This is to certify that the
thesis entitled

ANALYZING THE RELATIONSHIP BETWEEN SITE OPERATIONAL FACTORS AND CONSTRUCTION WORK FLOW RELIABILITY: AN SEM APPROACH

presented by

SAMARTH JAIN

has been accepted towards fulfillment
of the requirements for the

Master of Science degree in Construction Management

Tariq S. Abdelhamid
Major Professor's Signature

Aug 17, 2010
Date

ANALYZING THE RELATIONSHIP BETWEEN SITE OPERATIONAL FACTORS AND CONSTRUCTION WORK FLOW RELIABILITY: AN SEM APPROACH

By

Samarth Jain

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Construction Management

2010

ABSTRACT

ANALYZING THE RELATIONSHIP BETWEEN SITE OPERATIONAL FACTORS AND CONSTRUCTION WORK FLOW RELIABILITY: AN SEM APPROACH

By
Samarth Jain

The lack of an explanatory understanding of factors giving rise to low/high PPC highlights the importance of investigating the current production metrics implemented in Last Planner System and how these metrics affect workflow reliability in the production stage. The overall goal of this research is to understand causal relations related to workflow reliability at the production level in a construction project. To approach this goal, the research focused on developing a method to investigate the causal relationship between production constraints and their impact on workflow reliability as measured by the PPC metric. The research has concluded that the latent factors (Pre Requisite Work, Directives, Burden etc.) in construction management research are mostly subject to constructivist interpretation, i.e., they form as a result of collection of a set of measured variables and represent a collective existence of those variables, therefore, it is recommended that future researchers consider it strongly and test relationships with formative latent variables. It was also found that studying the impact of all factors together is more insightful than isolation studies. This research has developed a framework using which industry professionals can measure the impact of production delay factors on work flow reliability. This research contributes to the lean production management practices by developing a list of production factors that can be added to the constraint analysis sheet of the Last Planner and used to record the status of production on a quantitative scale, on a regular basis.

Dedicated to
My Grandfather, Late Mr. Padam Singh Jain,
My parents, Mr. Satish Chander Jain and Mrs. Usha Jain,
My aunt and uncle, Mrs Nirmal Jain and Mr. Ari K. Jain.

ACKNOWLEDGEMENTS

Finally! To be able to write this page gives me utmost joy as it marks the end of this painful but enriching experience of writing a master's thesis. It also marks the end of my education and, sadly, active association with Michigan State University. I would like to use this space to express my thanks to all the people who were directly or indirectly involved in making my journey at MSU and writing this thesis, a fruitful experience. And I will do this without worrying about adding citations and footnotes.

To my Uncle and Aunt, *Mrs. Nirmal Jain and Mr. Ari K. Jain*, I thank them for putting immense faith in me and my capabilities as a student and instilling the belief in me that I can come to MSU against all odds and fulfill my dreams, without their support this journey would not have been possible.

To my Advisor, *Dr. Tariq S. Abdelhamid*, no form of writing will be able to truly express my gratitude and appreciation for him. He was always there when I needed a professional advice or just someone to talk to. His enriched and simple thought process always helped in putting me back on the tracks when I derailed from my mission. His expert guidance and unfettering support made this rollercoaster of a journey look easier. His mentoring during my entire master's education and thesis writing, taught me a lot of valuable lessons of life, which I would forever strive to follow to become a better person. One of my greatest personal enrichments at MSU is my association with Dr. Tariq which I hold in the highest regard and I will cherish it forever. I thank him for being so patient with me all through these years and taking care of me both at a professional and a personal level.

To my Committee Members, *Prof. Timothy Mrozowski and Dr. Mark Meerschaert*, thanks to them for serving as co-chairs and playing the devil's advocate when it was required and giving me valuable inputs to help refine my thesis. Also, I thank them for making classroom-learning a highly enjoyable experience in their respective expertise.

A special note of thanks to *Mr. Steven J. Pierce and Dr. Tenko Raykov,* for their expert guidance towards the end of my research, they made climbing the last mountain easier.

I would like extend my special thanks to *Dr. Matt Syal,* for his advices on matters of master's program and career search. His energy levels are unmatched for a person who has so much on his plate, a source of inspiration for how to tackle the busy life that is dawning upon me.

I would like to extend my cordial thanks to *Dr. Mohamed El-Gafy,* for making classroom learning exciting, connecting with students at a personal level and he always inspires students to push the envelope.

I extend my gratitude to all the administrative staff and faculty members, with special mention to *Ms. Cathy Morrison*, who by their sheer presence, made college matters between any two classrooms stress-free.

I would like to express my appreciation and warmest regard for my colleague and friend *Don Schafer,* a man of few words but lots of wisdom and ideas. It was a pleasure to share the research laboratory with him. It was a discussion with him that helped me come up with this thesis idea, and his logistical support at crucial times helped my research.

To my parents, who are my pillars of strength and motivation, I offer my deepest respect and gratitude for encouraging and supporting me to pursue my dreams and showering all their blessings on me.

To my brother, *Saurabh Jain,* I offer my deepest love and regard for letting me selfishly pursue my dreams and taking on my responsibilities within the family. His sacrifice is the hardest and I will be forever indebted. You are the best.

A special note of thanks and regards to my uncle and aunt, *Mr. Anil Agarwal and Mrs. Rachna Agarwal,* for encouraging me to pursue my dreams.

Last but definitely not the least, I express my warmest hugs and give high-fives to all my friends, who I had the pleasure to know from my undergrad days, *Amanjeet Singh, Yash Pratap Singh*, and *Shilpi Mago*, they made sure that I stay focused in my endeavor, and friends who I met here for the first time on Spartan soil with special mention to *Lipika Swarup, Sagata Bhawani, Nikhil Mehrotra, Radhika Arora, Pranav Sané, Rajat Basu, Ali Lahouti and Alessandro Orsi* for giving me a family away from home. It is a testament to your spirit and cheerful company that tough times were so easily tackled, and fun times never left my side. Cheers to all of you.

Finally, thanks to all those friends and colleagues who I have not mentioned but they have a special place in my heart and memory, my interactions with you have left positive imprints on me that helped me shape my opinion about this multicultural world and help me grow as a responsible person. I hope to stay in touch with all of you and continually affect each other's lives in a positive manner.

......I did it!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER-1

INTRODUCTION

Small changes in the starting conditions in a complex dynamic system produce outcomes totally out of proportion to their magnitude, making the phenomenon or system inherently unpredictable in the long term. – Chaos Theory[1]

1.1 Introduction

Many factors contribute to a project's success, but recent research points to honoring contractual commitments, open and effective communication of team members, and clear project goals and objectives as very critical factors for success. At the production level, improving work flow reliability between production units is of paramount importance, perhaps even exceeding the importance of increasing the productivity of any give unit. A major contributor to improving work flow reliability has been the explicit application of production management techniques as inspired by Lean Construction. A key component in addressing work flow reliability is comparison between work planned and work performed on a weekly and even on a daily level.

Since the 1960s, construction management practices were mainly directed at the project planning and control levels, which have improved the ability to oversee and manage construction projects at a macro level but not at the site production level. Tools such as Critical Path Method (CPM) and Gantt Bar Chart are used for scheduling of construction activities as well as monitoring progress of the project in terms of duration by comparing the original schedule to the working schedule. The Earned Value Method (EVM) is another project control tool which provides a comparison between scheduled costs and actual costs expended over the duration of a project and assist in estimating the

[1] http://www.businessdictionary.com/definition/chaos-theory.html, adopted from several other sources as well.

financial health of the project. Other method such as Line-of-Balance Scheduling (LOB) method, which were developed in the '50s and faded in the '70s, has been made popular again in the 90's. LOB techniques are primarily implemented for projects with repetitive units.

Although, the project management methods and tools mentioned above have proven to be excellent tools in reviewing the status of projects at any given point of time, they haven't been able to provide a total control to the management team over the events that take place in the field. The CPM and EVM are used together and implement the 'percent work complete' to assess the situation of the project. The former is used to compare the stipulated duration vs. the actual duration of the project and the latter is used to compare the actual expenditure vs. the budgeted expenditure of the project. In both methods, the information available to the management team pertains to the current status of the project and provides no indication about the status of the upcoming work. Therefore, the management team can only take corrective actions for the problems that have occurred whereas no action can be taken in time to prevent any future problems from occurrence. This lack of control has handicapped the construction management teams in exercising a command over projects and has been a contributing factor to low workflow reliability; where workflow is the progression of work within an activity and between activities.

Improving the workflow reliability has been the primary goal of Lean Construction theory and practice. In order to achieve this goal, researchers in this field developed advanced techniques like lookahead planning to attain control over the tasks and activities performed at the jobsite. The purpose of the lookahead planning is to plan out the work to be performed in advance for the upcoming weeks (up to 6), and compare the performed work with the planned once the work week is over. This measurement is termed as "percent plan complete (PPC)" and indicates the shortcoming of the production planning on site with the help of reasons analysis. PPC is a better tool in comparison to "percent work complete" of EVM and CPM because the former compares the WILL vs. DID work whereas the latter compares the SHOULD vs. DID work (Mitropoulos 2005). This makes the PPC a more accurate source of measurement since it compares only the work (that WILL be done) reflecting the true production capability of the construction team to the actual performed work instead of the work (that SHOULD be done) that has piled up due to previous interferences. However, similar to "percent work complete", PPC is also a lagging indicator, and helps in surfacing the problems only after they have occurred. A reasons analysis conducted after measuring PPC identifies the reasons only after work stopped. This makes the nature of the solutions as remedial in nature rather than preventive. PPC in its current state is not a predictor of whether the work will be executed as planned.

Although research contributions have added 'planned work ready' (PWR) metric to gauge whether the work planned stays the same through the preceding six weeks and enters as such into the actual work week, it helps the planner to remove any constraints identified during the six week period but does not warn them about any hidden constraints or variation of a removed constraint which may lead it to resurface during the actual work week. It may be appropriate to mention that research on PPC at this stage is focused on ways to improve it by means of other support metrics; however, there is no

research that attempts to define PPC in terms of its relationship with the constraints that either cause the work to be executed or not.

Control means causing a desired future rather than identifying variances between plan and actual (Ballard 2000). Clearly, none of the project and production metrics provide the construction manager a control over the project in the context stated. CPM and EVM are only performance indicators of a project and do not diagnose the problem of the project, whereas PPC is more advanced and does help in correcting the problems through reasons analysis. The use of PPC has improved project controls (PPC has reached 90% in some cases (Ballard 2000)) but it is still short of providing 100% reliability over the week to week progress of work. There is a research need to understand, in a causal fashion, what factors contribute to reliable workflow so that these factors are addressed before the plan is executed. The aim of this research is to provide project participants with the ability to improve understanding of factors affecting workflow so that their objectives are met in time, cost and quality as agreed.

1.2 Need Statement

The Last Planner ® System uses PPC as a measure to track the progress of a project. PPC essentially helps measure the extent to which production planning results in reliable work flow, quantitatively. The purpose of PPC is to help compare the actual vs. planned work during a week and identify the causes of incomplete work, but this planned work is result of commitments made by the contractor, therefore, the PPC checks the true reliability of the production planning. Using PPC has an advantage over traditional project control tools like Earned Value Method and Critical Path Method because, PPC along with Last planner, in metaphorical terms, prescribes healthy behavior so that the body is ill-free, whereas the EVM and the CPM method only help in taking the temperature of the project. Another analogy from the financial sector, EVM and CPM are like Dow Jones Industrial average in that they indicate the general health of the market but the status of an individual company cannot be assessed just by looking at the Dow, also it cannot be inferred whether the company's stock value will go up or down the following day just by looking at the Dow value.

From a lean production perspective, schedule controls have been criticized for their inability to control and stabilize the workflow (Mitropoulos 2005). Kim and Ballard (2000) mentioned that EVM does not consider the work sequence, and as a result, managerial actions driven by EV typically increase the variation of workflow. In addition, the traditional control systems do not provide any indication about the status of upcoming work, i.e., how much of the upcoming planned work can be performed as planned, hence it limits their ability to control the project progress, and their ability to identify appropriate corrective action before problems are encountered (Mitropoulos 2005).

Jobsite management has different levels of control on the factors affecting work flow reliability. Some factors, such as material and tool availability, can be managed and controlled. Other factors, such as the availability of skilled craft workers and extreme weather, are difficult to eliminate even though various methods are available to minimize their impact (Dai et al. 2009b). The development of look ahead process and tracking of PPC in this light, have made great strides in production planning by improving the ability to increase the control over project progress; Ballard (2000) reported that with improved implementation of lookahead process the PPC achieved rose from 70% to 80-85% in some cases and above 90% in one case. Although PPC helps in identifying the problems and suggest corrective actions, it comes into action only after occurrence of the problem(s). To ensure 100% reliability in work planning, the planner must understand the relationship between PPC and the production factors, which is currently lacking in practice and research. It is widely believed that the majority of the factors affecting construction productivity can be improved through the efforts of jobsite management (Dai et al. 2009b). An understanding of the relationship between production factors and their effect on project work flow reliability will help identify in advance the potential problems that could affect the work performance during the work week and will better equip the planners to strive for a 100% PPC on a consistent basis.

Mitropoulos (2005) developed make ready metrics to improve upon the lookahead process and add the capacity to measure the accuracy of the forecast of PWR metric; it proposes to check the accuracy of forecast of work planned six weeks earlier vs. every progressive week (every subsequent lookahead horizon). Integrated with the lookahead planning and post-work analysis process, PWR provides the best opportunity to establish a causality model with the production factors which would help attain the ideal of 100% work flow reliability in a project. The identification of the need to develop methods to establish relationship between production factors and the PPC in order to concentrate on the planning efforts before work week defines the goal and objectives of this research, as decisions taken during the planning process have been found to have a significant influence on the probable outcome of the project (Arditi 1985).

1.3 Research Questions

The lack of an explanatory understanding of factors giving rise to low/high PPC highlights the importance of investigating the current production metrics implemented in Last Planner System and how these metrics affect workflow reliability in the production stage. As production is cumulative in nature, where underperformances and deficiencies multiply as we move downstream it is important to investigate the combined effect of constraints and underperformances on the next production performance output, and develop an effect-cause-effect relationship between production constraints and percent plan complete. This research poses the following questions:

1. What current ability exists to forecast production performance using the Last Planner system?
2. What factors give rise to reliable workflow? How can we use those factors to predict work flow in measure of PPC?
3. What method can be implemented to study these factors?

1.4 Research Goals, Objectives, and Methods

The overall goal of this research is to understand cause and effect relations related to workflow reliability at the production level in a construction project. This goal can be approached in many ways, albeit not fully reachable.

To approach this goal, the research will focus on developing a method to investigate the causal relationship between production constraints and their impact on workflow reliability as measured by the PPC metric. To accomplish this, the following objectives are proposed:

1. Study production management tools implemented at the site level and document the production delay factors encountered on construction site.

   Objective 1 is fulfilled by performing following steps:

   a. Conduct literature review on production planning and control tools, productivity measurement studies and identify factors causing work flow variability.

2. Develop a method to study the relationship between production delay factors and work flow reliability.

   Objective 2 is fulfilled by performing following steps:

   a. Develop a Survey Instrument to measure the existence of identified production factors.

   b. Based on the literature review, develop a framework to design a causality model between various production factors and work flow reliability.

1.5 Research Benefits and Contribution

This research will develop a method to assess the impacts of production factors on the workflow on a construction site. This method would be implemented by the production management team to help identify and remove factors that could result in unreliable workflow.

The research will contribute to the project and production management practices for construction projects by developing a method to better understand the cause and effect of factors influencing reliable workflow. The framework could be adopted to assess impacts of project planning factors at various stages of a construction project;

which will aid different participants in identifying factors and analyzing the collective impact of those factors on the work to be executed.

The research will mainly benefit contractors and subcontractors who implement the Last Planner System in their projects by aiding them in improving their understanding of factors impacting reliable workflow as well as the ability to conduct long term studies by using the survey instrument.

1.6 Chapter Summary

Section one discussed the current level of implementation and understanding of PPC for project control purposes and highlights the need to improve it to achieve 100% work flow reliability. The research goals and objectives were identified that would help in achieving the desired outputs from the research. The research aims to aid the construction production planners by developing a method that will enable them to understand the impact of various factors on the effectiveness of their weekly work planning.

CHAPTER-2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the existing literature of production management practices and tools used on construction projects. The purpose of reviewing production management practices is to understand the extent of control sought at the management level, what is the level of predictability possible in assessing the progress of the project, how accurate control tools act as indicators of project performance.

The terms 'production management' and 'production control' are used interchangeably in the context of construction industry; this is mainly due to the fact that the production management practices are often identified by the production control tools. Therefore, the literature review of both has been combined to facilitate explanation and discussion of the literature background.

The study also aims to review the production factors/constraints that make a project plan fail to achieve the desired performance and whether it is possible to control those factors if identified early. The aforementioned literature review helped in addressing the research questions and enriching the focus of achieving the research objectives.

2.2 Production Management and Control

"Production has three kinds of goal. First, there is the goal of getting intended products produced in general. Second, there are goals related to the characteristics of the production itself, such as cost minimization and level of utilization (internal goals). Third, there are goals related to the needs of the customer, such as quality, dependability and flexibility (external goals)" (Koskela 1999). These were the basis to form three different views of production; *transformation view, flow view, and value-generation view.* The transformation view is instrumental in discovering which tasks are needed in a production undertaking and in getting it realized. The flow view focuses on eliminating wasteful processes that delay and interrupt work flow. In value generation view, the basic goal is to reach the best possible value from the point of the customer.

Production has been an explicit topic of study mainly in industrial engineering, which has dealt mostly with one type of production; namely, manufacturing with only occasional forays into construction industry (Ballard 2000). The term "manufacturing" is most commonly used to describe the making of many copies from a single design, and is primarily focused on making products for the mass market, which in most cases the products are moveable within the assembly line or in certain cases not moveable like ships or airplanes (Ballard 2000). With this understanding of manufacturing, "manufactured housing" is the only point of coincidence between construction industry and the term production (Ballard 2000), without which construction industry is largely seen as a service based industry with designing and engineering viewed as services and not products.

Defining production as the designing, engineering and making of artifacts allow us to understand how construction is a type of production and how design is an essential component in construction (Ballard 2000).

The three views of production management had their inefficiencies when implemented in isolation; therefore, to overcome these problems, a theory of production that incorporates transformation, flow, and value view of production was introduced. Koskela (1992) formulated a TFV theory of production which integrated the transformation, flow, and value views. The new theory was advanced on the basis that the three views of production do not present alternative, competing theories of production, but rather theories that are partial and complementary. Table 2.1 below indicates the components of the TFV theory.

	Transformation View	*Flow View*	*Value Generation View*
Conceptualization of production	As a transformation of inputs into outputs	As a flow of material, composed of transformation, inspection, moving and waiting	As a process where value for the customer is created through fulfillment of his requirements
Main principle	Getting production realized efficiently	Elimination of waste (non-value adding activities)	Elimination of value loss (achieved value in relation to best possible value)
Methods and practices	Work breakdown structure, MRP, Organizational Responsibility Chart	Continuous flow, pull production control, continuous improvement	Methods for requirement capture, Quality Function Deployment
Practical contribution	Taking care of what has to be done	Taking care of that what is unnecessary is done as little as possible	Taking care of that customer requirements are met in the best possible manner
Suggested name for practical application of the view	Task Management	Flow Management	Value Management

Table 2.1 TFV Theory of Production (Source: Koskela 1992)

The term 'control' as found in Concise Oxford Dictionary, means to dominate, command; to check, verify; to regulate. In reference to the project control theory, control essentially means to keep an account of things, the main purpose being to monitor actual costs and schedule performance against target in order to identify negative variances (Ballard 2000). This is considered reactive, and a view of control as "making things happen" has been advocated.

Production control theorists working in manufacturing distinguish two primary ways of regulating work flow in manufacturing systems: push and pull. Push systems release materials or information into a system based on pre-assigned due dates (from a master production schedule, for example) for the products of which they are parts (Ballard 2000). Pull systems release materials or information into a system based on the state of the system (the amount of work in process, the quality of available assignments, etc) in addition to due dates (Hopp and Spearman 1996). In factory systems, pull should be driven ultimately from customer orders. In construction, pull is ultimately driven by target completion dates, but specifically applies to the internal customer of each process (Ballard 2000).

The traditional project control systems implement the push system, which does not always produce the desired results from the project. The limitations of different current production management practices will be discussed in the following section.

2.3 Current Production Management and Production Control in Construction

Project control tools are commonly used in the construction industry; unfortunately, many projects run over budget and behind schedule, which suggests that there is something wrong in our project control system (Kim and Ballard 2000). Construction projects are managed today by breaking them into pieces or activities, estimating the time and money to complete each, applying the critical-path method (CPM) (there are many other methods of scheduling that are deployed in construction but CPM is by far the most popular method) to identify a logical order, and then either contracting externally or assigning internally to establish responsibility. Project managers use the schedule to determine when each activity should start and push for work to being on the earliest start date (Ballard et al 2002). Time and cost targets are monitored on a pre-established cycle and actions taken when off-target measures result. This traditional system of project control is also known as the thermostat model of control (Moder, Phillips and Davis 1983). The thermostat model triggers action when a variance is detected and it assumes that there are direct links to the cause of the variance (Ballard et al 2002). Conventional project management in construction is inadequate because it does not rest on a TFV theoretical framework (Howell and Koskela 2000).

Projects today are complex, uncertain and quick (CUQ) (Shenhar and Laufer, 1995). Co-ordination of work on CUQ projects cannot be assured even with highly detailed CPM schedules because these schedules portray the project as a series of activities and ignore the flow of material and information within and between them. The reliable release of work from one crew to the next is assumed or ignored (Ballard et al 2002).

Controlling of projects using CPM scheduling is achieved using the Earned Value Method (EVM), both these techniques are implemented in tandem. The CPM compares the actual progress with the baseline schedule, and monitors the time floats on the critical and near critical activities. The EV method monitors the progress of activities using dollar value as the metric, that is, by comparing the Budgeted Cost of Work Scheduled (BCWS) with the Budgeted Cost of Work Performed (BCWP). For each activity, the schedule variance (SV) is calculated as the difference BCWP – BCWS. The cost variance, for each activity, is calculated as the difference Budgeted Cost of Work

Performed (BCWP) – Actual Cost of Work Performed (ACWP). The graphical illustration of the SV and CV calculation is shown in the Figure 2.1.

The project progress is indicated by aggregating the SV and CV values of the individual activities. If the $ value of the work performed (upto the reporting date) is more than the work scheduled and cost less than budgeted, the project is considered 'ahead of schedule' and 'cost underrun' (refer Table 2.2) (Mitropoulos 2005).

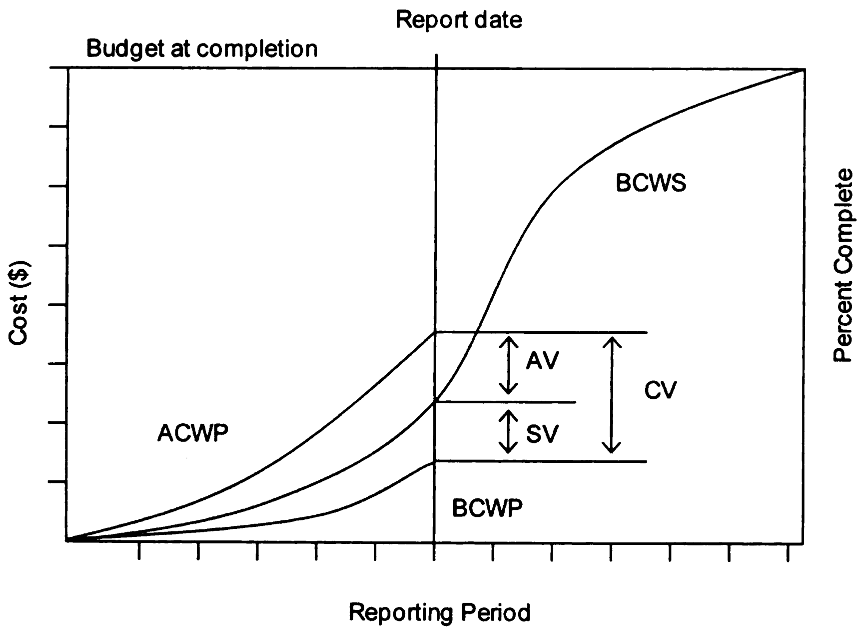

Figure 2.1 Variance Analysis (Source: Kim and Ballard 2000)

Variance	-	0	+
Cost Variance (CV)	Cost Overrun	On Budget	Cost Underrun
Schedule Variance (SV)	Behind Schedule	On Schedule	Ahead of Schedule

Table 2.2 Interpretation of Variance (Source: Kim and Ballard 2000)

Though, the EVM is considered the most advanced technique for integration of schedule and cost (Kim and Ballard 2000), researchers have criticized the EVM approach for a variety of reasons. Mitropoulos (2005) mentioned that CPM and EVM have a limited ability to control the project progress because they do not provide any indication about the status of the upcoming work, except through predictions, this further limit their ability to identify appropriate corrective action before problems are encountered. This may lead to a situation where a project that is ahead of schedule but has only a small portion of the upcoming planned work that can be performed may not be considered problematic. Conversely, a project that is behind schedule but has a lot of upcoming work that can be performed may be considered a lot more problematic. In addition, corrective action taken based on progress to date may compound the project problems if they do not consider the status of the upcoming work (Mitropoulos 2005).

Walt (2006) criticized Earned Value Method for being only a cost management tool stating that information relating to schedule performance is inadequate. Walt (2006) outlined three major deficiencies in the EVM method:

1. *The quality performance indicators are not directly connected to the project output.* For example, milestone completion or delivery of products may not meet the customer's expectation, yet EVM indicate acceptable values.
2. *The schedule indicators are flawed.* For projects completing late, the indicators always show perfect schedule performance (which is due to the fact that EVM is not designed to indicate performance related to time at all).
3. *The performance indicators are not explicitly connected to appropriate management action.* Even with EVM data, the project manager remains reliant on intuition as to any action needed.

Kim and Ballard (2000) described the EV method as a project control technique which provides a quantitative measure of work performance which involves a crediting of budget dollars or labor hours as scheduled work is performed and credited it as a superior control technique since it integrates schedule and cost performance of the project. At the same time, they addressed vulnerability in its conceptual framework, which, stands on the assumption that one earned hour is as good as another, and the correlative assumption that the productivity of each type of work activity is independent of the performance of other work activities, even when they are in predecessors-successor network.

The EVM technique uses cost accounts as management control points because they are the lowest level at which individual variance analysis can be made. The US Department of Defense (US DOD) describes a cost account as a natural control point for cost/schedule planning and control since it represents the work assigned to one responsible organizational element on one contract work breakdown structure element. Since integrated control of cost and schedule is core in EVM, it is desirable that cost accounts be identical to elements activities in the network schedule. But since cost accounts are too coarse to be assigned in schedule, each account has work packages with their own schedule durations and assigned budget (Kim and Ballard 2000).

