captured planning data as responses to the following three questions:

- *"How much effort was applied to this activity?"* This question measured the Level of Effort devoted to accomplishing the activity. If the activity was done, the interviewee assigns it a score between "1" and "5" depending on the level of effort expended in completing the activity: If the activity was not done, it is scored "0":
- *"When was this activity first started?"* This question measured the time of activity execution--the "when". The interviewee selected the

project phase when the activity was first started. If the activity was not done i.e., an activity with a zero effort score, the column is left blank.

- *"How important is this activity?"* The interviewee rated the activity on how important this activity is to any project. Importance is measured on a "1" to "5" scale similar to that used to measure level of effort.

As a detail, all model activities were not included in the Interview Guide. Those model activities that are continuations of previous activities and are not critical to model validation were excluded from the Interview Guide. For example: Model Activity 3-B: "Develop SU Execution Plan" was included, but its follow-up activity 4-O: "Update the Startup Execution Plan" was not. In total, 28 of 45 Model activities were included in the Interview Guide.

The Interview Guide underwent three revisions during the course of the study. One was major; the other two were minor. The major modification was the result of a two-project pilot test that simplified the interview form. The interview time was shortened to approximately four hours (the duration of the pilot interviews approached five hours per interview), and project data was limited to one startup per interview, not two, as originally planned. The subsequent minor revision consisted of format and wording modifications to the guide. Ultimately, all interview data were transformed to the format of the final Interview Guide prior to coding and database entry.

2.8.2 Startup and Project Success Questionnaires

The Startup Success Questionnaire and the Project Success Questionnaire were developed to gather data for measuring the success of the startup and the success of the project. They provided the raw data for input into the equations for computing the Startup Success Index and Project Success Index. Development of these success indexes is discussed later in this chapter, a discussion of the success questionnaires is presented below.

Initially, success data were collected in Section III of the Interview Guide ("Success Ratings, Percentiles, & Factors"), but this data produced inconsistent success scores because of the lack of explicit definitions for the success criteria questions. A decision was made to develop a separate set of questionnaires specifically addressing project and startup success. The objective of the follow-up questionnaires was to improve accuracy and precision of the startup and project success measurements by providing explicit definitions for each success indicator; and to provide a mechanism for measuring the relative importance of each success indicator to the overall objective of the project.

Eight startup success indicators were defined in the Startup Success Questionnaire including:

- Product Quality Performance
- Product Quantity Performance
- Schedule Performance

- Safety Performance
- Environmental Performance
- Operations Team Performance
- Impact on On-going Operations
- Level of Effort Required by the Startup Team

For each success indicator, five levels of satisfaction were offered ranging from "Extremely Satisfied" to "Very Dissatisfied". Figure 2.1 presents an example of how success data for one indicator, "Product Quality Performance", was collected.

1. Product Quality Performance	
At the end of Start Up, what was your satisfaction level with product quality as established at project authorization	
Satisfaction Level	Definition
☐ Extremely Satisfied	Product quality consistently <u>exceeded</u> project goals.
☐ Very Satisfied	Product quality goals were <u>consistently met</u> .
☐ Satisfied	Product quality goals <u>were met with expected amounts</u> of off-spec material.
☐ Dissatisfied	Product quality <u>met specification most</u> of the time but the amount of off-spec material was higher than expected.
☐ Very Dissatisfied	Product quality was <u>met only with significant process and construction rework</u> .

Figure 2.1 Example of Startup Satisfaction Definition

Similar definitions were developed for each of the other seven indicators. For a complete presentation of these success definitions see the Startup Success Questionnaire presented in Appendix B.

The relative importance (or weighting) of each success indicator was selected by the interviewee from the following:

- Most Important
- Above Average Importance
- Average Importance
- Below Average Importance
- Least Important

It was not a requirement that the importance factors be rank-ordered. The interviewee could assign the same importance level to all indicators if that was an accurate reflection of the project requirements.