Notably, if schedule variance is shown as a negative value on a specific cost account as of a reporting date, the manager of the 'red flagged' cost account gets in trouble. The manager attempts to remove this problem by increasing the earned value (BCWP) of his cost account as much as possible. Since detailed work procedure and/or sequence is usually at the manager's discretion, managers manipulate work sequences or release work assignments in order to make their performance better, without regard to work flow uncertainty and its negative impact downstream (Kim and Ballard 2000).

Kim and Ballard (2000) also stated that EVM does not differentiate between value-generating operations and non-value generation because calculation of BCWP disregards downstream demand. They attributed this to the lack of ability of EVM method to recognize the couplings that exist between accounts or activities: intermediate product and shared resources. Based on their research, Kim and Ballard (2000) concluded that making decisions for releasing work/taking corrective action on basis of cost account progress result in longer durations and higher costs than necessary. They proposed five criteria for generating quality assignments/releasing work: Definition; Soundness; Sequence; Size; and Learning. These five criteria would form an essential part of the lookahead planning process and for releasing quality work for a scheduled week (will be discussed later in this chapter).

Another, less widely used production management method in construction is the Line of Balance (LOB). Originally, developed by Goodyear Company as a linear technique in early 1940's, and was later developed by National Building Agency (UK) for repetitive housing projects, where a resource-oriented scheduling tool – that considered resources as a starting point – was considered more appropriate than the ones which are activity-dominated, as in CPM. The Line of Balance works on the premise that activities should be planned according to their production rhythms, in other words, the number of units that a crew can produce in a determined time unit. These rhythms are represented in a graphical format which shows clearly the production rates of the various activities against time (Henrich and Koskela 2006) (refer Figure 2.2).

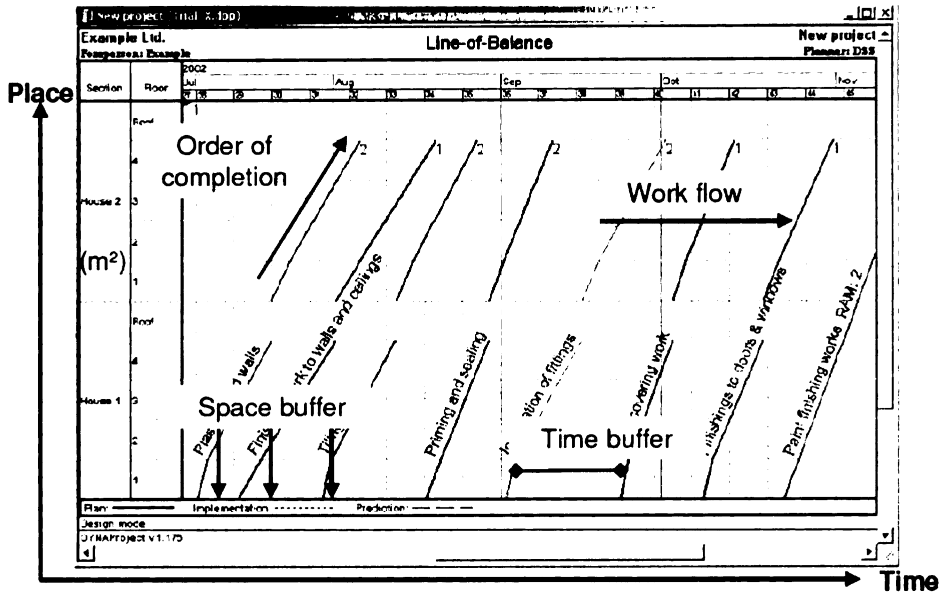

Figure 2.2 Example of Line of Balance Scheduling Method (Source: Kankainen and Seppanen 2003)

The LOB method provides a simple visual tool that helps the manager of a process to observe the progress of each activity. This assists the manager in making decisions such as: level of detail in activities planning, crew size, production expected and achieved, production rhythm and learning. This in turn helps the manager determine the number of crew simultaneously on the site, their position and location, the direction of production, and equipment available or able to be used (Henrich and Koskela 2006).

Some advantages of using LOB scheduling in the context of schedule planning as documented by Kankainen and Seppanen (2003) are; 1) it gives a better control of work groups, since they form the basis of planning activities, 2) allows for an integrated procurement schedule very early with master schedule so constraints on material availability, labor, contracts, and engineering are taken into account, 3) buffers can be planned to minimize the effect of work flow variability allowing production to be implemented as planned provided an adequate space buffer has been planned between space-critical tasks, 4) increasing productivity, less waiting hours and less hurried work, 5) use of resources can be planned to be continuous and level which results in lower costs and less deviations in production.

A certain advantage of LOB scheduling over CPM is that the production rates and duration information is represented in a graphic format in LOB while CPM does not give any indications. The LOB plot can show at a glance what is wrong with the progress of an activity, and can detect potential future bottlenecks. Obviously, LOB allows a better grasp of a project composed of repetitive activities than any other scheduling technique, because it allows the possibility to adjust activities' rates of production (Arditi et al 2002). LOB is oriented toward the required delivery of completed units and is based on knowledge of how many units must be completed on any day so that the programmed delivery of units can be achieved. Once a target rate of delivery has been established for the project, the rate of production of each and every activity is expected not to be less than this target rate of delivery (Lumsden 1968). The optimum rate of output that a crew of optimum size will be able to produce is called the ''natural rhythm'' of the activity (Arditi et al 2002). This natural rhythm is difficult to achieve in a non-repetitive project, therefore, the LOB method is less successful in such category of projects, or even phases of the same project such as foundation work.

While, it was noted as an advantage that buffers can be planned to minimize the effect of work flow variability (Kankainen and Seppanen 2003), the space buffers become a function of the productivity rate available to the company in their records based on their previous projects and there is no conscious consideration of constraints while deciding the duration of a particular project. The repetitive activities are treated with respect but the non-repetitive and discrete activities are usually clubbed after the first calculation of project duration, according to the precedence relationship with repetitive activities. The discrete activities are handled as workable backlog in case of any forecast of a possible bottleneck.

Again, the adjustment of productivity rates of adjacent activities or space-critical activities on the basis of time required in implementing a control-action to overcome a bottleneck or any other problem represents a gambling situation instead of an informed approach. The LOB method is trusted on the assumption that the natural rhythm of the activity will hold and space buffers and time buffers are added on the basis of previous experience and number of discrete activities. It reflects the lack of 'how to achieve the work' approach of the weekly work planner in the Last Planner System. Needless to say, the bottlenecks surface as a result of something not gone exactly as planned and identification of constraints after the execution stage. The graphical format of LOB may help in identifying the bottlenecks in future work but only once a current activity is left incomplete due to unidentifiable constraints, a sign of inefficient project control plan.

Clearly, like CPM, the LOB method also presents itself as a production management tool that is dependent heavily on past experiences and does not have a crash proof solutions kit that can confidently keep the progress under control and prevent spiraling of unforeseen problems. It separates itself from CPM on scheduling principles, i.e., CPM is an Activity-based scheduling based method whereas LOB is a resource based scheduling method but principally both methods are handicapped when it comes to prepare a production plan according to the true capacity of the construction team (currently, it is prepared on the assumed capacity of the construction team).

The need for an effective production control without the previously discussed shortcomings was identified in the Lean Construction philosophy during the 1990's. Research in this field has led to developments such as LPDS (Lean Project Delivery System) and LPS (Last Planner® System) which are positive developments in the desired direction. The use of lean tools in production control will be discussed in the following section.

2.4 Lean Production Management

Project and Production management is at the heart of Lean Construction and runs from the very beginning of a project to handover of a facility to the client. Lean project and production management is accomplished using Work Structuring and Production Control. Lean work structuring is process design integrated with product design and extends in scope from an entire production system down to the operations performed on materials and information within that system. It produces a range of outputs such as project execution strategies, project organizational structures, operations designs, master schedules, and phase schedules (Ballard et al 2002). As envisioned, LWS begins during the schematic design phase and continues to construction pre-planning.

Production control governs execution of plans and extends throughout a project. Production control consists of work flow control and production unit control. Work flow control is accomplished primarily through the lookahead process. Production unit control is accomplished primarily through weekly work planning (Ballard 2000). The Lean Construction Institute (LCI) developed Last Planner® System (LPS) (Figure 2.3) as a production control tool. The purpose of LPS is to tie up the work structuring at the front end planning stage with the actual production at site with a systematic and uninterrupted work flow while generating maximum value to the customer. The LPS is based on the Lean principles of:

- reaching consensus in all decision making
- using set-based design approach (both of these are realized in work structuring stage)
- doing a *genchi genbutsu*[2] on project site and develop lookahead plans and weekly work plans and assign tasks to workable backlog after doing a constraint analysis
- And emphasize on continuous improvement by the measure of charting percent plan complete (PPC) of the work and analysis of reasons for unaccomplished tasks to prevent a repetitive error.

[2] Defined as "Go and see for yourself to thoroughly understand the situation". Liker J. (2004)

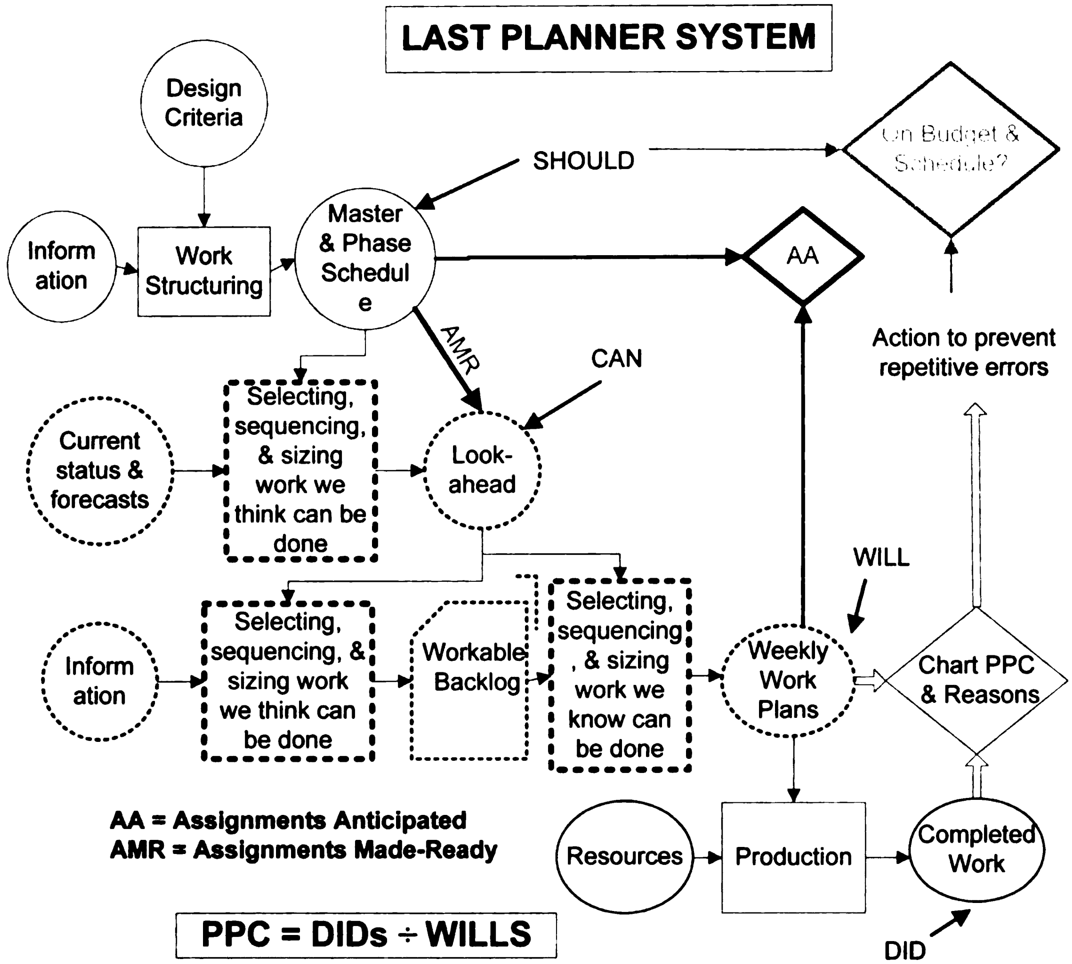

Figure 2.3'Last Planner System' (with additions in red) (Source: Abdelhamid 2008 – adopted from LCI)

In the LPS, front end planning belongs to the project definition and design phases of projects. One of the products of front end planning is master schedules. Master schedules primarily demonstrate the feasibility of project completion by target end date. Those purposes or functions do not require a high level of detail, which most often is inappropriate because of uncertainty regarding the future. Master schedules are expressed at the level of milestones, typically by phase. Phase schedules are produced by cross functional teams using pull techniques close to the scheduled start of the phase. Phase schedules feed into lookahead windows, usually 3 to 12 weeks in duration. Lookahead processes make scheduled tasks ready for assignment; such tasks are placed in Workable Backlog. Tasks are allowed to maintain their scheduled starts only if the planner is confident they can be made ready in time. Scheduled tasks are made ready by screening for constraints, then by assigning make-ready actions to remove those constraints.

The lookahead process generates early warning of problems so there is more time to resolve them. Weekly work plans are formed by selection of tasks from Workable Backlog. Every effort is made to make only quality assignments; i.e., those that are well defined, sound, in the proper sequence, and sized to capacity. The percentage of planned assignments completed also known as 'percent plan complete' (PPC) is tracked and reasons for non-completions are identified and analyzed to root causes. Action is taken on root causes to prevent repetition of errors downstream in the project or on future projects (Ballard 2000).

PPC is the number of completed assignments divided by the total number of planned assignments, expressed as a percentage. PPC becomes the standard against which control is exercised at the production unit level, being derivative from an extremely complex set of directives: project schedules, execution strategies, budget unit rates, etc. Given quality plans, higher PPC corresponds to doing more of the right work with given right resources (Ballard 2000). PPC measures the extent to which the front line team commitment was realized. Analysis of nonconformance can then lead back to root causes, so improvement can be made in future performance.

Since its introduction in 1994, the Last Planner system has been evolving to more improved versions. For example, lookahead planning and measuring 'percent plan complete' (PPC) have been incorporated as important steps in successful completion of work. PPC indicates the shortcoming of the production planning on site after a thorough reasons analysis is conducted. Practitioners on site constantly work towards improving PPC as they move downstream in the project.

In a study in 1997, Ballard identified that measurement of the PPC of weekly work plans revealed a chronic and widespread problem of low plan reliability. This problem was of vital importance because of its adverse impact on labor productivity both of the production unit that has a low PPC and those downstream production units which inherit the uncertainty passed onto them.

As depicted in Figure 2.4, improving PPC is critical for project managers because it increases the time-cost trade off limit by reducing the work flow variation. The benefit of maximum resource utilization is achieved only if the variation from work processes is removed, if the work variation is high (PPC is low) in upstream processes, increasing resource utilization in downstream processes will increase the wait times of crews, eventually losing the benefit of a time-cost tradeoff exercise.

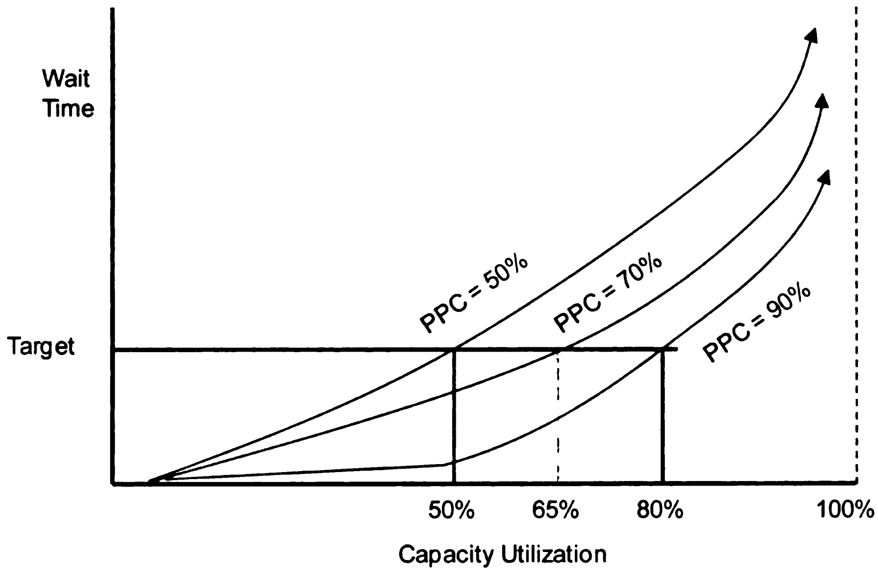

Figure 2.4 Improving the trade-off between time and cost by reducing workflow variation
(Source: Ballard et al 2002)

Ballard (2000) proposed lookahead planning as the key to improving PPC, and consequently the key to reducing project cost and duration. The functions of the lookahead process (Ballard 2000) are to:

1. Decompose master schedule activities into work packages and operations
2. Develop detailed methods for executing work
3. Shape work flow sequence and rate
4. Match work flow and capacity
5. Maintain a backlog of ready work
6. Update and revise higher level schedules as needed.

These functions are accomplished through various specific processes, including activity definition, constraints analysis, pulling work from upstream production units, and matching load and capacity (Ballard 2000). The lookahead process functions in the following manner; at first, the master and phase schedule activities are exploded into a level of detail appropriate for assignment on weekly work plans. Then each assignment is subjected to constraints analysis, as shown in figure 2.5, to determine what must be done in order to make it ready to be executed. If the planner is not confident that the constraints can be removed, the potential assignments are postponed to a later date.

Week	3/25/2002	4/1/2002	4/8/2002	4/15/2002	4/22/2002	4/29/2002
PPC	25%	62%	62%	35%	65%	
Tasks Completed	1	8	13	7	13	
Tasks Planned	4	13	21	20	20	
Coordination	3	1	3	8	2	
Engineering			1		1	
Owner Decision						
Weather						
Pre-requisite		1	3	1	2	
Labor				4		

Figure 2.5 Constraints Analysis sheet (Source: Abdelhamid 2008)

Different types of assignments have different constraints; contract, design, submittals, materials, prerequisite work, space, equipment, and labor etc. are few examples of constraints (Ballard 2000). These constraints if not removed cause tasks to be incomplete. Measuring performance at the Last Planner level not only allows a change at that level; root causes of poor plan quality or failure can be traced back at any organization level, process or function (Ballard 2000). The first thing in this process is identification of reasons why planned work was not done. Some of the reasons that have contributed to poor PPC are: faulty directives or information provided to the Last Planner, too much work was planned, failure in coordination of shared resources, change in priority, e.g., workers reassigned temporarily to a "hot" task, design error or vendor error discovered, etc (Ballard 2000).

Several implementation of lookahead planning and reasons analysis have identified typical reasons for plan failure, such as materials, craft-coordination, information, changes, emergencies, tools and equipment, design problems, and not having enough workers on site in the order of decreasing frequency. A case study was conducted in 1997 by Ballard et al, to track reasons for not achieving 100% PPC. Of the 249 assignments that were not fully completed, 71 were because of late or defective materials, 42 because prerequisite work was not completed, 37 because of changes in priorities, 33 because of absenteeism or accident (manpower), 23 because of failure to accurately estimate the amount of labor time required to execute assignments, and so on (Refer Figure 2.6). Studies showed that prior to implementation of the LPS lookahead process, the PPC averaged around 50%. Miles (1998) reported that the overall PPC improved to 75% with implementation of lookahead process.

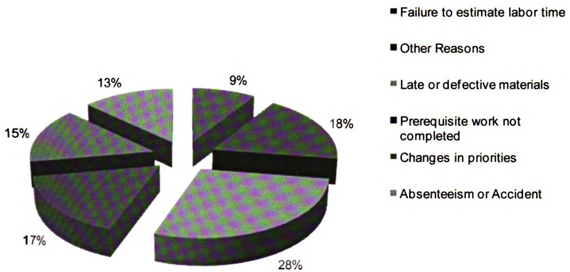

Figure 2.6 Pie Chart showing frequencies of various reasons for incomplete work (<100% PPC)

In a study of a large mechanical contractor's production control system, Ballard (1997) reported the performance measurements used by the mechanical contractor for the improvement of lookahead planning:

- Subjective evaluation by project superintendents/managers and consultants.
- Assignments Anticipated (Refer Figure 2.3). Measures the extent to which weekly work plan assignments previously appeared on lookahead schedules.
- Assignments Made Ready (Refer Figure 2.3). Measure the extent to which assignments that appeared on lookahead schedules appeared on weekly work plans when scheduled.
- Change of scheduled dates for specific assignments over time.

Mitropoulos (2005) built on those findings and developed 'Make Ready' metrics to assess and improve the "make ready" process (Figure 2.7). The first proposed metric called "Planned Work Ready" (PWR) indicates the portion of the planned activities that

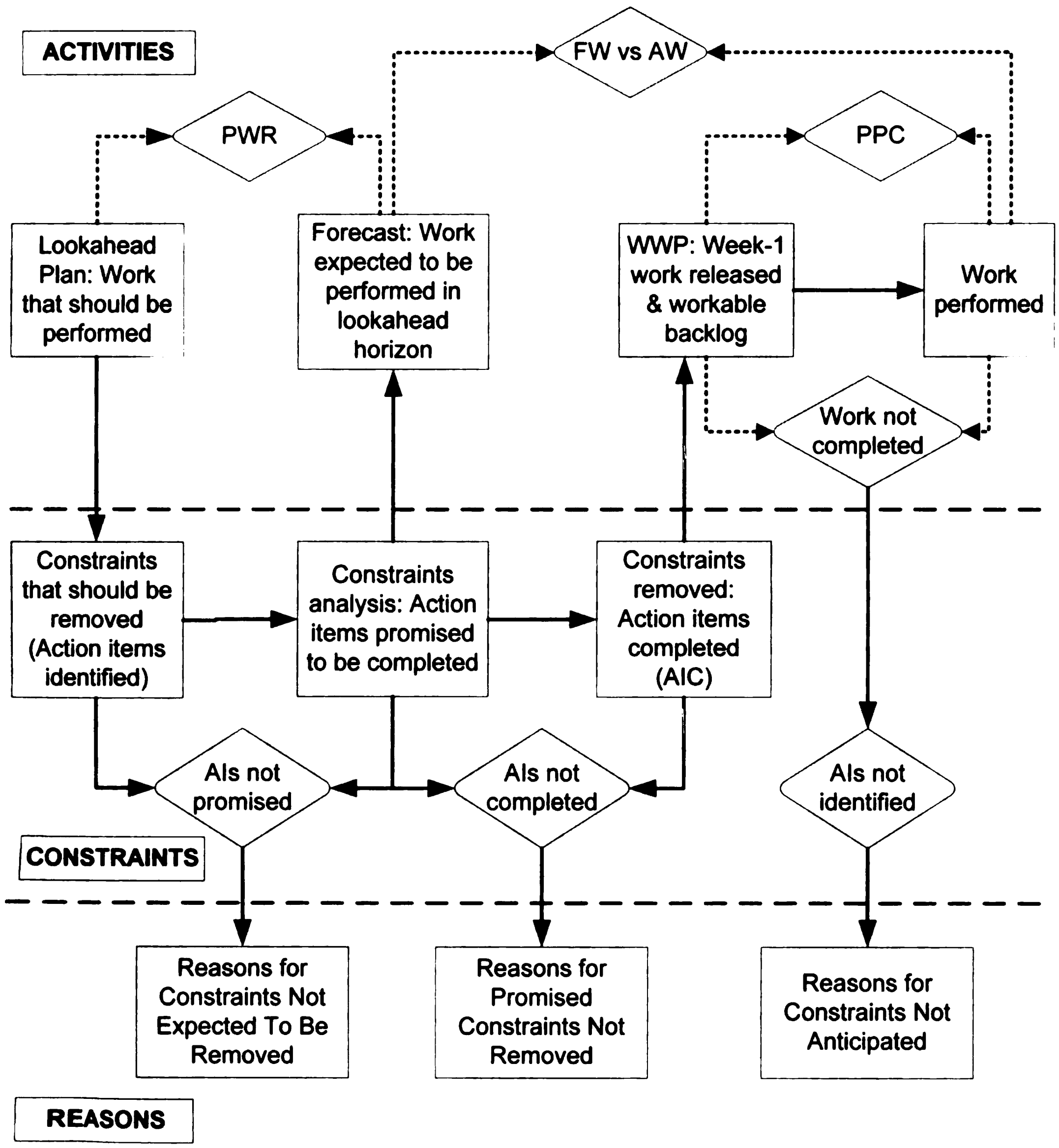

Figure 2.7 Elements and Metrics of Make Ready Process (Source: Mitropoulos 2005)

the project team is confident that can be performed in the lookahead horizon. The metric does not include only work that has all the constraints removed at the time of the forecast, but also work that is expected to be ready with a high degree of confidence. The main purpose of the PWR was to establish and track confidence in planned work over a period of time till the actual work week arrived.

PWR could be represented in two ways (Mitropoulos 2005): a) Percent of activities 'Ready' for each week in the lookahead, and b) Earnable Value. Figure 2.8 and 2.9 illustrates the PWR in its two parts.

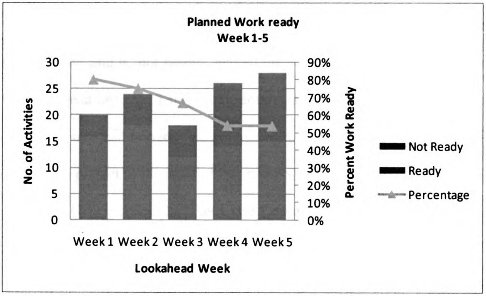

Figure 2.8 Planned Work Ready for lookahead period (Source: Mitropoulos 2005)

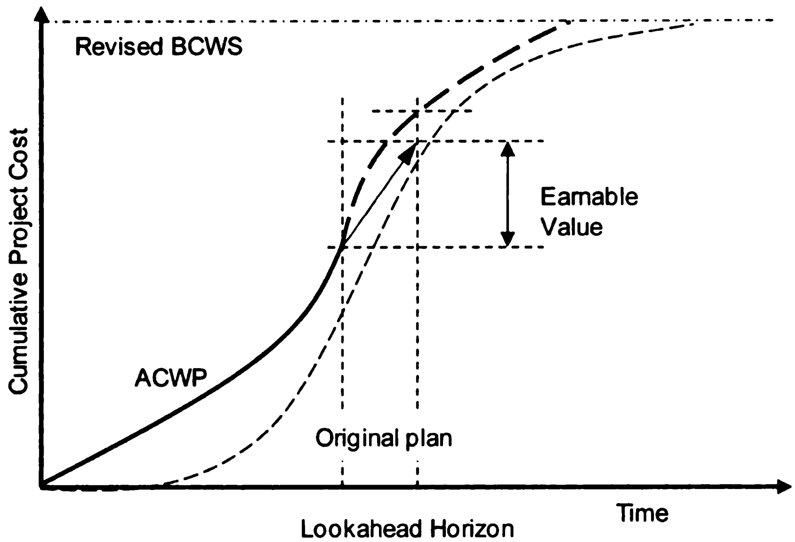

Figure 2.9 Earnable Value (Source: Mitropoulos 2005)

Figure 2.8 illustrates the percent of activities ready for the next 5 weeks in the lookahead horizon. For example, week 1 lookahead includes 16 activities that are expected to be 'ready' and 4 'not ready', and so on. Figure 2.9 illustrates the 'earnable value' in the lookahead horizon. This would require calculating the earnable man-hours of the work in the lookahead horizon and comparing with the available labor capacity in order to decide if the project needs more of less manpower (Mitropoulos 2005).