Like the Startup Success Questionnaire, the Project Success Questionnaire measured performance levels with a structured set of variables and performance definitions. Seven success variables are defined in the questionnaire including:

- Cost Performance
- Schedule Performance
- Demonstration of Design Capacity
- Unscheduled Down-Time

- Project Safety
- Environmental
- Operating Costs

For each project success variable, three categories of performance were presented. An example of how the indicator "Cost Performance" was measured is presented in Figure 2.2 below. A copy of the complete questionnaire is presented in Appendix C.

Assessment of Project Success Variables For the Success Variable Question please indicate the level of project performance		
Success Variable	Question	Performance
COST PERFORMANCE	<i>The Total Installed Cost for the Project was....</i>	☐ <u>Significantly Under</u> Authorized Budget. ☐ <u>Essentially At</u> Authorized Budget ☐ <u>Significantly Over</u> Authorized Budget

Figure 2.2 Example of Project Success Performance Definition

As with the Startup Success Questionnaire, the Project Success Questionnaire also included an Importance Factor score sheet for the success variables. The scoring was like that used in the Startup Success Questionnaire.

2.9 DATA COLLECTION

The data collection phase of the research included identifying projects for analysis, setting up interviews with project and startup managers, conducting the interviews, structuring of the database, and entering data into the database. The methods used for accomplishing these tasks are described below.

2.9.1 Identification of Projects

Most of the projects studied involved CII member companies but some non-CII member projects are represented as well. Potential projects and their respective project managers were identified in a two-step process. Initially, a Research Team member identified a project manager with startup planning experience. The project manager was then contacted by telephone and briefly interviewed to determine if he/she had the applicable experience in startup planning and if they had a suitable startup project for inclusion in the study. A project and interviewee was identified if the following general criteria were met:

- The project manager had significant involvement in the startup planning process (typically this was the owner's project manager) ;
- The startup was completed within the last five years;

- The total installed cost for the project exceeded \$10 million;
- The startup was, in the opinion of the interviewee, either very successful or very unsuccessful (average success or mediocre projects were intentionally avoided);

If these general selection criteria were met, a copy of the interview material was sent and an interview date set.

2.9.2 Project Interviews

Project interviews were conducted over an 18-month period. All interviews (with the exception of P-16 and P-30) were conducted in the project manager's office by the same interviewer. All interviewees were either the owner's employees or had direct responsibility to the owner for startup operations, including introduction of raw materials. The goal of the research was to complete 30 project interviews. In total, 30 interviews were completed, of which 26 were considered complete enough for analysis.

2.9.3 Database Development and Data Entry

The Microsoft Access 2.0 database software (Borges, 1997) was used to structure and in part, analyze the data. Using this software, a series of data queries

were made to develop the project data set for analysis. The extracted data files were exported to either Microsoft Excel 97 or the statistical software package SPSS (Statistical Package for Social Science) for Windows Ver. 7.5.

The questionnaire data is a mix of data formats including quantitative data, qualitative data, and interviewer notes from the open-ended questions. For many questions, these data could be entered directly into the project database, but some responses required a data-coding step prior to data entry. Data coding procedures were developed based on the parameter being measured. They included the following:

- Project Phase: The coding followed a simple 1 through 8 numbering, corresponding to the eight project phases.
- Satisfaction & Performance Levels: These were measured using a Likert scale format with a 1 to 5 intensity scale. The higher the intensity, the higher the score.
- Environmental and Safety: A "Yes" indicating violations of regulatory rules were scored as a "1": if the answer was "No", it was scored as a "5".
- Importance Factors: These were measured using an intensity scale of 1 to 5. "Most Important" scored "5"; "Least Important" scored "1".

After the data was coded, it was entered into the database and extracted as required to develop various files that make up project data sets.

2.10 DATA SET DEVELOPMENT

After entering the Interview Guide and Success Questionnaire data into the database, the data were classified into the following categories:

- Project Characteristic Data
- Startup Planning Data
- Startup Success Data

The objectives of this effort were to convert the interview data into usable data sets for analyses. Database queries were then made to construct the various data sets used in the analysis.