Mitropoulos (2005) stated that PWR is a forecast metric that would indicate the momentum of the project and in combination with percent complete it would provide a better indication of schedule performance. This is a flawed assumption since it has already been discussed in other literature and contested by researchers that EV does not indicate time performance. Even the momentum fails if it does not know what obstruction lies in the path, clearly not perceptible by the EV.

The second make ready metric was developed to assess the accuracy of PWR, this metric implemented the use of time-time charts and used to compare between forecasts and actual work for a specified week. Figure 2.10 illustrates a time-time chart. Squares in the same column show the difference between expected work and actual work, and how accurately the organization predicts the upcoming work. Each square i-j indicate that week 'I' is in progress and week 'j' is being looked at. For example, F0-1 is the forecast developed on week 0 for week 1 and F0-6 is the forecast developed on week 0 for week 6. the diagonal squares (i-i) show the actual work that is performed on week i (AWi). Comparisons between forecasts and actual work for a specific week (squares in the same column) show the difference between expected work and actual work, and how accurately the organization predicts the upcoming work (Mitropoulos 2005).

....looking at week....j

We are on week....i	0	1	2	3	4	5	6	7	8	9
0	AW-0	F0-1	F0-2	F0-3	F0-4	F0-5	F0-6			
1		AW-1	F1-2	F1-3	F1-4	F1-5	F1-6	F1-7		
2			AW-2	F2-3	F2-4	F2-5	F2-6	F2-7	F2-8	
3				AW-3	F3-4	F3-5	F3-6	F3-7	F3-8	F3-9
4	4 wks ago	3 wks ago	2 wks ago	last week	this week	next week	2 wks ahead	3 wks ahead	4 wks ahead	5 wks ahead
5						AW-5	F5-6	F5-7	F5-8	F5-9
6							AW-6	F6-7	F6-8	F6-9
7								AW-7	F7-8	F7-9
8									AW-8	F8-9
9										AW-9

Figure 2.10 Time-Time chart showing work forecast and work performed (Source: Mitropoulos 2005)

The third metric was developed to improve the organization's ability to remove constraints and improve the forecasting ability of the organization; this was proposed by developing Action Items (AIs) indicated on following deltas (refer Figure 2.7):

a) **Delta between constraints identified vs. constraints expected to be removed (promised).** These are the constraints that prevent planned work to become ready. This delta can also be expressed in terms of AIs identified and AIs expected to be completed. The proposed metric is AI promised/AI identified.

b) **Delta between constraints expected to be removed vs. constraints actually removed.** The proposed metric here is AI completed/AI promised.

c) **Delta between constraints identified vs. actual constraints found when the work was released.** This is the case where the constraint analysis failed to identify all constraints during planning. In LPS, this is captured as "planning failures". The proposed metric here is Number of new constraints (AIs) discovered during execution/Constraints identified. Further, Mitropoulos proposed the use of reasons analysis to understand why the identified constraints cannot be removed, why constraints were not removed and why constraints were not anticipated to help identify bottlenecks e.g., timing of identification, personnel workload, contractual issues etc. and provide direction on how to increase its ability to 'make work ready'. The summary of these metrics are presented in Table 2.3 (Mitropoulos 2005).

Purpose	Metric	Analysis
Assess how much planned work will be ready to perform in the lookahead period	a- Planned Work Ready (PWR) % of assignments expected to be ready as planned b- Earnable Value (Ballard 97) $ Value of work expected to be performed	Reasons for planned work not expected to be ready.
Assess and improve the forecast	Actual Work vs. Forecasted Work for different lookahead horizons. % of assignments in both Fi-j and AWj	1- Reasons for differences between forecast and actual 2- Reasons for difference between forecasts
Evaluate and improve the organization's ability to identify & remove constraints	1- AI promised/AI Needed 2- AI Completed/ AI Promised 3- Constraints not identified during make-ready process	1- Reasons for constraints that cannot be removed as needed 2- Reasons for constraints not removed as promised 3- Reasons for constraints not anticipated

Table 2.3 Proposed PWR Metrics (Source: Mitropoulos 2005)

The addition of PWR and other two metrics promise to add great value to the lookahead planning process by screening constraints at every progressive week and increasing the ability to deliver work as promised. The third metric, action items, implements a 'three level' constraints tracking method (as discussed earlier) during the reasons analysis phase to help planners categorize constraints according to their frequency of occurrence and ease of identification and removal. However, forecasting schedule performance and measuring the accuracy of the forecast can only add value if the forecasting tool being used provides an understanding of the nature of relationship between all the production factors on the outcome of work. This is the focus of this research.

The first step towards defining such relationship is identification of production delay factors. Prior research have directed efforts towards identifying these factors in order to understand the complex nature of construction projects and develop methods to simplify the planning, execution and control of production tasks. The following section presents a discussion of previous research that studied production delay factors of construction projects.

2.5 Production factors of Construction Projects

"Identifying factors that impact construction productivity is not a new effort. There have been numerous efforts of identifying and classifying the factors that impact construction productivity, with a few attempting to identify the relative importance of the individual factors (Dai et al 2009a)." One of the earliest of these related efforts was a United Nations (1965) study that reported how substantial improvements in labor productivity can be achieved through repetitive site operations. Borcherding and Oglesby (1974) and Maloney (1981) examined the effects of craft motivation on construction labor productivity. Thomas et al. (1989), Thomas and Sanvido (2000), and Horman and Thomas (2005) examined the impact of material management practices, delivery methods, and fabricators on productivity.

The loss of productivity as a result of scheduled overtime has also been examined in the past (Oglesby et al. 1989; Thomas and Raynar 1997). Diekmann and Heinze (2001) examined the influence of support personnel, drawing, equipment, and material buffer strategies on productivity in the piping and electrical trades. Rojas and Aramvareekul (2003) conducted a web-based survey to identify the relative importance of 18 factors affecting labor productivity. Liberda et a. (2003) identified the relative importance of 51 productivity factors categorized under the headings of labor, management, and external factors by interviewing industry experts. Dai et al. (2009b) in their latest such study have examined the underlying structure of the factors affecting construction productivity from the craft worker's perspective; they identified a total of 83 factors and judged for relative importance through a craft worker survey. The study highlighted that management factors, such as lack of detail planning, inadequate supervision, and lack of information, were found to account for half of the most critical factors.

The brief review of previous researches on specific productivity factors is not meant to be exhaustive, since a discussion involving each of those is beyond the scope of this research document. However, the research acknowledges that the factors addressed in our research were already known, with some supplemented by the author.

The production factors selected in this research are specific to the Last Planner production control system discussed in earlier sections of this chapter; the theoretical relationships that exist among the factors have largely been based on the opinions of a few selected industry professionals, specializing in Lean Construction, and also drawn from the previous researches mentioned. These relationships will be presented and discussed in Chapter 4.

2.5.1 Classification of Production Factors

Multiple studies have presented construction productivity models to explain the interaction of the productivity factors (Dai et al. 2009b). It is extremely difficult to distinguish the influence of any single factor since jobsite productivity is simultaneously influenced by multiple factors (United Nations 1965). Productivity classification schemes over the years have reflected a change in project characteristics, including an increased sophistication of project design (Dai et al. 2009b). Herbsman and Ellis (1990) grouped productivity factors into technological and administrative based on interviews with industry practitioners; technological factors were primarily related to project design, such as specifications, design drawings, and material selection, meanwhile, administrative factors were defined as being related to management and construction of a project, such as equipment, labor, and social factors. Thomas and Sakarcan (1994) defined two broad classification schemes for construction productivity: organizational and executional continuity. Organizational continuity referred to actual work to be done, such as work scope and size of the components. Executional continuity consisted of the work environment and management components, such as weather and work sequencing (Dai et al. 2009b). Olomolaiye et al. (1998) divided productivity factors into external and internal factors, representing those factors beyond and within the control of management, respectively. External factors included the nature of the industry, the construction clients, weather, the level of economic development, legislation, procurement policies, codes of practices, etc. Internal factors involved management, technology, labor, unions, and so on (Dai et al. 2009b). In the study by Rojas et al. (2003), the factors were classified into four categories, including management systems and strategies (e.g. scheduling), man power (e.g. experience and motivation), industry environment (e.g. adverse working conditions) and external conditions (e.g. scope changes).

This research focuses on the productivity factors from the standpoint of the Last Planner, that is, the focus is on the production factors that affect work flow reliability. Hence, the production delay factors would be classified viewing their applicability to the Last Planner System and how they affect the continuity of work. This research proposed that production delay factors are of two main types. The first type is the factors that essentially prevent a work (task) from starting up. These factors are identified in the Last Planner system during the constraint analysis stage and fall into three broad categories namely: Pre-requisite Work, Directives, and Resources. These categories represent the exhaustive list of factors that if present, signify presence of planning issues that prevent the start of task, for example, coordination issues, regulatory inspections - these are type of pre requisite work, RFI's unaddressed, submittals are unapproved - these two are type of directives, availability of space, labor - these are type of resources (Ballard 1997), and prevent the planned work from starting.

If all the production factors covered under Prerequisite work, Directives, and Resources are addressed then it ensures the start of work, however, it does not necessarily ensure the finish of the work that is started. This is because construction is a dynamic process and needs constant input of management and control during the entire process.

Experts in Lean production (Toyota Production System) point out that three main reasons result in workflow issues. These are *Muda* (Unnecessary work/waste), *Mura* (Variation), and *Muri* (Overburden). Muda is the Japanese term for unnecessary work (work that does not add value) like multiple handling of materials, doing rework, etc. Mura stands for variation in production capacity of the crew and it generally occurs because of factors such as absenteeism or irregular sizing of the work package from upstream work, slow learning curve, etc. Muri stands for overburden on crew which generally occurs due to putting overtime regularly, assigning more tasks to crew than they can handle. Equipment can also be burdened by using it for work that it is not designed for, etc.

In this research these three sources of workflow issues will be considered as sources of disrupting the ability of a crew to finish work started. Hence, two main categories will be considered as the source of workflow issues. Table 2.4 below indicates the two main categories affecting work flow reliability, with major factors affecting each category listed as well.

Factors that Prevent the Start of Work	Factors that Prevent the Finish of Work
a. Pre Requisite Work	d. Unnecessary work (Muda)
b. Directives	e. Variation in Production Capacity (Mura)
c. Resources	f. Overburden (Muri)

Table 2.4 Classification of production factors suited to Last Planner System

As previously discussed in this chapter, current production tools do not have the capacity to measure the causal impact of factors categorized into prerequisite work, directives, resources, waste, variation and burden. Therefore, this research explored ways that can help understand the causal relationship between production delay factors and work flow reliability. This thesis explored a statistical tool called Structural Equation Modeling (SEM), which is an advanced form of regression analysis and has been extensively applied in psychological research and has the ability to include both measured and latent variables in a relationship model. This was found to be a useful technique because it is not always possible in construction settings to measure all effects of the different production constraints. SEM provides an opportunity to analyze observed and unobserved measures of production constraints and their degree of impact on workflow reliability.

2.6 Structural Equation Modeling: An Introduction

Structural Equation Modeling (SEM) is a technique used for specifying and estimating models of linear relationships among variables (MacCallum and Austin 2000). Various theoretical models can be tested in SEM that hypothesize how sets of variables define constructs and how these constructs are related to each other. For example, a marketing researcher may hypothesize that consumer trust in a corporation leads to increased product sales for that corporation. The goal of SEM analysis is to determine the extent to which the theoretical view is supported by sample data (Schumacker and Lomax 2004).

SEM is primarily used in observational studies and is also applied in experimental studies. The SEM designs used for observational studies are broken into two categories: cross-sectional and longitudinal (MacCallum and Austin 2000).

A cross-sectional design is a single-occasion snapshot of a system of variables and constructs. Its key feature is the concurrent measurement of variables. The use of SEM in cross-sectional designs is common, with applications to manifest variable, latent variable, or measurement studies. A notable feature of such models is the specification of directional influences among variables.

There are two types of longitudinal designs; both involve measurements obtained from the same individuals on repeated occasions. In one type of longitudinal design called sequential design, different variables are measured at successive occasions and the model specifies affects of variables at a given occasion on others variables at later occasions.

In this type of research, the interest is in the pattern of influences operating over time among different variables. The sequence and timing of measurements are designed to allow for these hypothesized effects to operate. In another type of longitudinal design, a repeated measures design, the same variable or variables are measured at each occasion.

This is conducted to understand relationships among the repeated measures of the same variables as well as the pattern of change over time (MacCallum and Austin 2000).

Variables in a model may include both measured variables (MVs) and latent variables (LVs). LVs are hypothetical constructs that cannot be directly measured (MacCallum and Austin 2000), or were not measured. LVs are indirectly observed or measured, and are inferred from a set of variables that we do measure using tests, surveys, and so on. For example, intelligence is a latent variable that represents a psychological construct. The observed, measured, or indicator variables are a set of variables that are used to define or infer the latent variable or construct. For example, Dow-Jones index is a standard measure of the American corporate economy construct (Schumacker and Lomax 2004). In SEM, a construct is typically represented by multiple MVs that serve as indicators of the construct. The general form of SEM consists of two interrelated sub-models. The first is the measurement model, which relates latent variables to their observed indicators; the second is the structural model, which estimates the relationships between the latent variables (Heck and Thomas 2000).

A structural equation model, then, is a hypothesized pattern of directional and non-directional linear relationships among a set of MVs and LVs. Directional relationships imply some sort of directional influence of one variable on another. Non-directional relationships are correlational and imply no direct influence (MacCallum and Austin 2000).

Variables, whether they are observed or latent, can also be defined as either *independent* or *dependent* variables. An independent variable is a variable that is not influenced by any other variable in the model but can be correlated to each other; they are also called free variables, whereas if a variable is not correlated to any other variable then it is an independent random variable. On the other hand a dependent variable is influenced by another variable in the model. Citing from earlier example, the marketing researcher believes that consumer trust in a corporation (independent latent variable) leads to increased product sales (dependent latent variable) (Schumacker and Lomax 2004).

Figure 2.11 below presents a sketch of different components of a SE model. In the figure, F3 and F4 are the latent variables or constructs, V7 to V9 are the measured variables for F3 and V10 to V12 are the measured variables for F4. The single headed arrows between LV and their respective MVs indicate the relationship between the construct and their MVs.

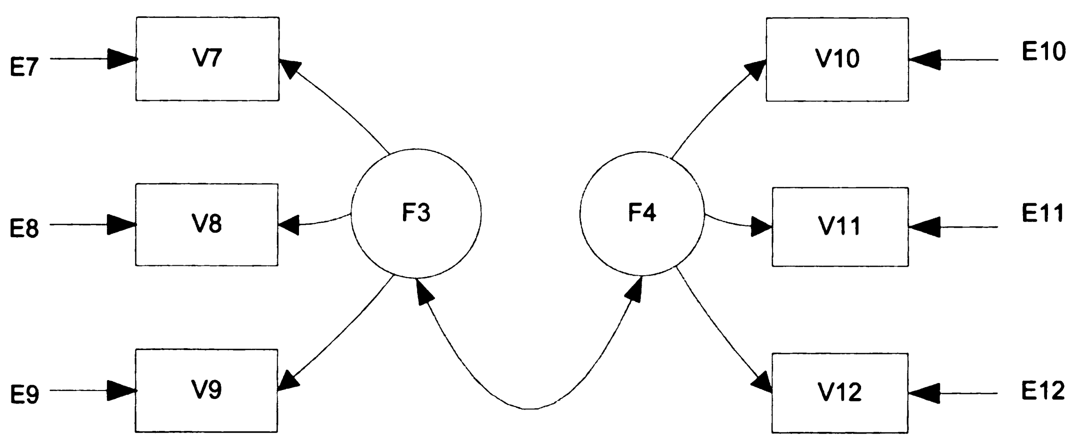

Figure 2. 11 Sketch showing different components of a structural equation model

The double sided arrow between the two constructs indicates that they are independent (free) latent variables. A single sided arrow would indicate directional relationship from one construct to another as shown in Figure 2.12. In Figure 2.12, the arrow flows from F1 construct to F2 construct, which means that F1 is an independent variable or an *Exogenous* construct, and F2 is a dependent variable or an *Endogenous* construct (Hair et al. 2005). It should be noted that E_n represents error in measurements, while the D_n term signifies residual values not explained by the measured variables.

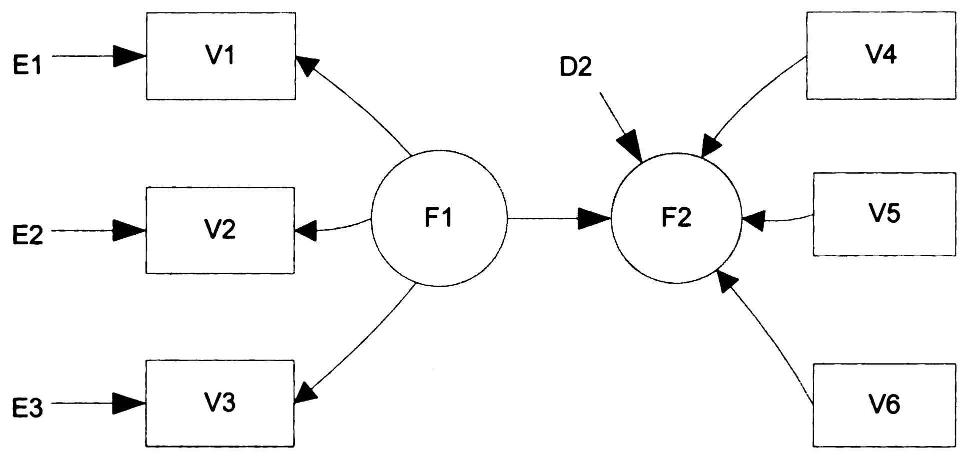

Figure 2.12 Sketch showing exogenous and endogenous constructs

In the most common form of SEM, the purpose of the model is to account for variation and covariation of the MVs (MacCallum and Austin 2000). In comparison with a conventional regression model, wherein, a single dependent observed variable is predicted or explained by one or more independent observed variables, Path analysis models (Type 1 SE Models) allow for multiple independent observed variables and multiple dependent observed variables, and Confirmatory Factor Analysis Models (Type 2 SE Models) consist of observed variables that are hypothesized to measure one or more latent variables (independent or dependent); for example, diet, exercise, and physiology are observed measures of the independent latent variable "fitness" (Schumacker and Lomax 2004). Path models are used when MVs are of primary interest or when multiple indicators of LVs are not available. Factor analysis, provides for testing models of relationships between LVs, which are common factors, and MVs, which are indicators of common factors (MacCallum and Austin 2000).

2.6.1 Basics of SEM Estimation and Assessment

Statistically, SEM differs from other multivariate techniques in that it is a covariance structure analysis technique rather than a variance analysis technique. As a result, SEM focuses on covariation among the variables measured, or the *observed sample covariance matrix* (Hair et al. 2005). A covariance matrix is preferred over correlation matrix mainly because the use of correlations as input can at times lead to errors in standard error computations. In addition, any time hypotheses concern questions related to the scale or magnitude of values, then covariances must be used because this information is not retained using correlations (Hair et al. 2005). Figure 2.13 below shows an example of structural model with covariances to be calculated (the covariances are shown enclosed in rectangles on the arrows).

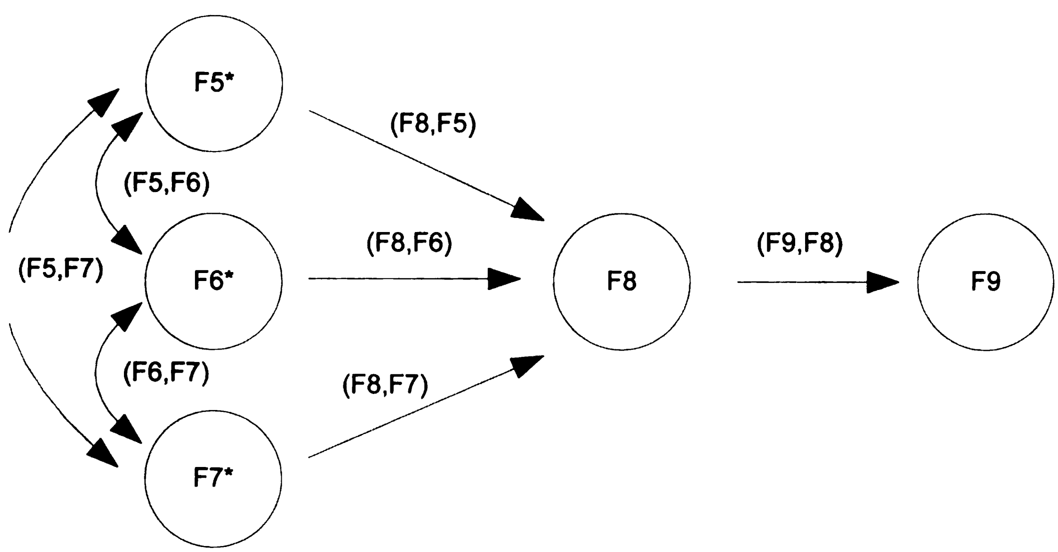

Figure 2.13 Sketch showing Covariances that are calculated in a structural model

Paths in the model shown in figure 2.13 represent a research question posed to understand relationships between constructs F5 to F9. For a model like this the Observed Covariance Matrix is as shown in Table 2.5. The use of a covariance matrix allows the use of multiple scales for the measuring of the variables. In addition, using the covariance does not require standardizing like in regression analysis where the correlation matrix is implemented for the exact reason.

Observed Covariance =	**Var(F5)**	Cov(F5,F6)	Cov(F5,F7)	Cov(F5,F8)	Cov(F5,F9)
	Cov(F5,F6)	**Var(F6)**	Cov(F6,F7)	Cov(F6,F8)	Cov(F6,F9)
	Cov(F5,F7)	Cov(F6,F7)	**Var(F7)**	Cov(F7,F8)	Cov(F7,F9)
	Cov(F5,F8)	Cov(F6,F8)	Cov(F7,F8)	**Var(F8)**	Cov(F8,F9)
	Cov(F5,F9)	Cov(F6,F9)	Cov(F7,F9)	Cov(F8,F9)	**Var(F9)**

Table 2.5 Observed Covariance Matrix for model in Figure 2.13 (Adopted - Hair et al 2005)

The unbolded values above the diagonal represent the 10 unique terms that are the same as those below the diagonal. Given this duplication, covariance matrices are generally expressed as symmetric matrices, with the unique terms only shown below the diagonal (Hair et al. 2005). Hence, after collection of data, it is plugged into the SEM software and an observed covariance matrix is generated.

The next step in an SEM analysis is to estimate the relationships (arrows between constructs) using simple bivariate correlations in a system of structural equations. This process estimates the strength of each relationship portrayed as a straight or curved arrow in a path diagram (Hair et al. 2005). A description of this procedure is in appendix A. With estimates for each path, an interpretation can be made of each relationship represented in the model. The researcher can assess the probability that the estimates are significant (i.e., not equal to zero) by applying statistical inference tests. The last step in an SEM analysis involves calculating an *estimated covariance matrix* and then assessing the degree of fit to the observed covariance model. The estimated covariance matrix is derived from the path estimates of the model (calculated in the previous step) by using the principles of path analysis in reverse. Then by comparing the two matrices SEM can test a model. Models that produce an estimated covariance matrix that is within the sampling variation of the observed covariance matrix are generally thought of as good models and would be said to fit well (Hair et al. 2005).

The difference between the observed and estimated covariance matrices is called *residual* and it is the key driver in assessing fit of a SEM model. As compared to a conventional multiple regression technique where residuals reflect errors in predicting individual observations, in SEM residuals means how far away an estimated covariance term is from the observed covariance term for the same two variables. Thus, residuals are used as the basic indicator of the goodness-of-fit of a theoretical model.

So far we have discussed an introduction and the basic concepts of SEM. Further literature review will discuss about SEM components and estimation technique in detail.

2.6.2 Components of Structural Equation Modeling

SEM is a technique widely used for confirmatory factor analysis; that is, it is useful for testing and potentially confirming a theory. A theory is needed to specify both *measurement* and *structural* models (explained later); modifications to the proposed relationships, and many other aspects of estimating a model. A theory based approach is necessary because all relationships must be specified by the researcher before the SEM model can be estimated; and it involves proposing that a dependence relationship actually is based on causation. A causal inference involves a hypothesized cause-and-effect relationship. If we understand the causal sequence between variables, then we can explain how some cause determines a given effect (Hair et al. 2005), albeit in an approxiamate, not exact manner.

In order to test the theory, a research design is required. The research design involves defining the concepts that the researcher wants to test in a cause-and-effect relationship in the form of variables. These variables are called latent variables because they cannot be measured directly but can be represented or measured by one or more variables (indicators). For example, a person's attitude towards a product can never be measured so precisely as to eliminate uncertainty, but by asking various questions we can assess the many aspects of person's attitude. In combination, the answers to these questions give a reasonably accurate measure of the latent construct (attitude) for an individual (Hair et al. 2005). A measurement model is the model that is drawn to specify the relationship between such a construct and its indicators is called a measurement model, such as F1 with V1-V3 or F2 with V4-V6 (refer Figure 2.12). The measurement model enables an assessment of *construct validity.*

The second aspect of a structural equation model is the structural model itself, which is the dependence or correlational relationship between all the hypothesized latent constructs (see Figure 2.13 for reference); testing the validity of structural model is the ultimate goal of SEM analysis (Schumacker & Lomax, 2004).

The main benefits of using the latent constructs instead of directly using measured variables comes from the criticism of other statistical tools like multiple regression analysis that it ignores all the potential measurement errors of the observed variables (Bae 2005). SEM takes care of this problem by specifying the measurement model which tests the reliability of measured variables by checking their internal consistency based on how highly interrelated the indicators are. Therefore, in the process, it highlights the existence of measurement error and accounts for it in the analysis (Hair et al. 2005).

After the latent constructs are established with their measured variables, the first step is to check for *construct validity*. Construct validity is the extent to which a set of measure items actually reflects the theoretical latent construct those items are designed to measure. Evidence of construct validity provides confidence that item measures taken from a sample represent the actual true score that exists in the population. Construct validity has four components. These are (Hair et al. 2005):

a. <u>Convergent Validity</u>: The items that are indicators of a specific construct should converge or share a high proportion of variance in common, known as convergent validity. There are several ways to estimate convergent validity. These are *factor loadings, variance extracted, and reliability.*

b. <u>Discriminant Validity</u>: is the extent to which a construct is truly distinct from other constructs. Thus, high discriminant validity provides evidence that a construct is unique and captures some phenomena other measures do not.

c. <u>Nomological Validity and Face Validity</u>: Nomological validity is tested by examining whether the correlations among the constructs in a measurement theory make sense. The matrix of construct correlations can be useful in this assessment. Face validity is the assessment of degree of correspondence of each measured variable and its conceptual definition. Technically, it is the most important validity test.

After establishing construct validity, the measurement model is developed. Before we move to that discussion, it is critical to understand the type of latent constructs and indicators associated with them as they are critical to SEM model design and validation.