2.10.1 Startup Success Index

An index is a summed composite of variables that are believed to reflect some underlying construct (Knoke and Bohrnstedt, 1994). Indexes are extremely useful because they can be mathematically treated as continuous variables; and conceptually they provide a quantitative measure of something this is wholly unobservable.

In this study, the Startup Success Index integrates eight startup success variables and serves as a proxy for the underlying construct “startup success”. This index was important to the research effort because it was the dependent variable in many of the statistical tests of the data sets. A discussion of the methodologies used to compute the success indexes and assess their reliability is presented below.

Development of the variables to be included in the Startup Success Index consisted of two-steps. Initially, a list of variables was identified by the Startup Research Team and then confirmed with the Interview Guide during the project interviews.

The Interview Guide asked the interviewee to rate the importance of the Research Team's eight startup success variables and to add additional ones if necessary. In 24 interviews, all agreed that the eight variables were important and that none should be eliminated. Furthermore, eight of the interviewee's suggested adding another term, "Startup Budget" to the list. This additional term was considered but dropped because of the paucity of reliable actual startup budget data. Although startup budget was considered important, a significant portion of the interviewees indicated that cost accounting methods used for tracking such costs varied so widely from project to project that metric consistency was not enough to be useful.

The Startup Success Index was computed using the Performance and Importance scores from the Startup Success Questionnaire. Conceptually, the Index is the ratio of the total points scored in each of the eight variables divided by the total possible points available. It is not based on a fixed number of points. Instead, a maximum possible point score was computed for each project based on the assigned importance factors and the maximum scale points for the startup success variables. This variable-points approach was adopted to account for the variance in startup objectives among the projects. The Startup Success Index was computed as follows:

$$\text{Startup Success Index for Project} = \frac{\sum \text{Total Earned Points Score}}{\sum \text{Max. Possible Point Score}}$$

$$\text{Startup Success Index } i = \frac{\sum_{n=1, k}^k (\text{Satisfaction Score } i, j \times \text{Importance Factor } i, j)}{\sum_{n=1, k}^k (\text{Max Satisfaction Level Score } j \times \text{Importance Factor } i, j)}$$

where :

i = Project Number

j = Startup Success Criteria Number (See Questionnaire for Number)

k = Number of Success Criteria in Index

The Total Earned Points Score is the summation of the product "Satisfaction Score times Importance Factor" for each index variable. The Total

Available Points Score is the summation of the products of "Max. Score times Importance Score" for each index variable. The Max Satisfaction Score is the maximum point value assigned to the activity and was typically 5-points (See the Data Coding section in this chapter for a discussion of these values).

The computation methodology is best demonstrated with an example. Figure 2.3 shows the Startup Success Index calculation for project P-29.

To assess the validity of the Startup Success Index it was tested in two ways. First, the Startup Success Index and the Project Success Index data were paired and their relationship statistically tested. Because a successful startup is a component of a successful project, it is reasonable to expect that some relationship between the two exist. A discussion of the Project Success Index and its relationship to the Startup Success Index is presented in the next section.

Startup Success Criteria	Satisfaction and Importance Scores		Computed Scores	
	Satisfaction (a)	Importance (b)	Earned Satisfaction Score (a * b)	Max. Possible Score (5 * b)
Product Quality	2	4	8	20
Product Quantity	2	4	8	20
Schedule Performance	2	5	10	25
Safety Performance	2	4	8	20
Environmental Performance	1	4	4	20
Operations Team Performance	1	4	4	20
Impact on Operations	2	5	10	20
Level of Effort	1	4	4	20
Total			56	165

$$\text{Startup Success Index} = \frac{\text{Total Weighted Performance Score}}{\text{Total Max. Possible Score}}$$