There are two types of latent constructs that exist namely *Reflective* constructs and *Formative* constructs. Reflective constructs are the constructs that are usually viewed as producing behavior or phenomenon that is captured by their indicators, meaning that variation in a construct leads to variation in its indicators (Bollen, 1989). In a reflective model, the latent construct exists (in an absolute sense) independent of the measures (Coltman et al. 2008). Such indicators are termed reflective because they represent reflections, or manifestations, of a construct (Roberts and Thatcher, 2009). For example, behavioral intention to use a system is often operationalized with three reflective indicators (eg. Davis et al. 1989). Hence, an individual's change in the latent behavioral intention construct results in corresponding changes in each manifest indicator of intention (Roberts and Thatcher, 2009). Figure 2.14 shows a visual example of reflective construct and indicators.

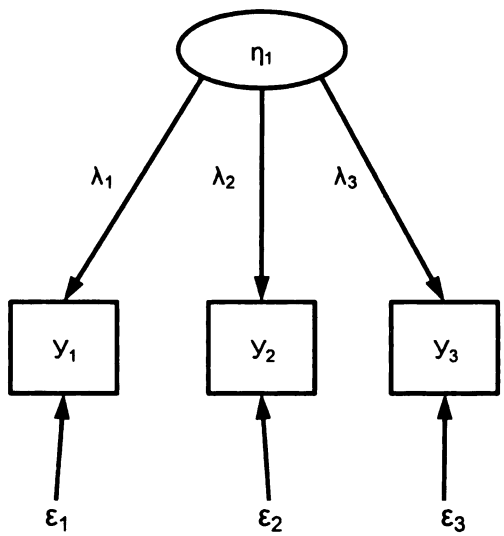

Figure 2.14 Sketch showing reflective construct and indicators (Source: Roberts and Thatcher 2009)

When defining a reflective construct, one views items or indicators as dependent on a latent variable. For the construct in Figure 2.14, a measured variable can be represented in an equation form as:

(i) $y_1 = \lambda_1\eta_1 + \varepsilon_1$

Where y_i is the *i*th indicators, η_1 is the latent variable that affects it, ε_1 is the measurement error for the *i*th indicator, and λ_i is the coefficient giving the expected effect of η_1 on y_i.

On the other hand, Formative constructs are the constructs viewed as being formed by their indicators (Bagozzi & Fornell 1982). In a formative model, the latent construct depends on a constructivist, operationalist or instrumentalist interpretation by the scholar (Coltman et al. 2008). Such constructs are formed or induced by their measures. Formative constructs are commonly conceived as composites of specific component variables or dimensions (Edwards and Bagozzi 2000). For example, at organizational level, knowledge embeddedness may be defined in terms of planning, analysis, design, and construction knowledge (Purvis et al. 2001). Hence, indicators of planning, analysis, design, and construction knowledge form the latent variable knowledge embeddedness. Figure 2.15 shows a visual example of formative construct and indicators.

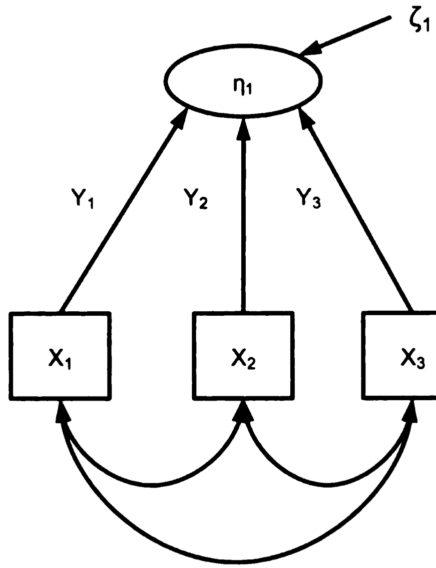

Figure 2.15 Sketch showing formative construct and indicators (Source: Roberts and Thatcher 2009)

When defining a formative construct, one conceives the indicators as causing the latent variable. For construct in figure 2.15, a latent variable can be represented in equation form as:

(ii) $\eta_1 = y_1x_1 + \ldots\ldots + y_nx_n + \zeta_1$

Where η_1 and all Xs are deviation scores, the deviation scores do not covary with the latent variable's disturbance term (ζ_1), and the disturbance represents all of the variance in the latent variable not accounted for by its indicators (Bollen and Lennox 1991). In succinct, the formative and reflective indicators have some conceptual differences and statistical differences that are critical to understand in order to correctly identify and validate those constructs. Table 2.6 presents the conceptual differences between formative and reflective indicators.

Concept	Formative Indicators	Reflective Indicators
Causality	Formative Indicators are viewed as causes of constructs (Blalock 1971). The construct is formed or induced by its measures.	Constructs are viewed as causes of reflective indicators (Bollen 1989). Reflective indicators represent manifestations of a construct.
Interchangeable	Not interchangeable -"omitting an indicator is omitting a part of the construct" (Bollen and Lenox 1991).	Interchangeable - the removal of an item does not change the essential nature of the construct. Although every item need not be the same, researchers need to capture the domain space of the construct.
Validity	Indicators are exogenously determined; hence, correlations are not explained by the measurement model (Bollen 1989).	Validity of indicators can be assessed through the measurement model (Bagozzi et al. 1991).

Table 2.6 Conceptual differences between Formative and Reflective Indicators (Source: Roberts and Thatcher 2009)

Unlike reflective indicators, the formative indicators are assumed to be uncorrelated (Barclay et al. 1995). It is important to note that although theoretically uncorrelated, in practice, formative indicators may actually co-vary. The important thing to understand is that even if correlated, formative indicators are not interchangeable; in fact, removing a formative indicator implies removing a theoretically meaningful part of the construct (Bollen and Lennox 1991). The statistical differences between formative and reflective indicators are listed in the Table 2.7. Due to their statistical properties, conventional procedures used to assess the validity and reliability of scales composed of reflective indicators are not appropriate for compostive variables with formative indicators (Roberts and Thatcher 2009). One way in which researchers can assess the validity of a formative construct is by including some reflective indicators to estimate a multiple indicators and multiple causes (MIMIC) model (Diamantopoulos and Winklhofer, 2001).

Concept	Formative Indicators	Reflective Indicators
Internal Consistency	Correlations may not be characterized by specific patterns (Bollen 1984).	Indicators should be internally consistent (Nunnally & Bernstein 1994).
Error Variance	Do not have "error" terms; error covariance represented only in the disturbance term, ζ. Disturbances represent all causes of an endogenous variable that are omitted from the structural model (Diamanotopoulos 2006).	Represented by error terms.
Identification	Taken in isolation, the measurement model in Figure 2.15 is statistically underidentified (Bollen and Lennox 1991). The model can only be estimated if it is placed withing a larger model that incorporates consequences of the latent variable in question (Bollen 1989). A necessary, but not sufficient, condition for identifying the disturbance term if that the latent variable emits at least two paths to other latent variables measured with reflective indicators (MacCallum & Browne 1993).	A model with three indicators is identified.

Table 2.7 Statistical differences between Formative and Reflective Indicators (Source: Roberts and Thatcher 2009)

In the MIMIC model, the formative indicators act as direct causes of the latent variable which is indicated by one or more reflective measures. The inclusion of reflective measures is necessary for identification purposes (Bollen 1989). According to Kline (2005), a model is said to be identified when it is theoretically possible to derive a unique estimate of each parameter. To identify a model with formative constructs, scholars suggest (1) placing formative construct within a larger model and (2) specifying at least two paths from the formative construct to reflective constructs or indicators (MacCallum & Browne 1993). If a model lacks more than one path to a reflective construct, the residual variance of the formative construct will be under-identified and must be fixed at zero. A MIMIC model meets all these conditions, as shown in Figure 2.16 below.

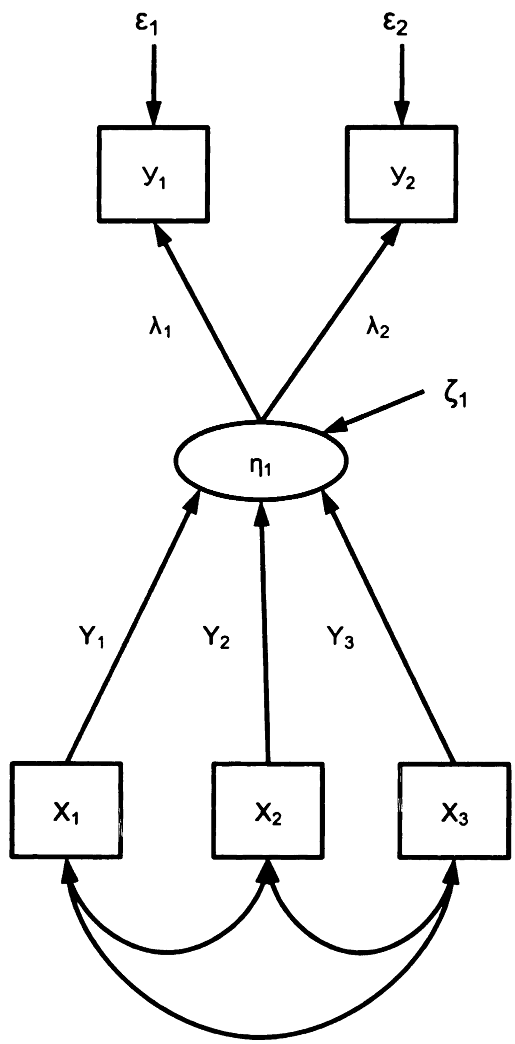

Figure 2.16 Sketch showing a MIMIC model (Source: Roberts and Thatcher 2009)

The construct validity for a formative/MIMIC model can be done by investigating the significance (should not be equal to zero) of the parameter estimates for each formative indicator (Bollen 1989). However, retaining non-significant indicators that contribute to the content domain of a formative construct is considered to be an acceptable practice (Jarvis et al 2003).

2.6.2.1 Development of Measurement Model

The first step after defining the constructs and undertaking the construct validity tests is development of the overall measurement model. The individual constructs brought together to develop the model must be checked for *unidimensionality.* Unidimensional mean that a set of measured variables have only one set of underlying construct. Allowing a single measured variable to be caused by more than one construct impacts unidimensionality; it is important because the existence of significant cross-loadings is evidence of a lack of construct validity. In addition, when a measurement model also hypothesizes no covariance between or within construct error covariances, meaning they are all fixed at zero, the measurement model is said to be *congeneric.* Congeneric measurement models are considered to be sufficiently constrained to represent good measurement properties, and are hypothesized to have construct validity and consistent with good measurement practices (Hair et al 2005).

Another critical aspect of developing a measurement model is determining the number of measured variables in a construct. The number of variables is critical for *model identification* purposes. The identification issue deals with whether enough information exists to identify a solution to a set of structural equations. The sample covariance matrix provides this information; one parameter can be estimated for each unique variance and covariance amoing p measured items, calculated as $\frac{1}{2}[p(p + 1)]$. One degree of freedom is then lost or used for each parameter estimated (k). There are three levels of identification, these are (Hair et al 2005):

a. *Under-Identified*: An under-identified model is one with more parameters to be estimated than there are item variance and covariances (i.e., there are negative degrees of freedom). For example, a measurement model with only two measured items and a single construct is under-identified. The covariance matrix would be 2x2, consisting of one unique covariance and 2 error variances. But, the measurement model of this construct would require that two factor loadings and two error variances be estimated (four parameters). Thus, a unique solution cannot be found because there are more parameters to be estimated than unique values in the covariance matrix.

b. *Just-identified*: With the same logic as discussed above, a three-item indicator is just-identified, meaning it includes just enough degrees of freedom (0) to estimate all free parameters. Since all of the information is used, confirmatory factor analysis will reproduce the sample covariance matrix identically. In SEM terminology, a model with 0 degrees of freedom is referred to as saturated. The resulting χ^2 goodness-of-fit statistic also is 0, therefore, experts say that a just-identified model do not test a theory.

c. *Over-identified*: These models have more unique covariance and variance terms than parameters to be estimated. Thus, for any given measurement model a solution can be found with positive degrees of freedom and a corresponding 2 goodness-of-fit value. At minimum, a four-item, unidimensional measurement model produces an overidentified model for which a fit value can be computed (degrees of freedom 10-8 = 2). Increasing the number of measured items only strengthens this result.

After checking for model identification, measurement scales are set for the measured variables. All the items indicating a construct need not be of the same scale type, nor do different scale values need to be normalized prior to using SEM, however, combining scales with different ranges can sometimes require longer computational time, therefore, using same scale type is preferred approach (Hair et al 2005).

The next step after developing the measurement model is to specify the measurement model. This is done by entering the data into the SEM software and running the process. However, selecting a proper sample size is an area of big debate in SEM literature. In the following section, we will discuss what is the minimum sample size suggested by experts for running an SEM successfully.

2.6.2.2 Sample Size in SEM

SEM in general requires a larger sample relative to other multivariate approaches. Expert opinions regarding minimum sample sizes have varied; they recommend considering the following aspects to calculate the required sample size for the SEM. These are:

1. Multivariate distribution of the data.
2. Estimation technique.
3. Model complexity.
4. Amount of missing data.
5. Amount of average error variance among the reflective indicators.

Some experts (Kline 2005) have suggested an absolute minimum sample size to have any hope of getting good results would be N = 100. But that would be a small sample and runs considerable risk of producing invalid results with Maximum Likelihood Estimation technique (MLE), while 100-200 would be a medium sample size, and over 200 would be generally considered a large sample. In cases with sufficiently large number of parameters to be estimated, Kline (2005) suggested that an ideal case would be 20 cases/parameter, but that 10 cases/parameter is more realistic. Raykov & Marcoulides (2006) also suggest 10/cases/parameter as a guideline. Kline (2005) suggests that anything less than 5 cases/parameter would probably not yield trustworthy results. MacCallum et al (1996) provided a method for determining the minimum sample size necessary to achieve a given level of power for tests of model fit. Recent work indicated that minimum sample size necessary to accurately recover population factor loadings is highly dependent on characteristics such as communality level of the MVs (MacCallum and Austin 2000), that is, models containing multiple constructs with communalities less than 0.5 require larger sizes for convergence and model stability (Hair et al 2005). A final decision on sample size can only be reached after the measurement model is identified.

After the data is collected of the desired sample size, the measurement model is specified in order to test the measurement theory. Since a latent factor is unobserved, it has no metric scale, meaning no range of values, thus, it is provided in one of two ways (Hair et al 2005):

1. A scale can be set by fixing one of the factor loadings and setting its value (1 is a good value).

2. The construct variance can be set to a value. Again, 1 makes a good value. Using a value of 1, for example, results in a correlation matrix of the relationships between constructs.

Once, the model is specified it is revisited for issues related to identification. The problems in identification are detected by the following symptoms:

a. Very large standard errors for one or more coefficients.

b. An inability of the program to invert the information matrix (no solution can be found).

c. Wildly unreasonable or impossible estimates such as negative error variances, or very large parameter estimates, including factor loading and correlations among the constructs (absolute value of 1.0).

d. Models that result in differing parameter estimates based on the use of different starting values.

In SEM, however, model estimates should be comparable given any set of reasonable starting values. Thus, to check for identification issues, a confirmatory factor analysis model is first estimated and parameter estimates are obtained. Next, the coefficients are fixed to their estimated value and model is rerun. If the overall fit of the model varies markedly, then identification problems are indicated.

These problems occur mostly due to (1) the number of variables are misspecified, e.g. there are a total of 12 variables but researcher specified number of variables as only 11. In this scenario, the covariance matrix is not identified. (2) When a variable is mistakenly specified twice, in this case the covariance matrix will be non-positive definite and no unique solution would be found (Hair et al 2005).

Once the model is specified it is estimated with the help of empirical data, the measurement model is tested for validity by using *goodness-of-fit* indices. Goodness-of-fit (GOF) indicates how well the specified model reproduces the covariance matrix among the indicator items. The most widely used GOF measure is the chi-square (χ^2) index. The difference in the covariance matrices ($S-\Sigma_k$), where S is the observed covariance matrix and Σ_k is the estimated covariance matrix, is the key value in assessing the GOF of any SEM model. This difference would be zero if the researcher's theory were perfect. To the extent that perfect fit is not the case, the chi-square value increases; because the critical values of the chi-square distribution are known, the probability (p-value) that any observed sample and estimated covariance matrices are actually equal can be found. In contrast with other regression techniques, for the chi-square GOF test in SEM, the smaller the p-value, the greater the chance that observed sample and estimated covariance matrix are not equal. Thus, in SEM a larger p-value (meaning statistically insignificant) is desired, the best scenario being a small chi-square value and a corresponding large p-value that is indicative of statistically insignificant difference between the matrices (Hair et al 2005).

Some other popular model fit statistics used in SEM technique are Goodness-of-Fit index(GOF), Root Means Square Residual (RMSR) and Standardized Root Mean Residual (SRMR), Root Mean Square Error of Approximation (RMSEA), etc. The indices mentioned and discussed are all *absolute fit* indices. That is they measure how well the model specified by the researcher reproduces the observed data, and they do not compare the GOF of a specified model to any other model; this is done by *parsimony fit* indices. A popular parsimony fit index used is Parsimony Normed Fit Index (PNFI), discussion of which is excluded as it is beyond the scope of this research. Another type of indices used are *incremental fit* indices, they assess how well a specified model fits relative to some alternative baseline model. A popular incremental fit index used is called Normed Fit Index (NFI) (Hair et al 2005).

Like the reflective models, model fit is assessed for MIMIC model through standard measures of fit mentioned and discussed above such as model chi-square, CFI, GFI, NFI, RMSEA or SRMR (Roberts and Thatcher 2009). The best choice of indices to be used for measurement model validity depends upon the model under consideration and were discussed in chapter 4 in a demonstration. The guidelines for establishing acceptable and unacceptable fit were also discussed in chapter 4, as they are recommendations based on number of variables and sample size selected (Hair et al 2005).

2.6.2.3 Development of Structural Model

After testing the measurement theory, the final stage in SEM involves specification and validation of the structural theory that is originally proposed by the researcher. The first step in the process involves specifying the model using path diagram. The structural theory is represented by specifying set of relationships between the constructs. In the structural model, two-headed arrows from the measurement model indicating correlations between all the constructs are replaced with a smaller number of one-headed arrows (directional relationships). In essence, the structural theory is created by constraining the covariance matrix using the set of free and fixed parameters representing hypothesized relationships (Hair et al 2005).

The issues of sample size and identification are easier to satisfy in a structural model. If both the conditions are satisfied for the measurement model, they are likely to be satisfied for structural model because the structural model is nested within the measurement model and is more parsimonious as it contains fewer estimated paths. The structural model is identified as long as there are no interaction terms included, the sample size is adequate (satisfies the measurement model), and a minimum of three measured variables per construct is used (Hair et al 2005).

After the model specification, special attention is needed to the design of construct loadings in the model. The measurement portion of the structural model consists of the loading estimates for the measured items, error variances and the correlation estimates between exogenous constructs. There are two approaches to go ahead with estimation of the structural model; first approach suggests that the estimates that are obtained from the measurement model should be fixed in the structural model, because otherwise the loadings will change due to the changes imposed during the transformation from measurement to structural model. The purpose behind fixing the estimates is to prevent the condition of *interpretational confounding* which essentially means that the measurement estimates for a construct are significantly affected by relationships outside of the specific measures used for the constructs. By fixing the parameters, estimating the structural model becomes easier due to lesser number of values to be estimated, however, this approach may lead to change in fit between the measurement and structural model due to problems with the fixed measures instead of the structural theory. The second approach allows estimating coefficients for all the loadings and error variances along with structural model coefficients. This approach helps in revealing the interpretational confounding by comparing the measurement model loading estimates with those obtained from the structural model estimates (Hair et al 2005).

The last step in the SEM analysis is to assess the structural model validity. Since, the estimated covariance matrix is computed based on restrictions (pattern of free and fixed parameter estimates) the estimated covariance matrix developed from the structural model will include more restrictions because more paths are set to 0 as compared to measurement model. As a result, the structural model cannot have a lower chi-square value than that obtained in measurement model. The validity of the model is tested in two steps:

a. The first step is to assess overall structural model fit, as the measurement model was assessed. The recommended technique is to assess the fit by using one absolute index, one incremental index and a model chi-square test at minimum. Experts recommend that one of the indices should be badness-of-fit index (RMSR or SRMR). The guidelines for acceptance of fit are same as the ones used for measurement model (Hair et al 2005).

b. The second step is to compare the measurement model fit and structural model fit. A structural model fit cannot fit any better (have a lower chi-square) than the overall measurement model; therefore, it can be said that structural theory lacks validity if the structural model fit is substantially worse than the measurement model fit (Hair et al 2005).

Reaching a good fit is not sufficient to prove that the structural theory is right. The researcher is required to examine the individual parameter estimates against corresponding predictions or paths, each representing a specific hypothesis. Once, the researcher confirms the estimates with the theory (in the predicted direction) and check for statistical significance of the fit, the structural model is said to be completely validated (Hair et al 2005).

2.7 Need and Application of SEM in Construction

As briefly mentioned earlier, SEM has been extensively used in behavioral and psychological research. However, it has been only recently used in the construction industry. "The limited research studies reported in the management literature that have addressed the problem of improving the project planning process have focused mainly on examining the individual impacts of a variety of influence factors on the effectiveness of project planning efforts (Islam et al. 2005)." Laufer and Cohenca (1990) examined the effect of eight situational variables on the efforts invested in construction project planning. The study showed how these situational variables individually influence project planning. Faniran et al. (1994, 1998) evaluated the influence of situational factors in project environments and organizational characteristics of performing organizations on project planning efforts and project planning effectiveness. Dvir et al. (2002) evaluated the relationship between three measures of planning efforts (development of functional requirements; development of technical specifications; and implementation of project management processes and procedures) and four measures of project success (meeting planning goals; end-user benefits; contractor benefits; and overall project success). The study supported previous research findings which found a significant positive relationship between the amount of efforts invested in the project definition and technical specifications functions of the project planning process on one hand, and project success on the other (Islam et al. 2005).

"The studies discussed and other related studies have contributed to understanding how the project planning process interacts with its environment, the potential applications of the findings to the development of strategies for improving project/production planning effectiveness is limited by inherent deficiencies in the methodologies applied" (Islam et al 2005). Firstly, the methodologies used in the previous studies have focused mainly on measuring directly-observable influence variables, and assessing the effect of these variables on the project/production planning process. However, the methodologies did not consider the interrelationships that exist within the variable sets of the influence factors in order to understand how individual influence factors work together in influencing planning effectiveness (Islam et al. 2005). SEM provides an opportunity to measure collective influence of factors by arranging all the factors in a measurement model and estimating the influences together. Secondly, a major limitation of the previous studies is that the findings were drawn mainly from a multiple regression analysis of qualitative data that had been converted into abstract numerical scales. The conversion of qualitative data to quantitative data leads to a large potential for error in measurement of a variable. Regression analysis cannot accurately account for the errors in measurement that occur as a result of this transformation. However, SEM also accounts for measurement errors, thus producing more accurate representations (Islam et al. 2005).

The SEM approach has been increasingly applied in the field of construction engineering and management to explore complex phenomena and dynamic relationships

(Kim et al. 2009). Mohamed (2003) used SEM to model the joint venture performance of overseas construction projects. Molenaar et al. (2000) suggested using SEM to predict the possibility of disputes at the early stage of a project. Islam et al. (2005) modeled the impact of project conditions on planning effectiveness, through SEM application. Wang et al. (2005) also proposed an SEM-based prediction model to ensure that partnering can be successfully implemented to realize probable benefits.

Kim et al. (2009) conducted the latest such research using SEM to model the relationship among various factors that affect the project success of international construction projects. The study adopted 64 performance influencing variables on project performance, initially classified into five categories but later conceptualized into 14 latent variables with the help of literature review and expert interviews. The study further compared the developed SEM model with a multiple regression model and an Artificial Neural Network (ANN) based prediction model using the same influence variables and concluded that the SEM model had a capacity to predict the project performance with moderately higher accuracy. While the overall accuracy for multiple regression model was estimated at 86.3% and average deviance of profit level was 0.82, the figures for ANN model were 88.8% and 0.67. The SEM model had an accuracy of 90.7% and only 0.56 of average deviance, thus clearly showing that SEM is more accurate and powerful in recognizing the complex structures of variables and offering some insights into underlying cause-and-effect relationships (Kim et al. 2009).

Kim et al. (2009) further discussed the advantages of SEM over other statistical tools for prediction purposes. These were:

a. The regression method does not identify all the relations necessary to reflect realistic situations and cannot cope with a complex problem such as hierarchical structures of dependencies between each factor. In contrast, the SEM can be used where the final outcome is best represented as a sequence and relation of interrelated variables. The SEM is also used to recast a complex problem into several smaller related path diagrams.

b. The SEM can measure direct as well as indirect effects among the various latent and observed variables. It also enables representing these multi-layered causal or correlational relationships and their degree of impacts toward the output variables by providing the structural coefficients. Thus, the SEM allows for intuitive apprehending of the interrelationships of the variables that are not visible in both regression and ANN model.

c. The SEM performs better in supporting the process of strategic decision making. The firm can choose to negotiate a favorable resolution process based on the SEM feedback; through this feedback system, the firm can choose well-fitted strategies designed to improve the firm's capacity to perform or to improve a project's particular conditions.

The SEM applications briefly mentioned and discussed above were all designed using a reflective model approach. The importance of SEM analysis are well established in the review, however, it is important to discuss the current trends emerging in approaching the SEM technique and inform the research to progress in the right direction using that information.

2.7.1 Current Trends in Application of SEM Technique

The use of SEM analysis technique in management literature is extensive (Diamantopoulos et al. 2008; Coltman et al. 2008; Ruiz et al. 2008). Traditionally, management scholars identify structural relationships among latent, unobserved constructs by statistically relating covariation between the latent constructs and the observed variables or indicators of these latent constructs; consequentially, they assume that this relationship between construct and indicator is reflective. With reflective measurement models, causality flows from the latent construct to the indicator (Coltman et al. 2008). However, not all latent constructs are entities that are measurable with a set of positively correlated items (Edwards et al. 2000). Several researchers (Ruiz et al. 2008; Roberts and Thatcher 2009; Coltman et al. 2008) have proposed and recommended formative model assessment over existing reflective models in their areas of research, i.e. business studies, and information systems, by showing results indicating a better fit and prediction capacity.

Ruiz et al. (2008) have strongly argued in their study of relationship between customer value and service value that constructs like *service value* cannot be formulated as reflective constructs, because, with reflective measures, all components are expected to covary with one another. However, the benefit component of service value may not correlate with sacrifice component, for example, a bank may reduce a customer's perceived sacrifice by opening a neighborhood branch, which saves the customer some time while using its services, but it doesn't necessarily mean that the benefits of the bank for the customer has changed (allowing more withdrawals per day than earlier. Thus, models using reflective components may misspecify the customer value construct, which can cause biased estimates of the structural relationships between constructs and undermine the validity of the statistical conclusions (Mackenzie et al. 2005). Similar model misspecification examples and arguments can be found in other research (Roberts and Thatcher 2009; Diamantopoulos et al. 2001). In the wake of this overarching misspecification problem, several researchers have recommended steps to investigate whether a construct should be reflective or formative.

Coltman et al. (2008) proposed a set of theoretical considerations that should be considered in deciding whether the measurement model should be formative or reflective. These are:

1. *The Nature of the construct:* In a reflective model, the latent construct exists independent of measures, for example, measures of a person's attitude or personality do not dictate or indicate whether attitude is there or not – we know it is there but can't directly measure it. In contrast, in a formative model, the latent construct depends on a constructivist, operationalist or instrumentalist interpretation by the scholar. For example, the human development index (HDI) does not exist as an independent entity. Instead, it is a composite measure of human development that includes: health, education and income. Any change in one or more of these components is likely to cause a change in a country's HDI score, not the other way round.

2. *Direction of Causality:* The second key consideration in deciding a reflective or formative construct is the direction of causality between the construct and indicators. For example, since construction production planning presents a proactive scenario, variation in productivity does not cause or reflect absenteeism in workforce; instead,

absenteeism in workforce causes variation in productivity. Therefore, it is crucial for the construction management researchers to design the construct carefully (an aspect of SEM not addressed in previous researches).

3. *Characteristics of Indicators:* In a reflective model, change in the latent variable must precede variation in the indicator(s). Thus, the indicators all share a common theme and are interchangeable. This interchangeability enables researchers to measure the construct by sampling a few relevant indicators underlying the domain of the construct. Inclusion or exclusion of one or more indicators from the domain does not alter the content validity of the construct. However, in formative models, since the indicators define the construct, the domain of the construct is sensitive to the number and types of indicators the researcher selects. Adding or removing an indicator can change the conceptual domain of the construct significantly. For example in construction production planning, measuring the availability of resources (latent construct) by indicators such as availability of tools and availability of labor, represent a conceptually more accurate Resource construct. Replacing availability of tools with labor cannot justify the construct, because these two are uncorrelated items and conceptually alter the definition of availability of resources.

The discussion above about the nature of the latent constructs and measurement model with examples in management literature recommending taking the formative indicator approach were used in this research to define the nature of the model and design the method for exploring the relationship between work flow reliability and production delay factors.

2.8 Chapter Summary

This chapter provided an overview of current production management practices discussing the conventional and lean production management tools. Existing researches on production factors affecting construction projects were discussed as part of the literature analysis in fulfillment of research goal and objectives. The Structural Equation Modeling analysis technique was extensively reviewed and its nuances were highlighted. The need and existing applications of SEM analysis technique in construction management were discussed. Overall, the literature analysis brought forth essential production delay factors, structural equation modeling techniques, and the current direction in SEM analysis which are all relevant in developing the intended method in this research to explore the relationship between work flow reliability and production delay factors.

CHAPTER-3

RESEARCH METHOD

3.1 Introduction

The goal of the research is to improve the understanding of factors affecting workflow reliability of construction projects at the production level. To approach this goal, the research focused on developing a method to investigate the causal relationship between production delay factors and their impact on workflow reliability. To accomplish this, the following objectives were proposed:

1. Study production control tools implemented at the site level and document the production delay factors encountered on construction site.
2. Develop a method to study the relationship between production delay factors and work flow reliability.

Figure 3.1 shows the process adopted for the research, which is comprised of four phases, which were followed to address objectives one and two. The first step was crucial in achieving the first objective and the remaining three steps helped in achieving the second objective.

The research began with a comprehensive literature review to identify the existing methods used in evaluating the performance of production management as implemented on construction projects, and causes of variation in work flow, and Structural Equation Modeling analysis technique. In the next step, the research identified the scope of development of the framework. Next, the development of a framework to design models capable of understanding the relationship between production factors and reliable work flow (construction site performance) took place. The framework steps were explained with the help of a demonstrated example.

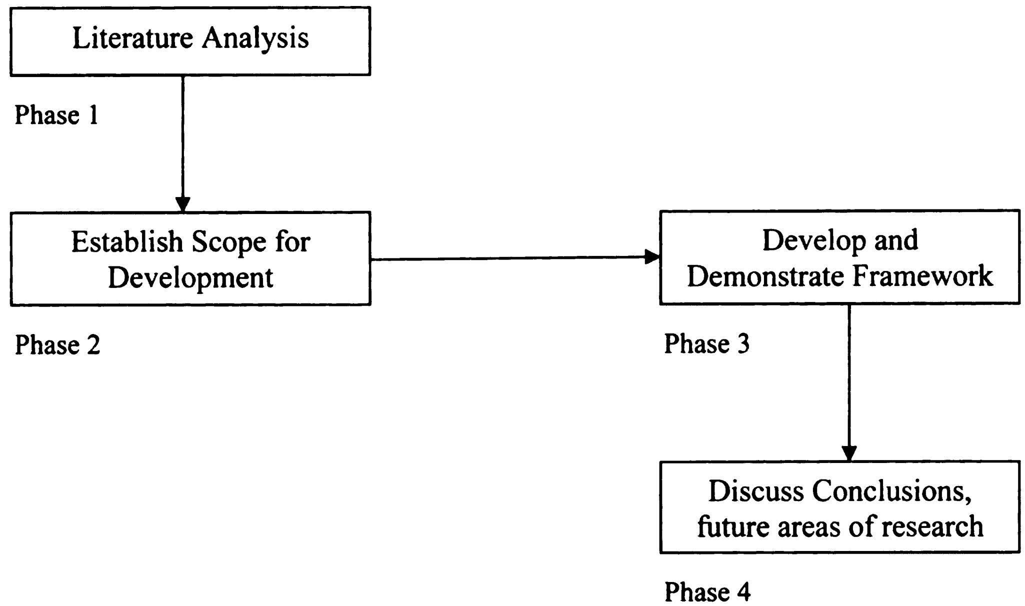

Figure 3.1 Research Methodology in 4 phases

The development of the framework to construct SEM model suited to construction industry research is expected to lead to the understanding of the causal relation between the production delay factors leading to unreliable workflow. Given the qualitative nature of most of the factors affecting production performance and workflow reliability, the techniques used in Structural Equation Modeling (SEM) will be instrumental in developing the proposed statistical procedure.

Figure 3.2 shows the detailed research methodology adopted where the steps have been broken down to detailed task levels to further explain the process. The outcome of each step is a deliverable and becomes the input for the next step.

In Phase-1 as shown in Figure 3.2, the literature review is broadly divided into three categories: Lean and Conventional production management and control techniques, literature on construction productivity factors, and structural equation modeling and its applications. The literature on project and production management helped to understand the current shortcomings of macro-level project controls as well as identifying the typical production delay factors encountered in practice. As mentioned earlier, Structural Equation Modeling (SEM) is adopted in this research as a statistical tool to explore the possibility of studying the production factors and work flow reliability in a causal fashion. The background study on SEM helped in identifying the steps and needed to prepare the framework to build a causal relationship model.

Phase-2 in the research involved establishing the scope of framework development for SEM model specific to application in construction management research. In this step, deliverables expected at the end of the framework development are outlined. In Phase-3, the framework for designing causal equation models was developed and explained using a demonstrated example in context of construction production planning. This step also produced a survey instrument that will help Last Planners record the level of existence of production factors and study their impact on reliable work flow. In addition, strategies to aid development of the SEM model were also established (only valid for formative models). In Phase-4, discussion on conclusions from the framework development process, benefits of research, and future areas of research were presented.

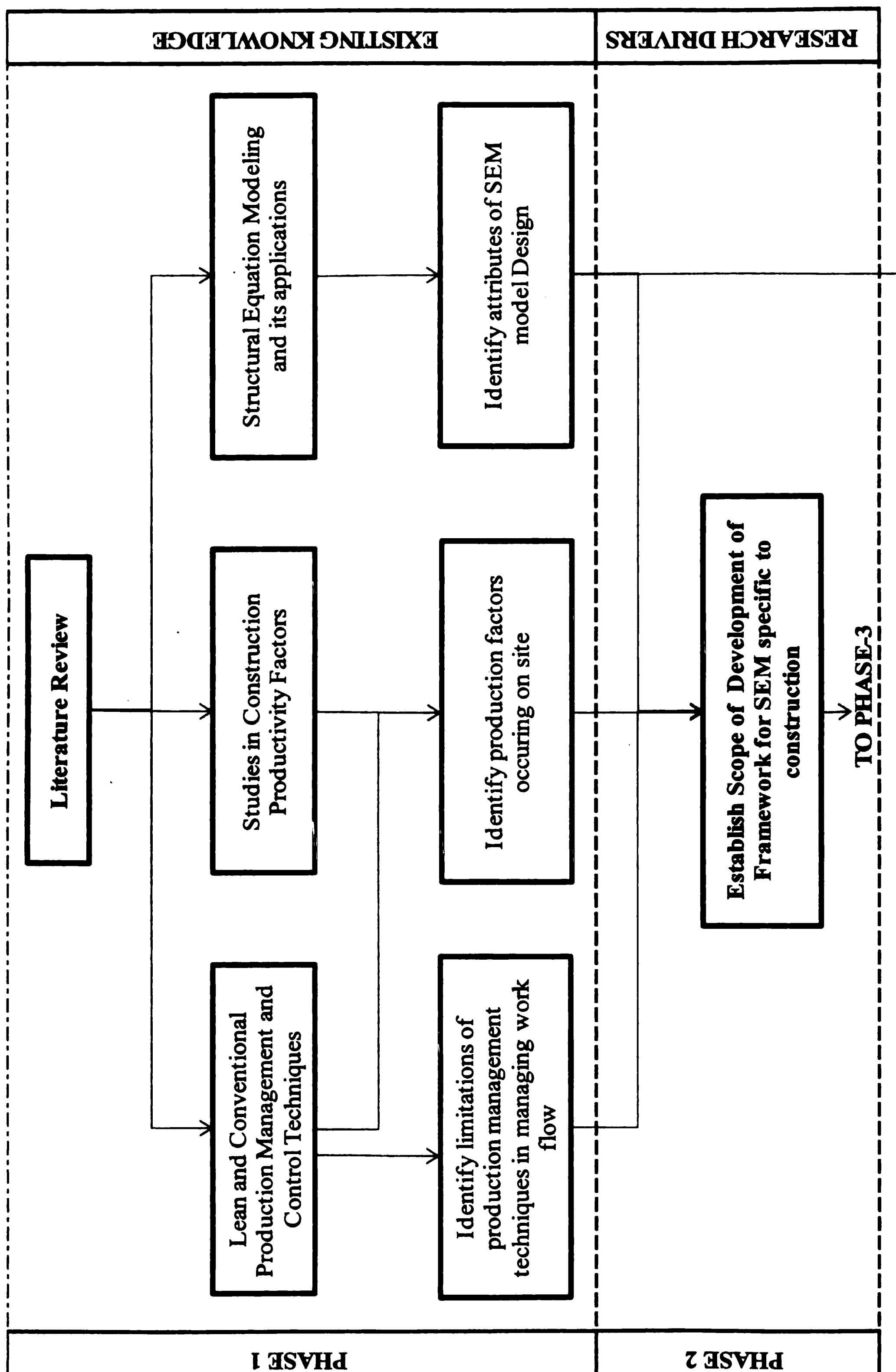

Figure 3.2 Detailed Research Methodology

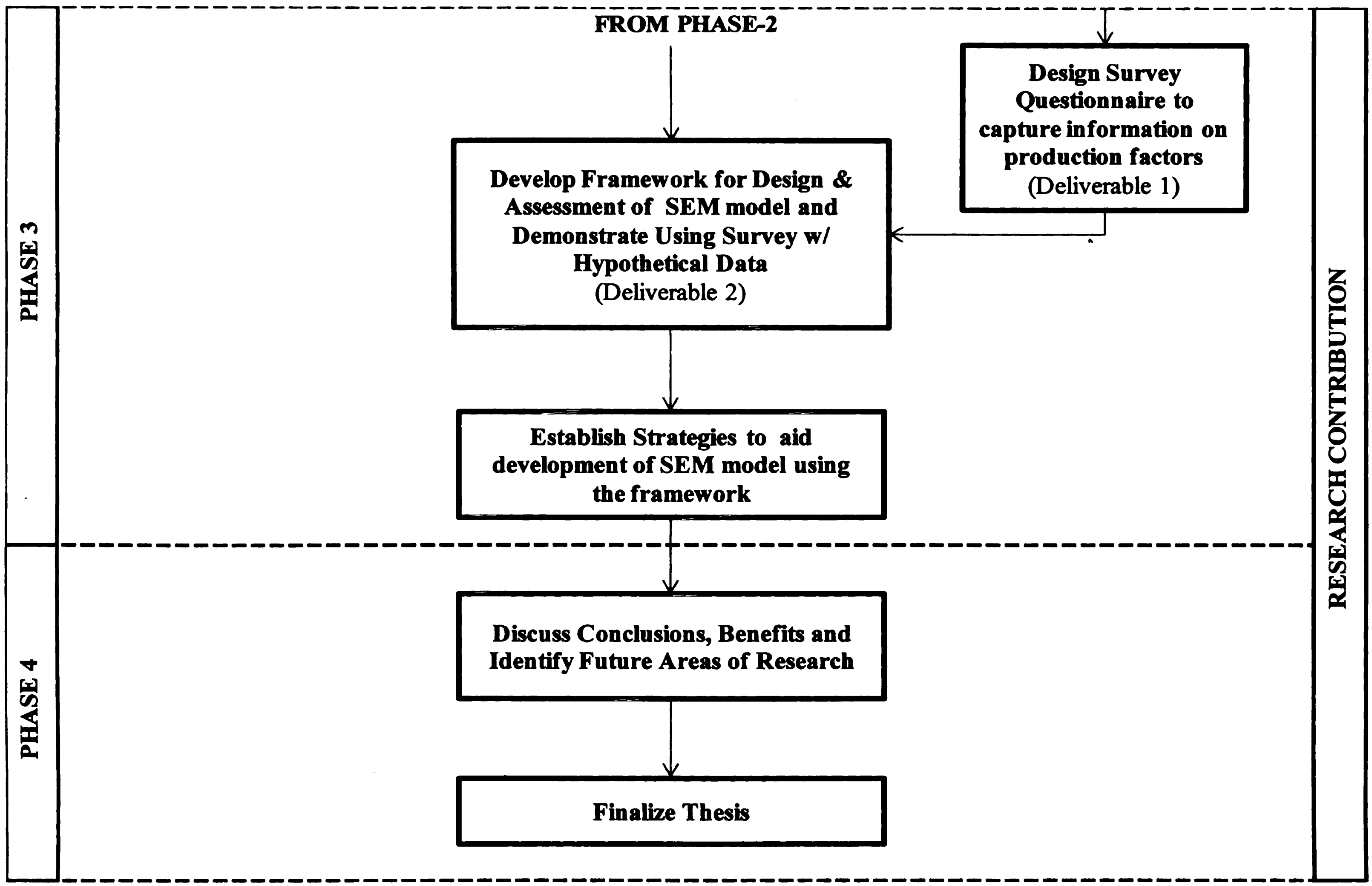

Figure 3.2 (Cont'd)

3.2 Existing Literature, Scope of Development and Research Contribution

The analysis of existing literature in Phase-1 provided guidelines for conducting the research. The outcome of literature analysis provided clear directions for establishing the extent to which the intended framework is to be developed. The current production planning and control tools, and literature on SEM applications provide the main research drivers of the research. The applicability and utility of the Structural Equation Modeling will act as a driver for establishing scope of the intended framework, in Phase-2.

The main outcomes of the research are delivered from Phase-3, where the research developed (1) the survey instrument to capture the extent of presence of production delay factors, and (2) the framework to design causal relationship equation using SEM in the production planning and control context. This phase includes method of recording the production delay factors, sorting them into categories required to fit the causality model, method of populating the model with the recorded data, etc. The framework was demonstrated along each step using the developed survey instrument with the help of randomly simulated hypothetical data in this phase of research. In addition, strategies to support the development of SE model were also developed.

Phase-4 discussed how the framework development benefits the studies on establishing cause-and-effect relationships between different elements of construction process.

3.2.1 Phase-1 Literature Analysis

Objective-1 Study production control tools implemented at the site level and document the production delay factors encountered on construction site.

Objective 1 is fulfilled by performing following steps:

a. Conduct literature review on production planning and control tools, productivity measurement studies and identify factors causing work flow variability.

The following section discusses the contribution to the research of literature analysis of conventional production management and control techniques, Lean production management and control techniques and Structural Equation Modeling.

3.2.1.1 Conventional Production Management Techniques

The literature analysis of conventional production management techniques will identify attributes of production planning and control tools that are implemented to measure, report and remediate the actions on the job site in order to achieve best results by most production planners in the industry. The purpose of reviewing these tools is to understand the criteria they use to measure progress, methods of measuring the progress, stages at which the progress is measured and the inferences that are drawn out of those measurements.

The analysis uncovered how the inefficiencies of the tools were addressed in previous research (Singh 2007). For instance, the main limitation of the current production control tools like CPM and EVM is that both tools are sensitive to disturbances in overall project progress and give inferences that only look at a short term solution without understanding the depth of the problem. These tools do not aid in preempting problems but merely act to subdue the recurring problems by reflecting possible solutions to patch the project performance. Both tools lack the ability to shield the production tasks from the production constraints and variations because there is no consideration of the interdependence between activities.

The LOB method of scheduling, another widely used production control tool mainly in Europe, has a slight advantage over the CPM method, because LOB method primarily calculates the schedule based on production rhythms (discussed earlier) and consider space constraint as an important input before planning out the project, which helps in preventing bottlenecks on project sites due to overcrowding of crew and shield the production task from invariability of work flow due to space availability. However, LOB is not suitable for phases of projects that have non-repetitive elements, such as footings.

The literature analysis captured the problems and studied the progression of such tools and the endeavors by different researchers to overcome those problems.

3.2.1.2 Lean Construction Management Techniques

The literature of Lean Construction was be analyzed to understand the development of a new and integrated project management method called the Last Planner system and its advantages over the traditional tools that were discussed in the previous section. For instance, the LPS implements operational shielding of production tasks from various constraints such as space constraint, quality constraint, material constraint etc. The literature discusses how the operational shielding of tasks has resulted in improved production performance but at the same time highlights a general lack of understanding of the complexities of a combined effect of production constraints on the final performance. A detailed study of all stages of implementation of LPS helped identify the different factors that plague the project and production performance and would facilitate ideas for improved production control.

The research on subsequent developments on LPS helped to identify the direction of progress in research and help pick the attributes of the production planning system that require further research and development. For instance, the PWR metric helped in increasing the confidence of production planners in their plan over the period of six weeks leading to the production week, but is unable to build confidence in the outcome of the production plan and develop strategies to handle inefficiencies and uncertainties.

3.2.1.3 Structural Equation Modeling

The literature analysis of SEM was performed to understand the applicability of the tool to this research. The review identified the process of using SEM for any study in general, and then modified it to suit this research. The review discussed different types of SEM designs and identified the appropriate design for this research, for instance, whether a cross-sectional design or a longitudinal design is best suited for this research, or a formative model is preferred over reflective model. The methodology of conducting an SEM research was documented and each step will be discussed to identify its ingredients, the process will help in comparing the nature of research data required to design and populate a SE model and the data available on construction projects, for instance, which production factors can be classified into measured variables or latent variables; and how to collect information of these factors. The sample size of the data required to get a good fit for a causality model depends on the type of design used by the model.

Given the exploratory nature of this research, the literature review allowed defining the scope of application of SEM, such as whether unique measurement methods of production factors should be adopted to build a universal relational model between production delay factors and work flow reliability. Figure 3.3 presents the different steps involved in designing a structural equation model. A discussion on each critical step helped establish the selection criterion for data and develop methods to convert data into usable formats.

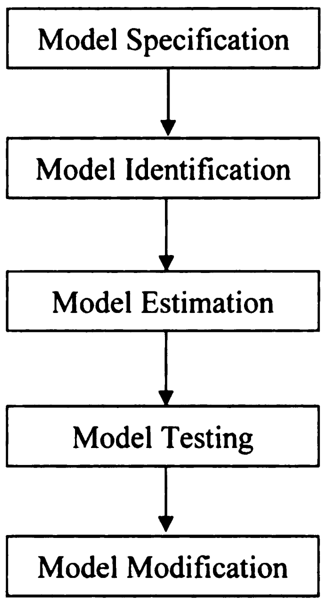

Figure 3.3 Five basic steps of designing a Structural Equation Model (Source: Schumacker and Lomax 2004)

The steps listed above form the core process of pursuing a relational equation using SEM. The discussion of these steps and the sub steps will contribute to development of the framework. The literature analysis will also reveal the software of choice for processing data of the structural equation model.

3.2.2 Phase-2 Establish Scope of Development

Objective-2 Develop a method to study the relationship between production delay factors and work flow reliability.

Objective 2 is fulfilled by performing following steps:

b. Develop a Survey Instrument to measure the existence of identified production factors.

c. Based on the literature review, develop a framework to design a causality model between various production factors and work flow reliability.

After the literature analysis exposed the current limitations of all three systems discussed, the essential attributes of the three areas were studied to establish the boundaries of exploration that will be reached during this research.

The first research question considered the extent with which the Last Planner system can help forecast construction site performance. Using the knowledge gained from the literature analysis, this step identified the next logical steps required to extend/create the forecasting capability of the Last Planner system. A discussion on the extent to which the Last Planner system is SEM-ready will help in deciding the desirable outcome of the research.

3.2.3 Phase-3 Develop Framework for designing Causality Equation

After reviewing the literature and establishing the scope of SEM development, a framework was developed to outline the sequence of activities that are to be adopted by production planners when developing a relational equation using SEM. A detailed discussion of the framework will illustrate how to measure production performance, collect and analyze data, developing the SEM model, estimating the model, adjusting the model, reporting and confirming the theory. The process map will also include steps that describe the transformation of project data to useful research data. The framework is a first step towards the development of prediction models specific to construction environments and production delay factors generated by those environments. Figure 3.4 depicts a prelim schematic structure of the framework that was developed.

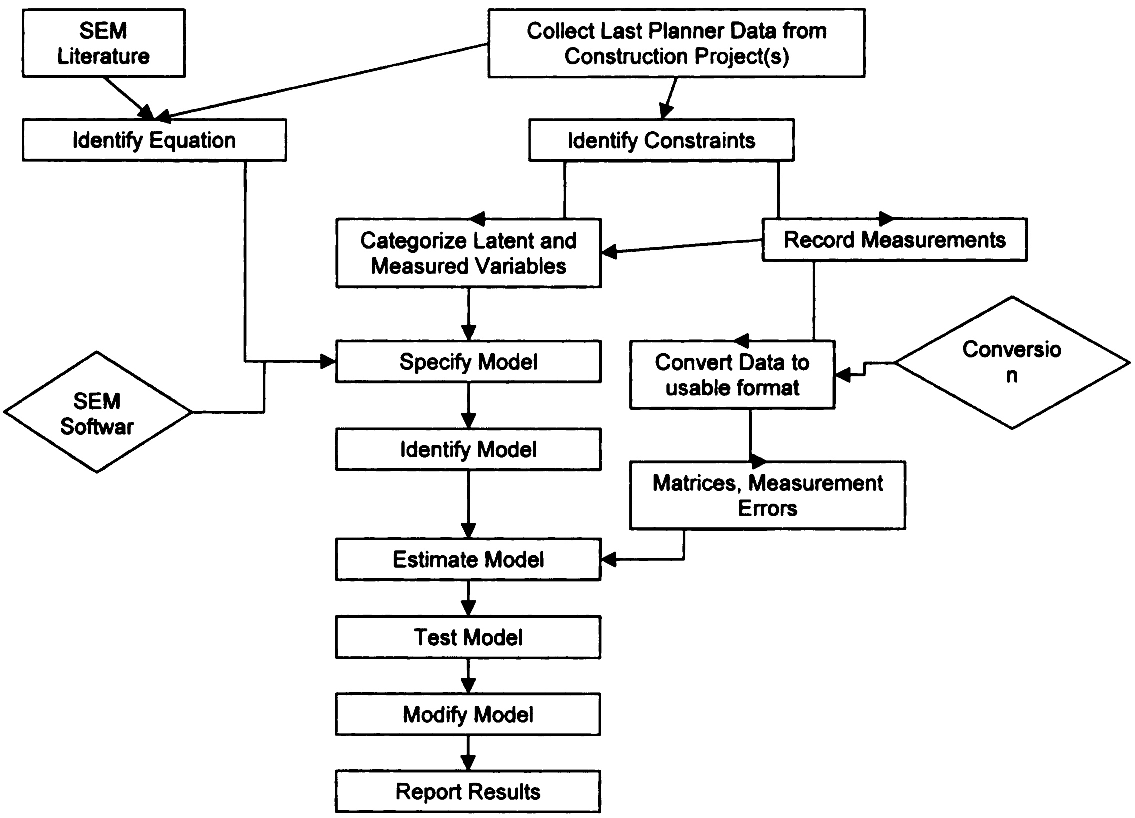

Figure 3.4 Sample representation of Final Framework

3.2.3.1 Framework Demonstration

Along the development of the framework, randomly simulated data will be used to demonstrate its implementation. The data will be generated on the basis of the survey instrument created (a deliverable) to collect the data in actual scenarios. The demonstration will further help in uncovering potential roadblocks in the execution of the process and will contribute to developing strategies and establish guidelines to successfully implement the framework. For instance, the demonstration may reveal issues such as model misspecification and identification issues or handling large sets of variables. More importantly the results reveal whether the assumed relational equation is appropriate for the observed data. SEM is a multi-approach design tool and demonstration may reveal a requirement to explore different approach to design the equation.

3.3 Chapter Summary

This chapter provided an overview of the approach that was adopted for achieving the overarching research goal to improve workflow reliability at the production level in a construction project. The brief outline of the research method illustrates how the different fields of Structural Equation Modeling, Lean Construction techniques, and conventional production management techniques were explored to develop a framework to establish a relation between site performance (reliable workflow) and production delay factors.

CHAPTER-4

FRAMEWORK DEVELOPMENT

AND DEMONSTRATION

4.1 Introduction

After the Phase-1 of the research (refer Fig. 3.2), which is extensively discussed in chapter-2, this chapter discusses the remainder of the 3 phases and presents the primary deliverables of this research that include scope establishment, development and demonstration of the framework for designing a relational equation. An extensive literature analysis on production management systems and structural equation modeling was conducted to develop the framework. The framework was primarily developed from essential attributes of structural equation modeling and incorporating all essential requirements for application in production management environments.

The framework builds on the current abilities of production management systems and their metrics identified in chapter-2 and develop strategies to adopt or modify those metrics to utilize them effectively for the relational equation development purposes. The development of framework is accompanied with demonstration to facilitate the understanding of the reader.

4.2 Scope of Framework Development

The extensive literature review on SEM revealed many attributes of SEM analysis. SEM is applied to a variety of fields and as a result several techniques within SEM have evolved to cater to analysis of data according to its nature and differing requirements. SEM modeling is particularly useful to (1) investigate proposed cause-and-effect relationships, and (2) conduct predictive analysis. The basic difference between these two uses is the method of data collection. To perform prediction modeling, the measurements of the MVs are taken repeatedly over time and their autoregressive effects are studied, bi-directional relationships between latent variables are accounted for as well. Cross-sectional designs allow only for the evaluation of relationships among variables at one point in time and do not allow for autoregressive effects or time lags, therefore, these studies are conducted to study cause-and-effect relationships based on past experiences and cannot dynamically predict the outcome. This research has focused on developing the framework to produce cross-sectional equation designs because the first step towards developing a prediction model is to establish a basic relational model between various factors, the repeated measures design will become the next step in the sequence (not developed in this research).