$$= (56/165)$$

$$= 0.34$$

Figure 2.3 Example Calculation for Computing Startup Success Index P-29

The second test of the Startup Success Index tested the level of *interrelationship* among the eight variables that make up the Startup Success Index. Inherently, good indexes are highly interrelated. This interrelationship, also called the *reliability* of the index, is tested using the Cronbach's alpha (α) statistic. A high alpha indicates a high level of inter-correlation, which gives confidence that the index items are measuring the same construct (Knoke & Bohrnstedt, 1994). Cronbach's alpha is computed as follows:

$$\alpha = \frac{k * r}{1 + (k - 1)r}$$

Where:

k = the number of indicators in the index

r = the average inter-correlation among the k index items

The computed alpha for the Startup Success Index was 0.71, which meets the acceptable alpha of 0.70 or higher reported by Knoke (Knoke & Bohrnstedt, 1994). The Cronbach alpha computation was performed using SPSS and the results are presented in (McLeod 1999).

2.10.2 Project Success Index

Project success and startup success are inter-related but not mutually exclusive. As such, there should be some reasonable (but not perfect) relationship between the two. To test this relationship a Project Success Index was created and then compared to the Startup Success Index. Evaluating the reasonableness of this relationship is useful to give credence to the Startup Success Index. The analysis also offers insight into how important startup success is to overall project success.

The Project Success Index was developed based in part on the research work of Gibson et.al. (Gibson, 1994). In the work, a four-variable Project Success Index was developed and tested. The current research has extended their four-variable index to a seven-variable one and added an adjustment step to take in account the project-specific weighting factors for each variable. It is believed that this adjustment step is one that greatly increases usability of the Index: the one-size-fits-all assessment paradigm is no longer required.

The Project Success Index is computed in a manner similar to the Startup Success Index computations. It uses response data from the Project Success Questionnaire and it incorporates the project-specific importance factors for each success variable. The relationship between the Startup Success Index and the Project Success Index is shown in Figure 2.4. The figure shows the predicted linear model and the 99.9% confidence interval range.

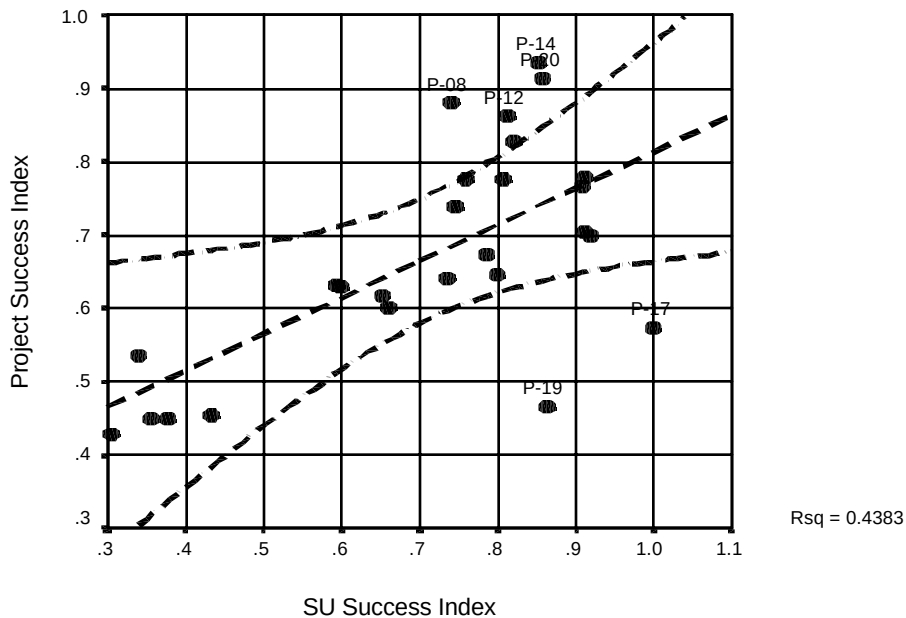


Figure 2.4 Startup Success Index vs. Project Success Index Regression

The scatterplot and regression analyses show a reasonable relationship between the two indexes. The R^2 of 0.43 is acceptable and understandable given the effect of the outlier projects (P-08,-12,-14,-17,-19, and -20). These outlier projects reinforce the belief that startup success is only one of several elements that contribute to project success. The t-statistic and related F-statistic are significant and support rejecting the null hypothesis that the regression

coefficients are zero. Regression statistics for this analysis is presented in [McLeod 1999].