4.3 Framework Development

The following discussion will lay out the framework for developing a Structural Equation Model specific to the problem of workflow reliability on construction sites. The framework described will include demonstration at every step (if required). The model developed as part of demonstration is based on information collected by the researcher by doing literature reviews. The model thus created at the end of the framework will only represent one of the many possibilities that arise in real world application, and should be considered as an example model by the reader for future applications only at the their own discretion/risk.

4.3.1 Phase-1 State Hypothesis

The first step in building the model is establishing the hypothesis that is being tested or confirmed in the model. "Theory must be the foundation of even the simplest of models, because variables could always be linked to one another in multiple ways. Most would be complete nonsense. Theory makes the model plausible." (Hair et al. 2005)

The hypothesis advanced by this research through an extensive literature review is: *Workflow reliability is impacted by production delay factors that come into effect during construction.* Thus, the researcher is interested in exploring one possible cause and effect relationship between production delay factors and resultant site performance (consistent site performance represents reliable work flow).

4.3.2 Phase-2 Identify the Constructs

The first step after underlining the theory is to identify the key constructs and establish relationship between the constructs (Hair et al. 2005). The researcher is interested in understanding the impact of production delay factors over work flow reliability. As discussed in chapter 2 earlier, in the Last Planner system during the constraint analysis stage, the needed inputs for an assignment are classified into three main categories namely: Pre Requisite Work, Directives, and Resources. These are primarily phenomena that if present, prevent the start of an assignment, that is, if there is a lack of pre-requisite work, or directives, or resources, then the planned work is prevented from starting (Ballard 1997). Therefore, these three categories assume prime importance in deciding the outcome of the work and were selected to study their relation with reliable workflow.

Lean theory advocates the presence of three main phenomena that lead to delayed or unsatisfactory completion of work. These are *Muda* (Unnecessary work/waste generation), *Mura* (Variation), and *Muri* (Overburden). Site factors that lead to any of these phenomena are instrumental in preventing a task from finishing on time and/or desired quality. Finishing the task at hand is equally important as starting it and work in process is not value added work until it is complete. Therefore, studying the impact of factors that prevent work to finish is equally important as impact of factors that prevent work from starting.

Thus, the key research question is: How do the key construction site phenomena - Prerequisite Work, Directives, Resources, Waste, Variation and Burden - affect work flow reliability? From literature review (Liker 2004; Ballard 1997) and researchers' experiences, the researcher developed the following relationships:

- 'Availability of Prerequisite Work' positively affects 'Work Flow Reliability'.
- 'Availability of Directives' positively affects 'Work Flow Reliability'.
- 'Availability of Resources' positively affects 'Work Flow Reliability'.
- 'Waste Reduction' positively affects 'Work Flow Reliability'.
- 'Variation Reduction' positively affects 'Work Flow Reliability'.
- 'Burden Reduction' positively affects 'Work Flow Reliability'.

These six above stated relationships form the basis of how the researcher feels the production factors influence work flow reliability on the construction site. After relationships are specified, the next step is to identify the model in a form suitable for analysis. This step involves identifying constructs as endogenous or exogenous, followed by demonstrating the relationship visually in a path diagram (Hair et al. 2005), in other words, the directional relationships are established between the constructs.

In the demonstration example, the listed relationships identify seven constructs. Table 4.1 below indicates which constructs are endogenous or exogenous. The researcher theorized that the factors that comprise each of these construction site phenomena are independent of each other (although in field, it has been demonstrated that waste comes from all other five constructs), therefore, each of these constructs representing all these phenomena are exogenous constructs. However, work flow reliability is being studied as an outcome of the presence of all these constructs, therefore, conceptually it is dependent on the entire six constructs, and as a result it is depicted as an endogenous construct. In addition, each construct is assigned an abbreviation for ease of repetitive mention of constructs in the research and also for convenience of handling them in the EQS software used for this research.

Name of Construct	Type of Construct	Abbreviation
1. Work Flow Reliability	Endogenous Construct	WFR
2. Availability of Prerequisite work	Exogenous Construct	PRE
3. Availability of Directives	Exogenous Construct	DIR
4. Availability of Resources	Exogenous Construct	RES
5. Variation Reduction	Exogenous Construct	VAR
6. Burden Reduction	Exogenous Construct	BUR
7. Waste Reduction	Exogenous Construct	WTE

Table 4.1 Categorizing the constructs into endogenous and exogenous constructs (with abbreviation)

The constructs are identified as endogenous or exogenous constructs and represented in a path model as shown in Figure 4.1. Because they are all latent constructs, i.e., they cannot be measured directly and represent a larger condition created by a myriad of factors, it becomes imperative to identify the variables that truly capture the constructs by direct measurement. These variables are better known as *indicators or measured variables* (Hair et al. 2005). For example, Variation in work cannot be measured so accurately as to eliminate uncertainty, but by measuring factors that influence or cause variation we can measure the variation to a greater accuracy.

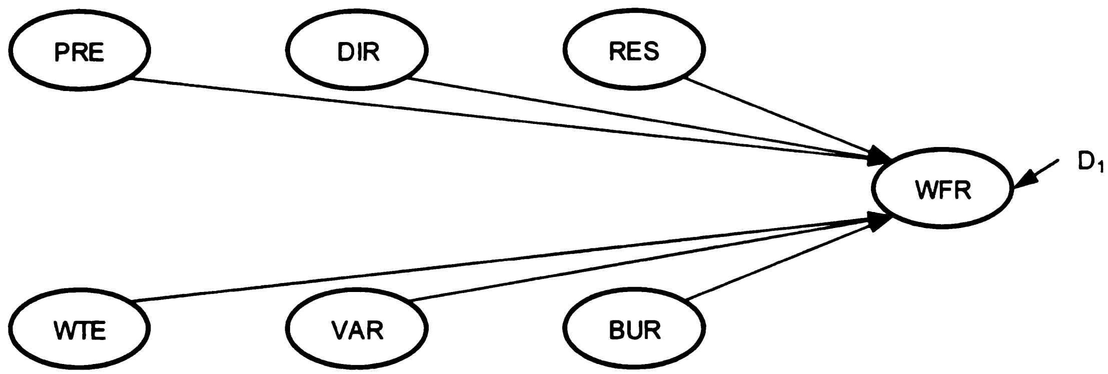

Figure 4.1 Path Diagram of the proposed structural model (1st Stage)

Thus, the next step in the process is to define the constructs and operationalize them by selecting their measured variables and their scale type. Identifying scale type is critical because it converts the qualitative data into quantitative data. The quantitative data is required to develop the *observed covariance matrix,* however, it may be noted that the scale is not standardized because of the reasons discussed in section 2.6.1 of chapter 2.

4.3.3 Phase-3 Define and Operationalize the Individual Constructs

This step begins with defining the constructs involved. The definition is necessary in order to provide basis for selecting or designing individual indicator items. This step is followed by *operationalizing* the constructs by selecting their measurement scale items and scale types (Hair et al. 2005). This step often involves a series of scale items in a common format such as Likert scale or a semantic differential scale, but in certain circumstances it involves the use of composite scales. It can be done in two different ways. The first approach is to define and operationalize constructs as they were in previous research studies, using literature search on the individual constructs and identify scales that previously performed well. The second approach is to develop new measures because the theory under study does not have a rich history of previous research (Hair et al. 2005).

The hypothesis in question does not have a rich history of previous research; however the identified constructs are concepts that have been discussed in previous research (Ballard & Howell 1998; Ballard 1997; Liker 2004) therefore, a mixed approach was followed to define and operationalize the constructs. The constructs were developed by populating them with measured variables and vetting with experts to rate how well the definition and variables match the construct. A preliminary checklist of measured variables was generated and binned under the identified constructs. The checklist was prepared using a mix of previous research and researcher's experience in the use of constraints analysis on the field (the source for each item in checklist is provided in Appendix C). The language of items sourced from previous search was modified to present them in question format. The checklist was then sent to 5 experts in the field of lean construction; the experts were asked to rate in a yes/no format against each item in the checklist, whether the item suitably captures a production delay factor on the construction site and contributes to the measurement of the construct it is classified into. Based on the expert's responses, the checklist items receiving majority of the votes (3 out of 5) were retained and the rest were discarded. The variables and definition are listed after receiving majority voting on them. The definitions are as follows:

a) <u>Work Flow Reliability (WFR)</u>: Work flow reliability concerns a state of consistency, dependability, and predictability, and improving reliability generates a more consistent, dependable, and predictable flow (Thomas et al. 2003). It is therefore, the measure of consistency of flow of activities carried out for completion of a set of tasks in order to achieve a larger production goal in adherence with a plan. Two Likert items are provided as item indicators for this construct. These are:

Measured Variables	Scale	Scale Reference
WFR1. The PPC is high; 90% or higher	1-10	(10-100% Agree)
WFR2. We are headed to a timely completion of the project	1-10	(10-100% Agree)

Table 4.2 Measured Variables for Work flow Reliability Construct

Since both the indicators are reflections of the construct in question, that is, a high work flow reliability can be represented by high PPC as well as high probability of timely completion of the project instead of vice versa, these two indicators are reflective indicators (refer chapter 2 for definition).

b) Availability of Prerequisite Work (PRE): As suggested by the name it includes all the planning factors that make sure that the prerequisite work is available in time, desired quality, and in time etc. It is difficult to measure precisely the 'availability of prerequisite work' without measuring the production factors that together contribute to availability of prerequisite work. The measured variables designed for this construct are:

Measured Variables	Scale	Scale Reference
PRE1. Prior work is complete with desired quality.	1-10	(10-100% Complete)
PRE2. The pre-requisite work has been verified to meet current work needs (dimensions, locations, etc)	1-10	(10-100% Agree)
PRE3. All regulatory inspections needed were conducted and successfully passed.	1-10	(10-100% Agree)
PRE4. The prerequisite work is officially handed over from prior trade.	1-10	(10-100% Agree)
PRE5. The weather forecast is favorable for performing work.	1-10	(10-100% Agree)
PRE6. Access to the work area (permits, etc) has been obtained and cleared with respective party.	1-10	(10-100% Agree)
PRE7. All coordination issues with following trade have been addressed by the project team.	1-10	(10-100% Agree)
PRE8. Overall, the prerequisite work is complete.	1-10	(10-100% Complete)

Table 4.3 Measured Variables for Availability of Pre Requisite Work Construct

As discussed in chapter 2 earlier, each formative construct needs at least two directional paths emitting from it to reflective variables or reflective constructs or a mix of both. As depicted in Figure 4.1, each of the six exogenous constructs have a path emitting from it to the WFR construct, which is a reflective construct. Therefore, all the formative constructs require only one more path emanating from them to a reflective indicator or a reflective construct. Mackenzie et al. (2005) recommended introducing a global measure as a reflection of the construct itself to meet this model specification condition. Hence, variable PRE8 is designed as a global measure to capture the overall condition of pre requisite work, to fulfill the condition of model identification. All other measured variables are formative indicators.

c) Availability of Directives (DIR): As suggested by the name, it includes all the planning factors which take care of the procedural and technical requirements during construction, for example, D&E documents, submittals, RFIs etc. It is difficult to measure precisely the 'availability of directives' without measuring the factors that contribute to it. The measured variables populated for this construct are:

Measured Variables	Scale	Scale Reference
DIR1. The D&E documents for current work are acceptable.	1-10	(10-100% Agree)
DIR2. The D&E documents for current work are available.	1-10	(10-100% Agree)
DIR3. All RFI's for current work are addressed satisfactorily.	1-10	(10-100% Agree)
DIR4. The owner is agreeable to any design/scope changes, if any.	1-10	(10-100% Agree)
DIR5. The standard of work performance is available.	1-10	(10-100% Agree)
DIR6. The standard of work performance is clearly expressed.	1-10	(10-100% Agree)
DIR7. The submittals are approved.	1-10	(10-100% Agree)
DIR8. The submittals are available.	1-10	(10-100% Available)
DIR9. Final design instructions have been confirmed by architect/engineer to avoid change.	1-10	(10-100% Agree)
DIR10. All lien waivers are in order.	1-10	(10-100% Agree)
DIR11. All permits are available.	1-10	(10-100% Agree)
DIR12. All lien waivers are submitted.	1-10	(10-100% Complete)
DIR13. Overall, all the directives are in order.	1-10	(10-100% Agree)

Table 4.4 Measured Variables for Availability of Directives Construct

The variable DIR13 is the only reflective indicator in the construct and is designed solely for model identification purposes. All other measured variables are formative indicators.

d) Availability of Resources (RES): This construct involves making sure that all the resources; material, labor and equipment are available in right quantity, desired quality and at the right time. It is difficult to measure precisely 'availability of resources' without considering possible factors involved in making the resources available. The measured variables populated for this construct are:

Measured Variables	Scale	Scale Reference
RES1. The material is/will be delivered on time.	1-10	(10-100% Agree)
RES2. The material specifications match contract/submittal specs.	1-10	(10-100% Agree)
RES3. Space is available for material lay-downs.	1-10	(10-100% Available)
RES4. Path available for material transport.	1-10	(10-100% Available)
RES5. The labor is informed of all work assignments.	1-10	(10-100% Agree)
RES6. The labor needed is available.	1-10	(10-100% Available)
RES7. The tools to be used are in good working condition.	1-10	(10-100% Agree)
RES8. Right tools are available in enough quantity for crews to work with.	1-10	(10-100% Available)
RES9. The equipment to be used is in good working condition.	1-10	(10-100% Agree)
RES10. Right equipment is available in the desired quantity.	1-10	(10-100% Available)
RES11. Overall, all the required resources are available.	1-10	(10-100% Available)

Table 4.5 Measured Variables for Availability of Resources Construct

The variable RES11 is the only reflective indicator in the construct and is designed solely for model identification purposes. All other measured variables are formative indicators.

e) Waste Reduction (WTE): is defined as creating a production environment that leads to least amount of waste (non-value adding work, poor quality work etc.) generation. Since it is difficult to measure it precisely, several measured variables are created to measure lack of waste more accurately. These measured variables are:

Measured Variables	Scale	Scale Reference
WTE1. The amount of work is sized appropriately to avoid overproduction.	1-10	(10-100% Agree)
WTE2. Transportation of raw/processed materials requires single handling (as opposed to more than once).	1-10	(10-100% Agree)
WTE3. Transportation of raw/processed materials is over short distances.	1-10	(10-100% Agree)
WTE4. No amount of rework/correction is required for completed work.	1-10	(10-100% Agree)
WTE5. No over-processing (unnecessary finishing) is performed for completed work.	1-10	(10-100% Agree)
WTE6. Inventory is delivered just-in-time to the production unit.	1-10	(10-100% Agree)
WTE7. The production unit makes no unnecessary movements to complete the work.	1-10	(10-100% Agree)
WTE8. The production unit is always working to complete the work.	1-10	(10-100% Agree)
WTE9. The production crew is consulted on the best way to perform the work.	1-10	(10-100% Agree)
WTE10. The production crew is consulted on the safest way to perform the work.	1-10	(10-100% Agree)
WTE11. Overall, sufficient steps have been taken to prevent generation of waste.	1-10	(10-100% Agree)

Table 4.6 Measured Variables for Waste Reduction Construct

The variable WTE11 is the only reflective indicator in the construct and is designed solely for model identification purposes. All other measured variables are formative indicators.

f) Variation Reduction (VAR): is defined as creating a production environment that decreases the possibilities of variation in production capacities and performance of the crews. Since it is difficult to measure it precisely, several measured variables are created to measure variation reduction as accurately as possible. These measured variables are:

Measured Variables	Scale	Scale Reference
VAR1. There was no absenteeism in the workforce.	1-10	(10-100% Agree)
VAR2. The production crews operate with reserve capacity.	1-10	(10-100% Agree)
VAR3. The learning curve effect is realizable for the crews.	1-10	(10-100% Agree)
VAR4. Recovery plans from occupational accidents are standard practice.	1-10	(10-100% Agree)
VAR5. The production rates of the crew are consistent over time (match Takt).	1-10	(10-100% Agree)
VAR6. The production plan has workable backlog in case of interruptions to current assignment(s).	1-10	(10-100% Agree)
VAR7. The production plan has time buffers to prevent interruptions to project completion.	1-10	(10-100% Agree)

Table 4.7 Measured Variables for Variation Reduction Construct

All except VAR5 are formative indicators, since they contribute to form the environment for reduction in variation. The VAR5 variable is a reflective indicator because it is a result of Variation Reduction that the production rates of the crew are consistent over time.

g) Burden Reduction (BUR): is defined as maintaining a production environment that reduces the physical, cognitive and psychophysical burden on the crew and equipment to avoid burnout and stoppages as a result. Since it is difficult to measure it precisely, several measured variables are created to measure burden (or lack of it). These measured variables are:

Measured Variables	Scale	Scale Reference
BUR1. The work environment is free of potential environmental hazards (air-borne pathogens, dust, chemical agents, ultra-violet light, and ionizing radiation).	1-10	(10-100% Agree)
BUR2. The work environment is comfortable to function in (temperature and humidity, lighting, sun exposure, noise levels).	1-10	(10-100% Agree)
BUR3. The work environment is not congested.	1-10	(10-100% Agree)
BUR4. Overtime is not needed on our jobs.	1-10	(10-100% Agree)
BUR5. The work is adequately paced to avoid physical fatigue.	1-10	(10-100% Agree)
BUR6. The workers are equipped with PPEs, as necessary.	1-10	(10-100% Agree)
BUR7. The workers are not allowed to engage work involving heavy muscular loads.	1-10	(10-100% Agree)
BUR8. The workers have access to material-lifting equipment.	1-10	(10-100% Agree)
BUR9. A Job Safety Analysis is performed.	1-10	(10-100% Agree)
BUR10. Workers are trained on proper lifting techniques.	1-10	(10-100% Agree)
BUR11. Rest cycles are built into the work method.	1-10	(10-100% Agree)
BUR12. Workers receive sufficient information regarding the process flow and output.	1-10	(10-100% Agree)
BUR13. The rate of information does not exceed the mental capacity of the worker to process.	1-10	(10-100% Agree)
BUR14. Identical or very similar signals don't occur for a long time.	1-10	(10-100% Agree)
BUR15. Adequate time is allowed for decisions and resulting actions in the normal circumstances.	1-10	(10-100% Agree)
BUR16. Adequate time is allowed for decisions and resulting actions in emergencies.	1-10	(10-100% Agree)
BUR17. Hand tools used are the correct ones for the task.	1-10	(10-100% Agree)
BUR18.Hand tools used are adequately maintained.	1-10	(10-100% Agree)
BUR19. All safety signs and visuals are correctly located.	1-10	(10-100% Agree)
BUR20. Overall, the workers do not feel any kind of burden.	1-10	(10-100% Agree)

Table 4.8 Measured Variables for Burden Reduction Construct

The variable BUR20 is the only reflective indicator in the construct and is designed solely for model identification purposes. All other measured variables are formative indicators.

After operationalizing the constructs, the next step is to validate the constructs. Construct validation is performed to verify "the extent to which a set of measured items actually reflects the theoretical latent construct those items are designed to measure" (Hair et al. 2005).

4.3.4 Phase-4 Construct Validation

There are four components of the procedure to establish construct validity. Three of those components namely convergent validity, discriminant validity and nomological validity (partially) are tested once the model is estimated and factor loadings (parameter values on directional paths) are calculated.

Convergent validity is established by measuring all the factor loadings on the paths of the construct. The minimum statistically significant loading is a value above .7 because square of that value is around .5, explaining half the variation in the item with the other half being error variance. This validity tests stands good for reflective constructs, because in theory the indicators of the reflective constructs closely represent the latent variable and are interchangeable. Therefore, if the factor loadings of those variables are less than .7, then they are not converging and therefore not valid. However, these similar thresholds are not applicable to formative indicators, since formative indicators can influence even 0.1 of variance in the item and yet be an important part of the construct. Therefore, convergent validity is not checked for our example in question.

Discriminant validity checks the uniqueness of each construct as compared to another in the complete model. This is tested by comparing the variance-extracted percentages of any two constructs with the square of the correlation estimate between these two construct. Since the latent construct should explain its item measures better than it explains another construct, the variance extracted percentages should be greater than the squared correlation estimate. Hence, applying the same logic of formative indicators as in convergent validity test, this test is not an effective test for formative indicators.

The other two validation tests are *nomological validity* and *face validity*. Nomological validity assess the degree to which the construct as measured by a set of indicators predicts other constructs that past theoretical and empirical work says it should predict. In the current example, the theory in concern has implemented a lean thinking and proposed an entirely new set of constructs than the ones used in past research. Therefore, the constructs proposed in this research lack nomological validity and stand as suspects with the burden of proof lying on the researcher proposing the new constructs. They can be validated only after estimating the structural model.

The final test of validity is called face validity, and is the most important test of validity because it tests theoretical soundness of the variables in a construct (Hair et al. 2005). This validity is done based on researcher's judgment and expert opinions. It has already been mentioned earlier in the chapter in section 4.3.2 that the constructs were populated with their respective variables based on vetting by expert judges after an extensive literature review. Therefore, it is reasonable to say that the constructs pass the test of face validity.

After validating the constructs, SEM analysis can move forward in two different ways. First approach is to specify and estimate the measurement model followed by specifying and estimating the structural model. The second approach involves directly specifying and estimating the structural model. The following section presents a discussion on the first approach.

4.3.4.1 Develop the Overall Measurement Model

The main purpose of developing a measurement model is to specify the relationship between measured variables and their constructs. This step involves creating a path model between the constructs and their measured variables and also estimating the parameter loadings on those paths. However, the relationships between different constructs are kept bi-directional (to indicate covariance) specifically to strictly test the measurement theory of the model. By testing measurement theory, means, statistically identifying the relationships between constructs and the measured variables and testing for measurement model fit. This involves specifying the path model in the software program and estimating the model using the collected data. Figure 4.2 shows the measurement model for the example used in this research.

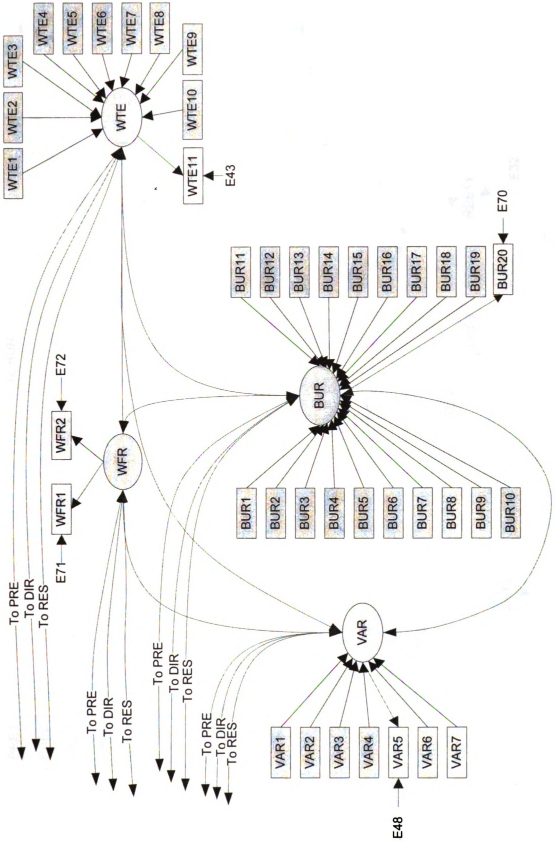

Figure 4.2 Diagram showing the constructs in a measurement model relationship

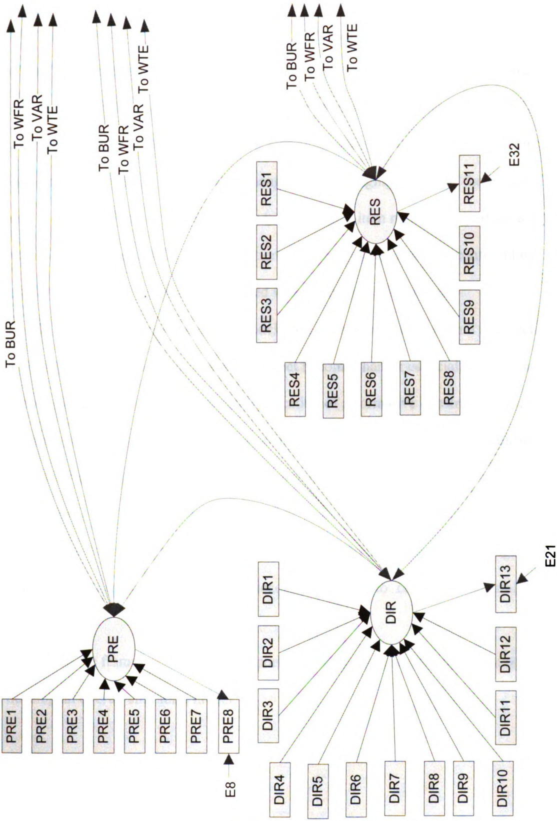

Figure 4.2 Cont'd.

After the model is specified and estimated, the factor loadings between construct and variables and the error variance terms are known entities. Therefore, their values are fixed to the loading estimates obtained from the measurement model before the structural model is estimated. Due to change in the relationships between constructs (from correlational to directional) during transformation from measurement to structural model, the loading estimates are subjected to change, thus, changing the fit of the model. This change signifies difficulty in sorting out which indicator item measures a particular latent construct (Hair et al. 2005). This situation is called interpretational confounding and generally results from instability associated with under-identified factors.

In addition, in a measurement model, given that constructs are in a bi-directional relationship, the identification of each construct becomes harder especially in a formative construct. Recalling the guidelines of identification of a formative construct from chapter 2, a formative construct needs at least two directional paths into reflective indicators or constructs or a mix of both. Meeting this requirement is difficult when there are no two (at minimum) theoretically sound reflective indicators for a construct. Therefore, especially for formative models this approach to SEM analysis is discouraged. This research recommends and adopts the second approach to conduct structural model analysis.

Since the framework does not support measurement model testing, the next step is to develop an overall structural model.

4.3.5 Phase-5 Develop and Specify the Structural Model

Specification of a structural model is an extension to specification of the measurement model. In the measurement model, only relationships between constructs and their MVs are specified and the constructs are specified as correlated. However, in the structural model, the relationships between various constructs are specified as originally proposed in the theory. As mentioned earlier, six relationships were hypothesized as part of the theory, these were:

H_1 = 'Availability of Prerequisite Work' positively affects 'Work Flow Reliability'.

H_2 = 'Availability of Directives' positively affects 'Work Flow Reliability'.

H_3 = 'Availability of Resources' positively affects 'Work Flow Reliability'.

H_4 = 'Waste Reduction' positively affects 'Work Flow Reliability'.

H_5 = 'Variation Reduction' positively affects 'Work Flow Reliability'.

H_6 = 'Burden Reduction' positively affects 'Work Flow Reliability'.

These hypotheses mean that structural relationships between constructs would be specified according to the dependence relationships mentioned, i.e., a directional arrow is emanating from all of the six constructs towards work flow reliability. In addition, the directional relationships between the constructs and their measured variables are also specified (if measurement model is not already developed).

The structural model designed per the hypotheses in the example is shown in Figure 4.3. The model diagram is designed by using the Diagrammer function of the EQS software.

Note: It is advised to create the diagram of a model only after the measured variables are defined in the Data file of EQS. Otherwise, the data file and the diagram file will not coordinate during the Estimation procedure of the model.

The first step after developing the structural model is to specify the structural model. Specification involves 'setting the scale' for the latent variable. Because it is unobserved, a latent factor has no metric scale, meaning no range of values. This scale can be provided in two ways:

1. A scale can be set by fixing one of the factor loadings and setting its value. It is recommended that the value is set to 1.

2. The construct variance can be set to a value. Again, 1 is the recommended value.

However, method 2 is not applicable to formative constructs, since the software reads formative constructs as dependent variables; it does not assign them a variance of their own. Further, in case of formative constructs, it is recommended that the factor loading on the path from the construct to the reflective variable (added for identification purposes) since it is conceptually a representation of the construct itself.

In Figure 4.3, the structural model for the example, the red arrows indicate the fixed factor loading on the reflective variable of each construct. For the WFR construct, since both its MVs are reflective, one can choose any one variable and fix its factor loading to 1. Once the model is specified it is checked for identification.

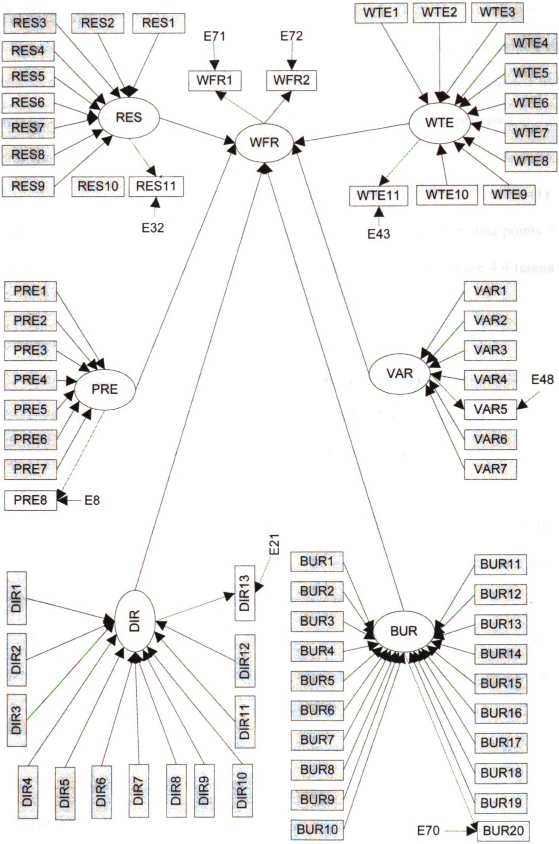

Figure 4.3 Diagram showing the Structural Model of the proposed Hypotheses

4.3.5.1 Model Identification

The first step in model identification is to check whether enough information is provided by the sample covariance matrix to estimate all the parameters. This is calculated by counting the number of data points and the number of parameters to be estimated in the model. The equation for data point calculation is

$$\text{Number of data points} = p(p+1)/2, \text{ where} \qquad (1)$$

p is the number of measured variables. In the example, $p = 72$. Therefore, data points = 2628. The number of parameters to be estimated can be counted from figure 4.4 (count the number of asterisks).

The number of asterisks present in the figure are:

72 loading estimates (ignore the fixed loadings for this purpose)

+ 8 error variance terms (ignore the fixed loadings for this purpose)

+ 6 exogenous-endogenous structural terms

= 86 free parameters

The difference between the data points and parameters to be estimated gives the *df* of the model, which in this example is 2628 – 86 = 2542. Since the *df* is more than zero, the model is considered over-identified (which is the ideal condition).

The second condition to check for model identification is *rank* condition and requires the researcher to verify algebraically whether two equations can define any dependent variable. If such a condition exists then it means it violates the rank condition of the model. Such an error can be associated with linear dependence error message, post analysis. In formative constructs or dependent latent variables, setting the disturbance term is a delicate issue.

The disturbance term represents all remaining causes of the latent variable other than the set of indicators which form the respective latent variable. It is suggested by Diamantopoulos (2006) that setting the disturbance term to zero is legitimate practice as long as the researcher is theoretically sure that all possible causes of the construct are included as indicators in the model. Not setting the disturbance to zero also has reported to create the rank condition error, but this practice should not be used simply to overcome rank identification issues.

The third condition for model identification is the MIMIC modeling rule for formative indicators. As discussed earlier, each formative construct needs at least two paths emanating from it to reflective indicators or reflective constructs. This condition is met for the example, as indicated in figure 4.4. The next step after developing a structural model is to design a study and collect data for model estimation purposes which is discussed in the next section.

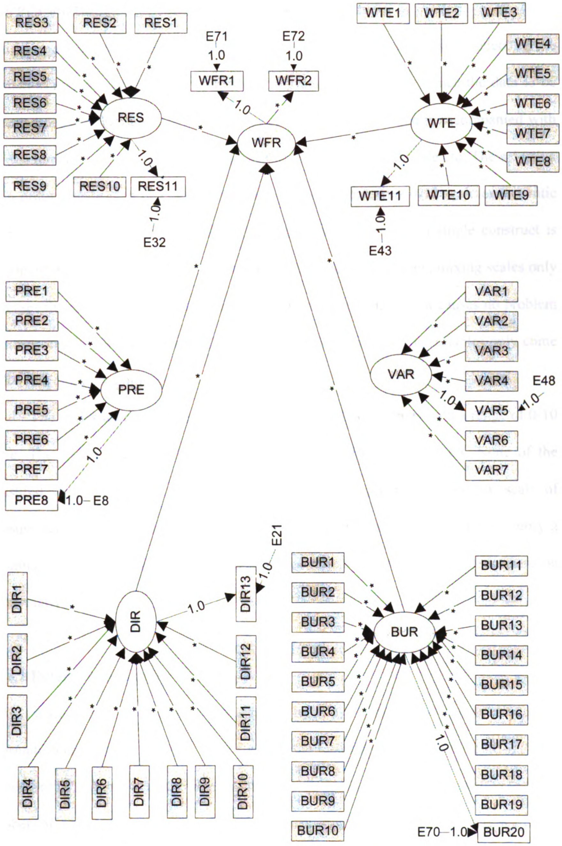

Figure 4.4 Structural Model showing fixed and free parameters.

4.3.6 Phase-6 Design Study to Produce Empirical Results

Designing a study involves several aspects like deciding on sample size, selecting the estimation method, and selecting a method to handle missing data. Since the data to be collected needs to be quantitative in nature, each measured variable is accompanied with a measurement scale like ordinal scale, interval scale, categorical scale etc. The selection of an ordinal scale is most common practice for example, Likert 0-10 scale or semantic differential scale etc. A mixture of scales within the variables of a single construct is welcomed if necessary to capture the variable in its truest form, since, mixing scales only increases the software processing and results interpretation time but it causes no problem in estimating the model. Similarly, having different scale ranges for variables only come with a risk of extra computational time.

The scales used for the example in research are Likert scales with a range of 0-10 value. The scales against each variable are shown in Tables 4.3 to 4.8. None of the measured variables have a physical quantity to measure; therefore, no real scale of measurement has been assigned. This is primarily because all of the variables signify a planning measure each and can only confirm or report completion of that measure on some relative scale.

4.3.6.1 Determining Sample Size

SEM is a study involving large sample sizes. "The role of sample size is to produce more information and greater stability, which assists the researcher in performing SEM. Once the researcher has exceeded the absolute minimum size i.e. one more observation than the number of observed covariances, larger samples mean less variability and increased stability in the solutions. As reviewed in the literature, several considerations are taken care of while determining the sample size for a model. These are:

1. *Multivariate Distribution*: As data deviate from the assumption of multivariate normality, the impact of sampling error tends to increase on the results of the model. To counter these non-normality effects, the ratio of respondents to parameters need to be higher. Expert opinions regarding these ratios, to minimize the problem with deviations, are varied. Hair et al. (2005) cited a ratio of 15 respondents/ parameter; whereas, Kline (2005) suggested that an ideal case would be 20 cases/ parameter but anything less than 5 cases/ parameter would probably not yield trustworthy results. Raykov et al. (2006), also suggest 10 cases/ parameter as a guideline.

2. *Estimation* Technique: The most common procedure to estimate SEM models is Maximum Likelihood Estimation (MLE) method. MLE is an iterative approach that makes small sample sizes more likely to produce invalid results. Kline (2005) have suggested an absolute minimum sample size to have any hope of getting good results would be N = 100, while 100-200 would be a medium sample size, and over 200 would be generally considered a large sample. Hair et al. suggest a sample size in range of 150-400, but subject to some more considerations like number of constructs in the model. It is recommended that if the factors (latent variables) are larger than six then the sample size can exceed 500. However, MLE method is sensitive to extremely large amount of data and almost any difference is detected, making the GOF measures suggest poor fit (Hair et al. 2005). The estimation method used in the example is also MLE.

MacCallum et al (1996) provided a method for determining the minimum sample size necessary to achieve a given level of power for tests of model fit, a discussion on those steps is beyond the scope of this research. Therefore, the researcher suggests reading MacCallum et al. (1993 and 1996) for a detailed discussion on topic of power analysis and sample sizes.

Factors like missing data also need to be considered in determining the sample size. If more than 10% missing data is expected than higher sample size is needed to overcome the missing data (for a detailed discussion on the 10% missing data as threshold, the researcher suggests reading Hair et al. 2005).

As highlighted in the discussion it is evident that the researcher should be informed about the number of parameters to be estimated to calculate a sample size. The sample size determined after taking all considerations into account for the example in demonstration is 400. The next step after determining sample size is to prepare for analysis of missing data, as it is rare to find a set of data especially involving large sample sizes to not have missing data problem (Hair et al. 2005).

4.3.6.2 Handling Missing Data

"Missing data can have significant impacts on any analysis, particularly those of a multivariate nature" (Hair et al. 2005), such as SEM. Missing data can occur due to reasons like data entry errors, data collection problems or even refusal to answer by the respondent to a particular or a set of questions. Missing data has both practical and substantive impact on data analysis; the practical impact being that in multivariate research, missing data may eliminate so many observations that an adequate sample may be reduced to inadequate sample. From a substantive perspective, in case of non-random missing data (a pattern of missing data can be seen), statistical results can be biased and lead to erroneous results (Hair et al. 2005).

Missing data can be handled using several approaches. The approach to handle a missing data depends on the (1) nature of the missing data, i.e., if the data is Missing Completely at Random (MCAR), or Missing at Random (MAR), (2) extent of missing data, i.e., what amount of data is low enough for the analysis to produce erroneous estimate, (3) the type of missing data, i.e., whether it is ignorable or not ignorable data (Hair et al 2005). After all these determinations are made, the method of imputation for missing data is selected, if required. Considerable amount of literature is present on handling missing data; again, a topic outside the scope of this research. Further, the example used in this research consists of randomly generated hypothetical data set, therefore, no missing data exists to present as an example. The reader is referred to one excellent source for handling missing data (Hair et al. 2005).

The next step after designing the study to produce empirical results is to actually collect the data. The following section presents a discussion on data collection.

4.3.7 Phase-7 Data Collection

Collecting data requires identifying the proper sample population. It is important to keep the theory in mind while selecting the sample population; bad population will lead to bad responses, which may lead to bad fit of the model. For example, the theory proposed in the research is concerned with studying the causal relation between site production factors and reliable work flow. The appropriate population group for collecting data is construction industry professionals who function as a member/leader of the management team and use/ have experience with the Last Planner system. Given the interest in collecting responses based on enough experience with the Last Planner system and reliable work flow, the requirement was set for at least 1 year work experience or 1 project experience in that role.

However, due to the limitations of finding such a large number of professionals meeting the experience requirement, the example demonstration had to be estimated using randomly generated hypothetical data. The data was generated using the RANDBETWEEN command in Microsoft Excel for 400 points for each of the 72 variables, with possible answers on the scale 1-10.

Since the data is hypothetical, no real conclusions can be drawn from the SEM analysis on the example, rather conceptual conclusions will be drawn in the spirit of demonstration of the modeling process and its benefits.

4.3.7.1 Multi-Collinearity

The next step after collecting the data is to check for multi-collinearity in the constructs. In formative constructs, high multi-collinearity can destabilize the model. The Variance Inflation Factor (VIF) statistic is used to determine if formative indicators are too highly correlated. Scholars, suggest that VIF values greater than 3.3 indicate high multi-collinearity (Roberts and Thatcher 2009).

The VIF factors for constructs of the demonstration model were calculated using MINITAB software using the regression analysis command and selecting the VIF output. The results for construct "Availability of Prerequisites" are presented in Table 4.9.

Regression Analysis: PRE1 versus PRE2, PRE3,...

The regression equation is

PRE1 = 5.21 - 0.0407 PRE2 - 0.0108 PRE3 - 0.0465 PRE4 + 0.144 PRE5 - 0.0144 PRE6 + 0.0016 PRE7 + 0.0382 PRE8

Predictor	Coef	SE Coef	T	P	VIF
Constant	5.2147	0.7699	6.77	0	
PRE2	-0.04073	0.05372	-0.76	0.449	1.036
PRE3	-0.01078	0.05406	-0.2	0.842	1.05
PRE4	-0.04651	0.05195	-0.9	0.371	1.008
PRE5	0.14388	0.0507	2.84	0.005	1.04
PRE6	-0.01438	0.05338	-0.27	0.788	1.039
PRE7	0.00165	0.05246	0.03	0.975	1.027
PRE8	0.03816	0.05147	0.74	0.459	1.03
	S = 2.94846	R-Sq = 2.5%			R-Sq(adj) = 0.7%

Table 4.9 Multi-collinearity test for Prerequisite Construct using MINITAB

As indicated in Table 4.9, the multi-collinearity results for indicators of "Availability of Prerequisite" construct are between 1.008 to 1.05 which are well below the threshold of 3.3. Similarly, the VIF results for all other formative constructs were below 3.3. Thus, in the hypothetical scenario, multi-collinearity does not pose threat to the validity of the proposed formative constructs.

The next step is to estimate the structural model and test its validity. This step is demonstrated in the next section, using the example.

4.3.8 Phase-8 Assess Structural model validity

The structural model shown in figure 4.4 can now be estimated. The procedure to run the model in EQS is briefly discussed to facilitate the understanding of the software (for detailed discussion on using EQS, refer Byrne 2006, an excellent source on this topic). After the path model is created using the diagrammer and model is specified by fixing appropriate loadings like one factor loading per construct and all error and disturbance loadings. The data is entered in the data type file of EQS using raw data format and not in form of covariance or correlation matrix as it cannot produce robust statistics using the matrices (Roberts and Thatcher 2009).

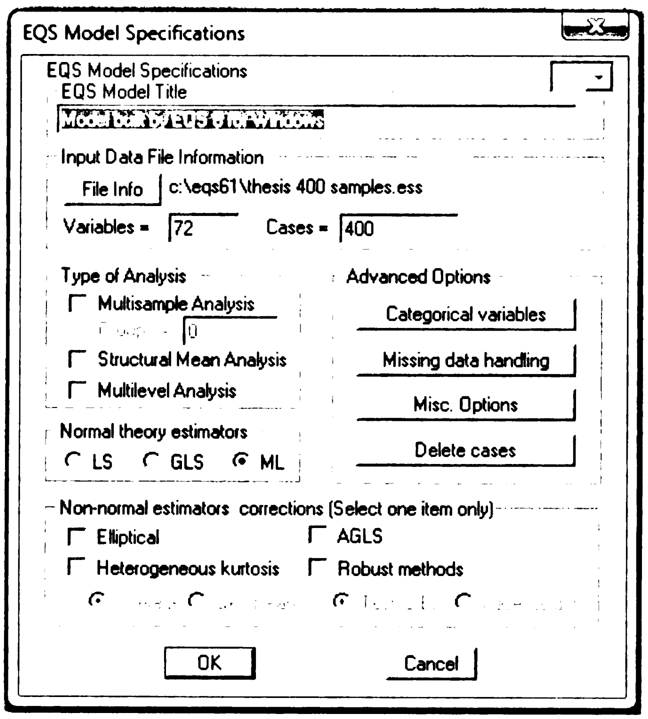

Figure 4.5 EQS window showing selection of Estimation method

When on the diagrammer file, care should be exercised that the data file is open in the background, click Build EQS> Title/Specifications to create the command file for the software. The 'model specifications' window as depicted in Figure 4.5 appears and requests for type of estimation method. The best practice recommends, as mentioned before, selecting MLE method along with robust methods to overcome non-normal estimators. After clicking 'Ok', the command file is generated which looks like Table 4.10 below (note that this command file is created for the example used in this research). The figure only shows a partial file, for complete file refer to Appendix B in the end.

```
/TITLE
Model built by EQS 6 for Windows
/SPECIFICATIONS
DATA='c:\eqs61\thesis 400 samples.ess';
VARIABLES=72; CASES=400;
METHOD=ML,ROBUST; ANALYSIS=COVARIANCE; MATRIX=RAW;
/LABELS
V1=PRE1; V2=PRE2; V3=PRE3; V4=PRE4; V5=PRE5; V6=PRE6; V7=PRE7; V8=PRE8;
V9=DIR1; V10=DIR2; V11=DIR3; V12=DIR4; V13=DIR5; V14=DIR6; V15=DIR7;
V16=DIR8; V17=DIR9; V18=DIR10; V19=DIR11; V20=DIR12; V21=DIR13;
V22=RES1;;......
/EQUATIONS
V8 =   1F1 + E8; V21 =   1F2 + E21; V32 =   1F3 + E32; V43 =   1F4 +
E43;
V48 =   1F5 + E48; V72 =   *F7 + E72; F1 =   *V1 + *V2 + *V3 + *V4 +
*V5 + *V6 + *V7; F2 =   *V9 + *V10 + *V11 + *V12 + *V13 + *V14 + *V15
+ *V16 + *V17 + *V18 + *V19 + *V20 ;F3 =   *V22 + *V23 + *V24 + *V25 +
*V26 + *V27 + *V28
/VARIANCES
 V1 = *; V2 = *; V3 = *;  V4 = *;
/COVARIANCES
/PRINT
EIS;
FIT=ALL;
COVARIANCE=YES;
TABLE=EQUATION;
/OUTPUT
Information matrix;
Parameters;
Sigma;
Covariance matrix;
Standard Errors;
Listing;
DATA='EQSOUT.ETS';
/END
```

Table 4.10 Command file generated after selecting estimation method

On the command file, go to Build EQS > Output to select various outputs required from the estimate. The Output options window is as shown below in Figure 4.6.

The researcher can choose to store all or selected results from the window. After the output options are selected the model is estimated by clicking Build EQS > Run EQS. The estimation output is generated in an output file format. Refer to Appendix B for complete results from the model run. The overall fit statistics for the model are reported in the Table 4.11.

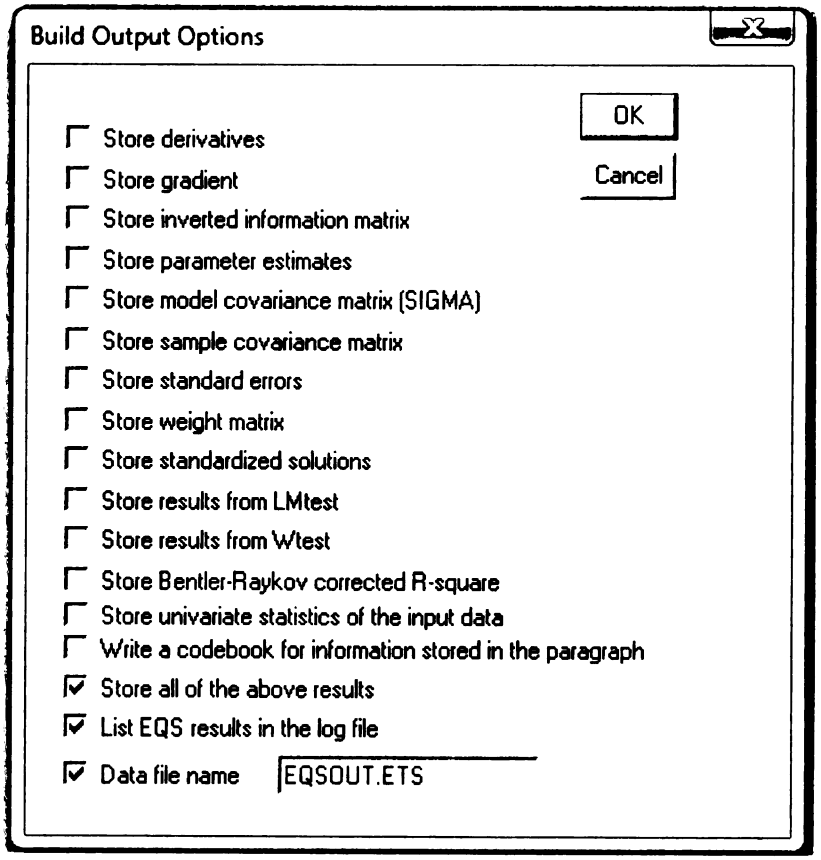

Figure 4.6 Window showing Output options for Model Estimation Results

```
                      MULTIVARIATE KURTOSIS

   MARDIA'S COEFFICIENT (G2,P) =    -86.9022
   NORMALIZED ESTIMATE =             -8.4185

GOODNESS OF FIT SUMMARY FOR METHOD = ML

  INDEPENDENCE MODEL CHI-SQUARE = 3399.033 ON 2556 DEGREES OF  FREEDOM

  INDEPENDENCE AIC =   -1712.967   INDEPENDENCE CAIC =  -14471.151
         MODEL AIC =   -1939.475          MODEL CAIC =  -14338.273

  CHI-SQUARE =      3028.525 BASED ON    2484 DEGREES OF FREEDOM
  PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS      0.00000

  THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS
  2755.168.

  FIT INDICES
  -----------
  BENTLER-BONETT     NORMED FIT INDEX =     0.109
  BENTLER-BONETT NON-NORMED FIT INDEX =     0.335
  COMPARATIVE FIT INDEX (CFI)         =     0.354
  BOLLEN'S          (IFI) FIT INDEX   =     0.405
  MCDONALD'S        (MFI) FIT INDEX   =     0.506
  JORESKOG-SORBOM'S  GFI  FIT INDEX   =     0.839
  JORESKOG-SORBOM'S AGFI  FIT INDEX   =     0.830
  ROOT MEAN-SQUARE RESIDUAL (RMR)     =     0.423
  STANDARDIZED RMR                    =     0.051
  ROOT MEAN-SQUARE ERROR OF APPROXIMATION (RMSEA)     =     0.023
  90% CONFIDENCE INTERVAL OF RMSEA  (       0.020,          0.026)

  RELIABILITY COEFFICIENTS
  ------------------------
  CRONBACH'S ALPHA                    =     0.058
```

Table 4.11 Goodness-of-Fit Statistics for the demonstration model

4.3.9 Phase-9 Interpreting the Results

As recommended in the literature, an SEM should be tested for fitness using three indices; one basic goodness-of-fit index, one badness-of-fit index, and one incremental fit index. The most commonly used fit indices are Chi-Square Index, RMSEA index, and CFI Index, in that same order. Table 4.12 displays threshold values for the GOF measures.

Statistic	No. of Variables (m)	N < 250			N> 250		
		$m \leq 12$	$12 < m < 30$	$m \geq 30$	$m \leq 12$	$12 < m < 30$	$m \geq 30$
Chi-Square		Insignificant p-values expected	Significant p-values can result even with good fit	Significant p-values can be expected	Insignificant p-values can result with good fit	Significant p-values can be expected	Significant p-values can be expected
CFI or TLI		.97 or better	.95 or better	Above .92	.95 or better	Above .92	Above .90
RNI		May not diagnose misspecification as well	.95 or better	Above .92	.95 or better, but do not use with N > 1,000	Above .92, but do not use with N > 1,000	Above .90, but do not use with N > 1,000
SRMR		Could be biased upward, use other indices	.08 or less (with CFI of .95 or higher)	less than .09 (with CFI above .92)	Could be biased upward; use other indices	.08 or less (with CFI above .92)	.08 or less (with CFI above .92)
RMSEA		Values <.08 with CFI=.97 or higher	Values <.08 with CFI=.95 or higher	Values <.08 with CFI above .92	Values <.07 with CFI of .97 or higher	Values <.07 with CFI of .92 or higher	Values <.07 with CFI of .90 or higher

Note: m= number of variables; N=number of observations (sample size)

Table 4.12 Characteristics of different Fit Indices demonstrating Goodness-of-Fit across different model situations(Source: Hair et al. 2005, Reproduced)

1. The *Chi-Square* Index for the model is 3028.525 with $df = 2484$, p = 0.000. As discussed earlier, since the p-value is lesser than .05, the chi-square value is statistically significant which means the model does not have a good fit. Interpreted literally, this test statistic indicates that given the present data, the hypothesis bearing on Work flow reliability causations, as presented in the model, represents an unlikely event and should be rejected (Byrne 2006). Since, the sensitivity of chi-square index to sample size has already been identified in the literature review; it is necessary to run a few more fitness tests to reach a conclusion.

2. The comparative fit index (CFI) of the model is reported as 0.354 which is much less than the recommended 0.9 or higher (refer table 4.12). Therefore, the model does not pass the CFI test.

3. The RMSEA value for the model is reported as 0.023 with a 90% confidence interval of RMSEA (0.020, 0.026). The RMSEA value is lower than the recommended 0.07 value. Therefore, the model passes the RMSEA (badness-of-fit) test.

The model under testing failed two out of three fit tests, therefore, it can be concluded that the model hypothesis can be rejected for the chosen sample population. However, it is important to note that the GOF measures such as *Chi-square* index are sensitive to sample size (as explained in chapter 2). For example, in this scenario, if the sample size was 4000, the chances of achieving a good chi-square fit would still be remote because the Maximum Likelihood Estimation (MLE) procedure would be thrown off. Traditionally, there is a trade-off sample size with the GOF. In this example, the trade-off sample size was not determined.

```
Covariance Matrix to be Analyzed (Trimmed)

                          BUR16       BUR17       BUR18       BUR19
BUR20
                                V66         V67         V68         V69
V70
     BUR16     V66          7.788
     BUR17     V67          0.424       8.295
     BUR18     V68          0.507       0.294       8.195
     BUR19     V69         -0.377       0.194       0.155       8.017
     BUR20     V70         -0.341      -0.145      -0.215       0.142
8.090
       WFR1    V71          0.050       0.042       0.739       0.379
0.258
       WFR2    V72          0.228      -0.267      -0.797       0.175
0.346


  BENTLER-WEEKS STRUCTURAL REPRESENTATION:  (SPECIFICATION STATUS)

        NUMBER OF DEPENDENT VARIABLES = 15
      DEPENDENT V'S :     8    21    32    43    48    70    71    72
      DEPENDENT F'S :     1     2     3     4     5     6     7

        NUMBER OF INDEPENDENT VARIABLES = 73
      INDEPENDENT V'S :     1     2     3     4     5     6     7     9    10
11
      INDEPENDENT V'S :    12    13    14    15    16    17    18    19    20
22
      INDEPENDENT V'S :    23    24    25    26    27    28    29    30    31
33
      INDEPENDENT V'S :    34    35    36    37    38    39    40    41    42
44
      INDEPENDENT V'S :    45    46    47    49    50    51    52    53    54
55
      INDEPENDENT V'S :    56    57    58    59    60    61    62    63    64
65
      INDEPENDENT V'S :    66    67    68    69
      INDEPENDENT E'S :     8    21    32    43    48    70    71    72
      INDEPENDENT D'S :     7

        NUMBER OF FREE PARAMETERS = 144
        NUMBER OF FIXED NONZERO PARAMETERS =   16

 3RD STAGE OF COMPUTATION REQUIRED    957288 WORDS OF MEMORY.
 PROGRAM ALLOCATED  40000000 WORDS

 DETERMINANT OF INPUT MATRIX IS   0.20969D+63

 PARAMETER            CONDITION CODE   (IDENTIFICATION STATUS)
   D7,D7              LINEARLY DEPENDENT ON OTHER PARAMETERS
```

Table 4.13 Covariance matrix (trimmed) and model specification & identification results.