2.11 DATA ANALYSIS

Various sample data sets were analyzed using a variety of statistical techniques. For example, a bivariate analysis was used to assess the significance of the activities from the Planning for Startup Model to Startup Success. This method as well as the other methods used in this research is described below. The analyses of the interview data are covered in Chapters Four and Five.

2.11.1 Multiple Regression Analysis

Multiple regression modeling was used to test the relationship between the Startup Success Index and selected variables from the data set. All regression modeling was performed using the statistical software packages SPSS for Windows Ver 7.5 and Microsoft Excel 97. A discussion of the basic models used in these packages and of the applicability of these assumptions to the data set follows.

All of the regression models tested were structured in the format of the Classical Normal Linear Regression Model (CNLRM). This is the well-known

linear regression model coupled with the expressed assumption that the error term is normally distributed. It is expressed mathematically as:

$$Y = \beta_i + \beta_2 * X_{2i} + \beta_3 * X_{3i} + ... + \beta_k * X_{ki} + U_i$$

Where:

Y = Estimated Value of the Dependent Variable

β_i = Estimated Partial Regression Coefficient

X_i = Explanatory Variable or Regressor

U_i = Estimated Disturbance or Error Term

Note: In many statistical text it is common to denote the estimated coefficients, β_i , with a " $\exists$ " or caret to designate it as a sample statistic which then can be used to infer a "true" population parameter. In this work, inference extends to the sample population only. Therefore, the " $\exists$ " has been omitted.

The partial regression coefficients, the β 's, were estimated using the method of Ordinary Least Squares (OLS). This method is considered to be a good estimator, in part, because it is unbiased, it maximizes R^2 , and it is efficient (Kennedy, 1996). Furthermore, the OLS computation methods are well developed and available in most statistical software, including SPSS and Excel.

Since the objective of the regression model is to estimate the partial regression coefficient as well as hypothesis testing, it is necessary to specify the probability distribution of the disturbance term U_i .

OLS estimates of β are linear functions of U_i and therefore are directly affected by the assumptions made about the probability distribution of U_i . Since the probability distribution of β is necessary to draw inferences about its population values, the nature of the probability distribution of U_i assumes an important role in hypothesis testing (Gujarati, 1995).

It is very convenient to assume these errors are distributed normally – but is this true? There are several statistical tests for normality but the most intuitive approach is to evaluate the "Normal P-P plot" which compares the cumulative expected probability of the error term with the observed cumulative probability. An example of this plot using data from regression runs (Run 07) is presented in Figure 2.5 below.

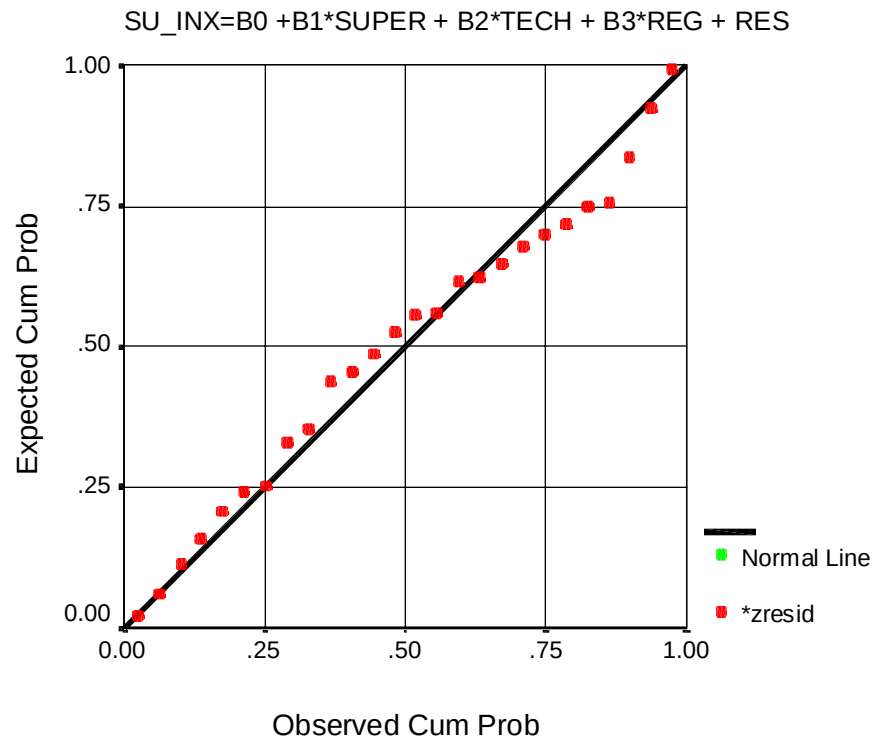


Figure 2.5 Normal P-P Plot of Regression Residuals for Run 07

The plot validates the assumption of normality because it shows acceptably close agreement between the expected error and the observed error under the normal distribution assumption.

2.11.2 Bivariate Analysis

Bivariate analysis uses a linear regression technique to assess the relationship among pairs of continuous variables. It was the method used to assess the relationship between individual planning activities in the Planning for Startup model and the Startup Success Index. The bivariate analysis was performed using the SPSS statistical software.

The strength of the bivariate linear relationship was used to indicate the contribution of an individual Model activity to startup success. The measure of an activity's contribution was the strength of the linear relationship which is measured by the Pearson correlation coefficient, "r". The higher the absolute value of r, the stronger the relationship (SPSS, 1990). The Pearson correlation coefficient is computed by the equation:

$$r = \frac{\sum_{i=1}^n (X_i - X_{avg})(Y_i - Y_{avg})}{(n - 1)S_x S_y}$$

Where:

r = Pearson Correlation Coefficient

X_i = Effort or Phase Score for the Activity

Y_i = Startup Success Index

S_x = Standard Deviation of X

S_y = Standard Deviation of Y

The method assumes a continuous and linear relationship exists between the variables, and that they are normally distributed. The method is considered by statisticians to be robust. In other words, the conclusions regarding statistical significance are correct even if the assumptions regarding the probability distribution of the sample data set are violated (Knoke & Bohrnstedt, 1994).

2.11.3 Significance Testing

After the various models and coefficients were computed they were tested for statistical significance. Significance testing was applied to the following:

- The partial regression coefficients developed during the regression modeling;
- The inter-correlation coefficients developed in the bivariate analysis; and
- The difference in categorical means between the "very successful" and the "very unsuccessful" startups.

Significance testing followed the traditional approach (Freund 1992) of hypothesis testing as outlined here:

- Formulate the null hypothesis H_0 and the alternative hypothesis H_A .
- Specify an acceptable level of significance. Typically, a one-tail test with a 0.05 confidence level was used.

- Select a test statistic and the corresponding critical value. In this research it was either the F-statistic or t-statistic.
- Use SPSS or Excel software to compute the test statistics.
- Compare the test statistic with the critical statistic and, accordingly reject the null hypothesis or accept it.

2.12 PROJECT CHARACTERISTICS

In this section the various characteristics of the projects comprising the sample data set are described. Initially, summaries of interviewee characteristics are presented, which include project role, company affiliation, and number of years of project experience. Descriptive statistics of the sample projects are then presented that include industry type, project size, site conditions, construction contracting methods, process technology, and the regulatory environment of the project.

The data set contains twenty-six projects. Twenty-five were private sector projects; the remaining one was a joint, private/public sports authority project. All of the projects were completed during the period 1986 - 1997. Twenty-four were completed in the United States, and one each in Canada and the United Kingdom.