Other than the fit indices results, the output file also generates the covariance matrix and summary of model specification and identification issues, as shown in Table 4.13. The specification status confirms the researcher's specification of dependent and independent variables, as well as the free and fixed parameters. In identification status, the ideal message is "Parameter estimates appear in order, No special problems were encountered during optimization". It is important to locate the message prior to any interpretation of results (even for GOF indices). One of the most common errors, as shown in Table 4.13, is the condition code "Linearly dependent on other parameters". This situation occurs because either the parameter is underidentified in the model or it is empirically underidentified as a consequence of the data. Strategies on handling these errors are discussed in a later section of this chapter. Note that as a result of the error mentioned, the results of this model are not correct, however, they are being discussed to help the reader to interpret the results.

The primary focus of the estimation process in SEM is to yield parameter values such that discrepancy (i.e. residual) between the sample covariance matrix S and the population covariance matrix Σ, i.e. $(\Sigma - S)$ is minimal. Values greater than 2.58 are considered large; the lower the value of residuals, the better the hypothesized model fits the sample data. It should be noted that EQS produces two results; residual covariance matrix, and standardized residual matrix. It is recommended to use the latter result to avoid misinterpretation due to the unit of measurement of the observed variables (Byrne 2006). An example of standardized residual matrix is shown in Table 4.14.

Standardized Residual Matrix

		BUR16 V66	BUR17 V67	BUR18 V68	BUR19 V69	BUR20 V70
BUR16	V66	0.000				
BUR17	V67	0.053	0.000			
BUR18	V68	0.063	0.036	0.000		
BUR19	V69	-0.048	0.024	0.019	0.000	
BUR20	V70	0.001	-0.006	0.000	-0.010	-0.004
WFR1	V71	0.009	0.006	0.091	0.045	0.029
WFR2	V72	0.029	-0.032	-0.097	0.022	0.042

		WFR1 V71	WFR2 V72
WFR1	V71	0.087	
WFR2	V72	-0.042	0.001

AVERAGE ABSOLUTE STANDARDIZED RESIDUAL = 0.0389
AVERAGE OFF-DIAGONAL ABSOLUTE STANDARDIZED RESIDUAL = 0.0399

LARGEST STANDARDIZED RESIDUALS:

NO.	PARAMETER	ESTIMATE	NO.	PARAMETER	ESTIMATE
1	V72, V8	0.572	11	V30, V4	0.147
2	V72, V14	0.462	12	V29, V10	-0.147
3	V35, V15	0.174	13	V34, V10	-0.146
4	V71, V13	0.170	14	V28, V13	-0.144
5	V64, V42	0.157	15	V38, V24	0.143
6	V69, V15	0.157	16	V45, V7	-0.142
7	V47, V18	-0.150	17	V36, V27	-0.141
8	V65, V18	-0.149	18	V53, V6	0.141
9	V65, V29	-0.148	19	V62, V30	0.140
10	V15, V1	0.147	20	V49, V28	0.140

Table 4.14 Standardized Residual matrix (Trimmed) and largest standardized residuals

The data in Table 4.14 indicates that the largest standardized residual is 0.572, and the average standardized residual is 0.0399, both values reflect good fit to the data. A further review of frequency distribution (refer Appendix B) reveals that 97.79% of residual values fall between -.1 to .1. This confirms that the model as a whole appears to be quite fitting.

Assessment of residual covariances and model fit can only reveal information about how close the model as a whole is to the data. However, assessing individual parameter estimates is equally critical so as to make sure that the parameter estimates exhibit correct sign and size and are consistent with the underlying theory. Any estimates falling outside the range indicate that either the model is wrong or the input matrix lacks sufficient information. A parameter estimate is said to be unreasonable if it shows the following characteristics (Byrne 2006):

a. Correlations > 1.00

b. Negative Variances

c. Covariance or correlation matrices that are not positive definite.

Also, the model is considered a poor fit if the standard errors are excessively large or small. However, since standard errors are a function of units of measurement in observed and/or latent variables, therefore, it is difficult to establish 'largeness' or 'smallness' of the value (Byrne 2006).

A sample of the data generated on parameter estimates by EQS is shown in Table 4.15.

```
MEASUREMENT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS
  STATISTICS SIGNIFICANT AT THE 5% LEVEL ARE MARKED WITH @.

   PRE8   =V8   =     1.000 F1     +  1.000 E8
 DIR13    =V21 =      1.000 F2     +  1.000 E21
 WFR2  =V72 =       .030*F7     +  1.000 E72
                     .074
                     .403
..............................
CONSTRUCT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS
  STATISTICS SIGNIFICANT AT THE 5% LEVEL ARE MARKED WITH @.


    F1    =F1   =     -.001*V1    +    .079*V2    -   .001*V3    -    .005*V4
                      .004            .052            .005        .005
                     -.262           1.523           -.219       -.863

                -    .003*V5     +    .003*V6     +    .001*V7
                     .005            .005            .004
                    -.591            .635            .207
...............................
VARIANCES OF INDEPENDENT VARIABLES
  STATISTICS SIGNIFICANT AT THE 5% LEVEL ARE MARKED WITH @.
                  V                                  F
                 ---                                ---
 V1   -   PRE1              8.756*I                                I
                              .620 I                                I
                           14.124@I                                I
                                  I                                I
 V2   -   PRE2              7.819*I                                I
                              .554 I                                I
                           14.124@I                                I
                                  I                                I
 V3   -   PRE3              7.829*I                                I
                              .554 I                                I
                           14.124@I                                I
                                  I                                I
 V4   -   PRE4              8.135*I                                I
                              .576 I                                I
                           14.124@I                                I
STANDARDIZED SOLUTION                                        R-SQUARED

PRE8   =V8   =   .076 F1   + .997 E8                                .006
DIR13 =V21 =   .004 F2   + 1.000 E21                              .000
 RES11 =V32 =   .163 F3   +   .987 E32                             .027
 WTE11 =V43 = .182 F4   +   .983 E43                               .033
F1    =F1   =     -.015*V1     +   .997*V2     -   .012*V3     -   .059*V4
                 -   .036*V5     +   .039*V6     +   .012*V7
F2    =F2   =     -.129*V9     -   .008*V10    -   .076*V11    +   .044*V12
                 +   .972*V13    -   .065*V14    +   .007*V15    +   .071*V16
                 -   .135*V17    +   .016*V18    +   .050*V19    -   .030*V20
```

Table 4.15 Standard Errors, Variances of Independent Variables, and Standardized Solution (Edited).

The data in Table 4.15 is presented in order of unstandardized estimates followed by standardized solutions both for measurement equations and the variances (not reported completely in the Table 4.15, for complete reference see Appendix B). The unstandardized estimates are presented in the order of:

WFR2 = V72 = .030*F7 (estimated value) + 1.000 E72
.074 (Standard error)
.403 (Test Statistic (Visible only if significant))

The standardized solutions are presented in a single line along with a related R^2 value, as shown below:

PRE8 = V8 = 0.076 F1 + .997 E8 .006 (R^2)

The R^2 value indicates the proportion of variance of the response variable accounted for by its predictor variables. It may be noted that in standardized solution, parameters that were previously fixed to 1.0 take on new values; also, variances of independent variables cease to exist because they take on the value of 1.0 (Byrne 2006).

In reviewing the standardized estimates, the researcher should verify that particular parameter values are consistent with the literature. The test statistic in the unstandardized solution represents the parameter estimate divided by its standard error and operates as a z-statistic in testing that the estimate is statistically different from zero. Based on α level of .05, the test statistic needs to be > ± 1.96 (or greater than two times the standard deviation value, if checking for a different α level) before the hypothesis (that the estimate = 0) can be rejected. Non-significant parameters, with the exception of error variances, can be considered unimportant to the model in interest of parsimony (simplification of model) (Byrne 2006).

The above discussion brought out the salient aspects of SEM modeling, EQS software results and their interpretation. The model estimation results revealed that good fit (in this case bad fit) alone is insufficient to support a proposed structural theory. The researcher also must examine the individual parameter estimates against corresponding predictions or paths, each representing a specific hypothesis. The methodology indicated that during the development and assessment of the model, the most critical aspect was to achieve a proper identification of the model. As the literature review pointed that the model identification issues are recurring in nature and manifest both in the theoretical aspect and computational aspect of modeling, this research proposes strategies based on previous research and expert opinions to remove those problems in context of formative construct modeling.

4.4 Discussion of Strategies to Assist in Model Development

Some of the common concerns expressed in previous research regarding the formative modeling approach are model misspecification of formative constructs (Mackenzie et al. 2005; MacCallum et al. 1993).

Firstly, the disturbance term, as previously discussed, is that part of the construct that is not explained by its measured variables but which impacts the variable (Diamantopoulos 2006). Therefore, to add a disturbance term to a formative indicator is considered a standard part of specification. However, EQS requires constraining of error and disturbance term variances to zero or 1 during the estimation process. This requirement often leads to error messages such as: (1) Constrained at Upper Bound, or (2) Constrained at Lower Bound. One approach to remedy this problem is to remove the disturbance term from the construct altogether. This practice is not a strongly advised practice because it essentially mean that the researcher has high confidence that the chosen formative indicators for the construct completely explain the variance of the construct, which is rarely the case. Thus, this practice needs a sound theoretical justification in order to be implemented to fix the problem.

Secondly, since formative constructs are essentially transformed into multiple indicators multiple causes (MIMIC) models for identification purposes; one of the methods to identify those models is to have one path to a reflective indicator and one path to a reflective construct (a well suited method when the model configuration supports it). However, having two paths in that configuration are not enough in many circumstances, therefore, it is recommended to have at least two reflective indicators to the formative construct. This is advantageous because: (a) the formative construct is identified on its own and can go anywhere in the model; and (b) one can include it in a Confirmatory Factor Analysis (CFA) model and evaluate its discriminant validity and measurement properties. However, the disadvantage in this method is that it forces the researcher to design an extra variable when initially it did not exist (Jarvis et al. 2003). In addition, it uses up extra degree of freedom of the model and may affect the sample size in case there are many such constructs.

The strategies above were discussed to support the model identification and specification process of formative models. For further discussion on improving the model identification for formative constructs, the reader is encouraged to refer sources like Jarvis et al. (2003), MacCallum et al. (1993), and Mackenzie et al. (2005).

The strategies above help in overcoming the recurring and frustrating problems in estimating SEM models, especially, the formative type models. Overall, the framework for this research was developed based on the literature review and demonstrated to facilitate understanding. The following section presents a graphical representation of the developed framework in Figure 4.7.

4.5 Developed Framework

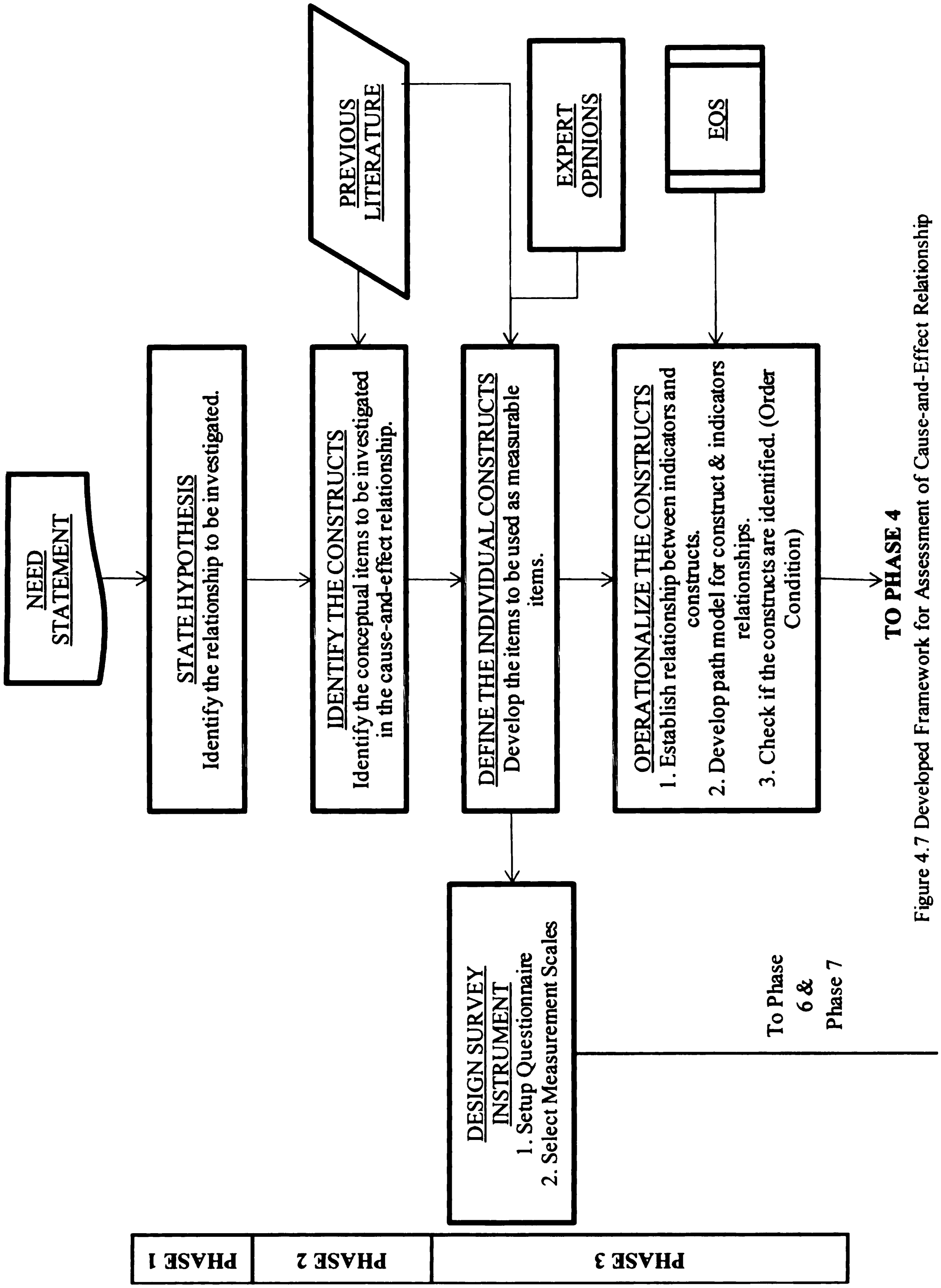

Figure 4.7 Developed Framework for Assessment of Cause-and-Effect Relationship

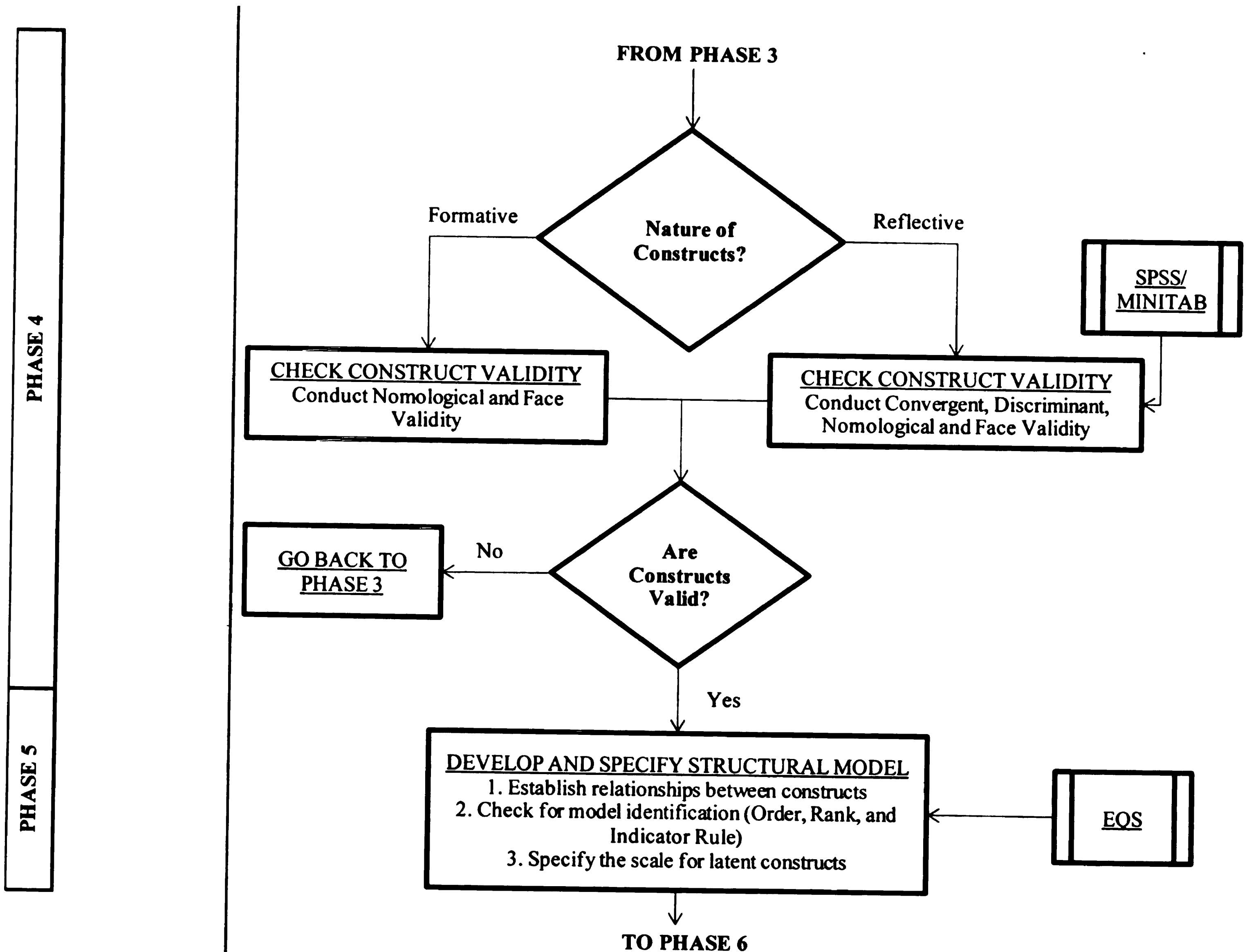

Figure 4.7 (Cont'd)

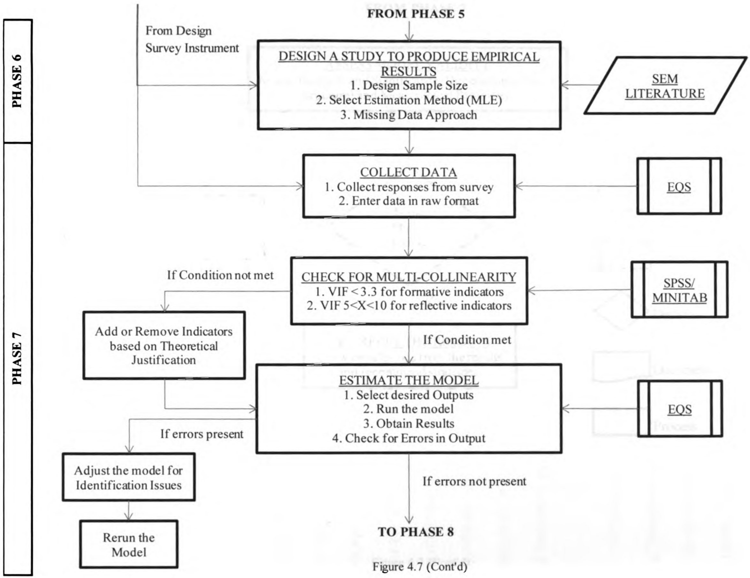

Figure 4.7 (Cont'd)

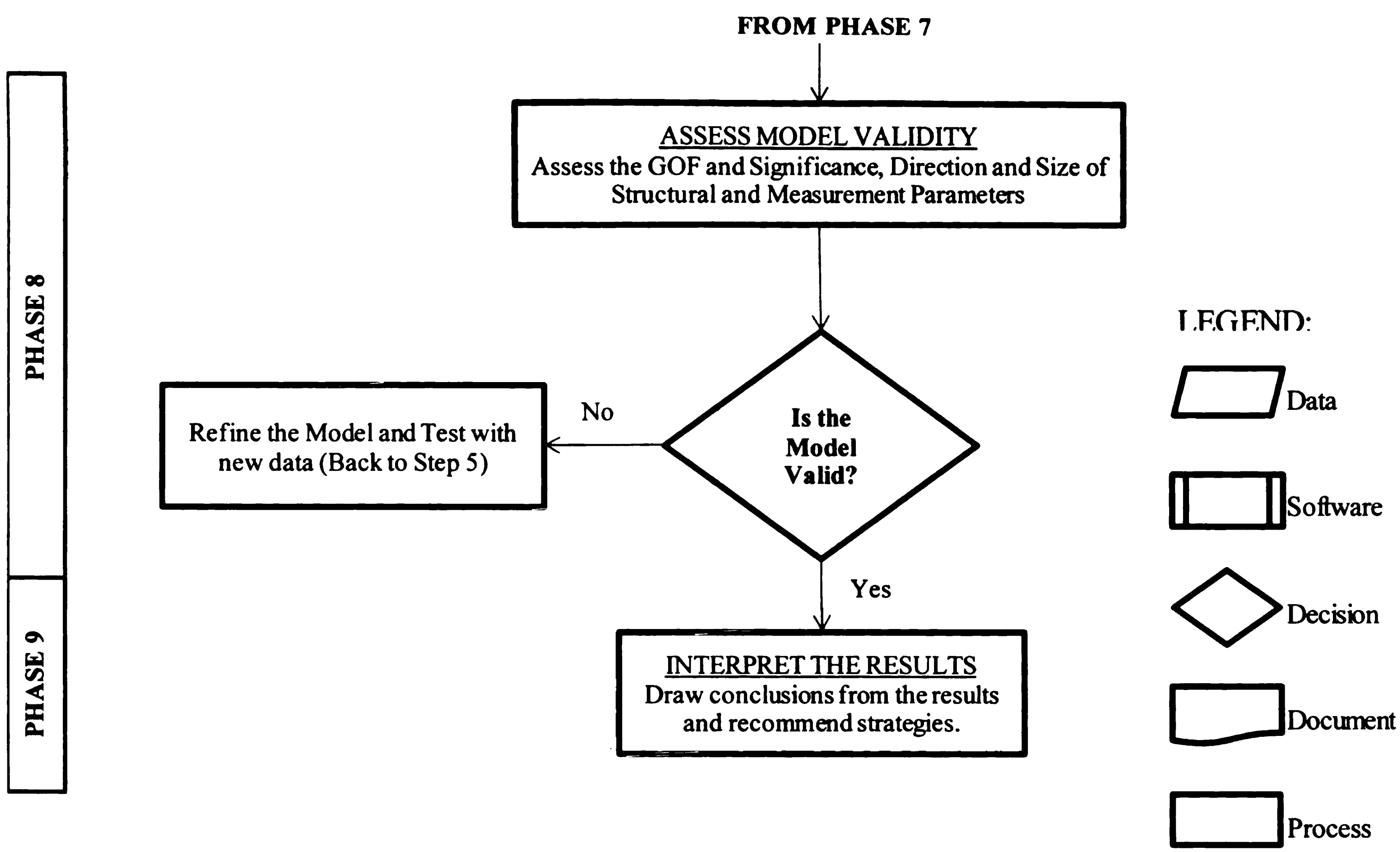

Figure 4.7 (Cont'd)

4.6 Chapter Summary

This chapter discussed the SEM development framework in the context of the research objectives. The survey questionnaire prepared to measure the production delay factors on a construction site was also discussed. Further, a demonstration development example for studying impacts of production delay factors on work flow reliability was presented. The chapter also provides insight into some strategies for handling specification and identification issues with SEM.

The example used for framework demonstration was based on the hypothesis that "All production delay factors impact workflow reliability", albeit with a hypothetical data. The purpose of the detailed demonstration was to provide guidance for interpreting the results and their statistical significance once a model is developed. The demonstration illustrated the use of the EQS software and MINITAB in order to develop the SEM and analyze the results. In the demonstration, it was found that departure from standard methods of developing an SEM, as found in literature, is acceptable due to the nature of the proposed model studies, for purpose of exploring the relationship between production delay factors and reliable workflow.

Overall, this chapter presented the main deliverables, framework and survey questionnaire, as formulated from the objectives of the research.

CHAPTER-5

SUMMARY AND CONCLUSIONS

5.1 Introduction

Chapter 5 provides an overview of the research conducted and its major findings along with a brief discussion of how the goals and objectives were accomplished. This chapter also discusses the limitations of this research and offers suggestions for future research.

5.2 Research Overview

This research provided a framework for studying relationship between production delay factors and work flow reliability which was constructed based on literature review and input from experts of Lean Construction and demonstrated by an example. To reiterate, the last four chapters are briefly discussed below explaining how the framework was constructed.

Chapter 1 presented the current level of implementation of production management and control tools and understanding of work flow reliability for the purposes of (1) improving production planning effectiveness and as a result (2) improving work flow reliability. Based on the need statement, the chapter stated the overall goal and objectives of this research along with its scope, and the potential benefits that could be achieved on accomplishment of the research goal.

Chapter 2 provided an overview of current production management practices discussing the conventional and lean production management tools. Existing researches on production factors affecting construction projects were discussed as part of the literature analysis in partial fulfillment of research goal and objectives. From the literature of productivity delay factors, chapter 2 provided an insight into types and classification of productivity factors. The Structural Equation Modeling analysis technique was extensively reviewed and its nuances were highlighted. The need and prior applications of SEM in construction management were discussed. Overall, the chapter brought forth the essential attributes which were used to develop the intended framework to explore the relationship between work flow reliability and production delay factors.

Chapter 3 discussed a four phased methodology that was adopted to accomplish the research goal and objectives based on the literature review. The contribution of each phase in achieving the research objectives was discussed. The chapter underscored the need for reviewing literature in categories of conventional and lean production management tools, productivity delay factors in construction and SEM analysis technique.

Chapter 4 presented the main contribution of this research as it developed the survey instrument to collect data for analysis of the impact of production delay factors on work flow reliability. The literature review in chapter 2 and the first part of chapter 4 contributed in achieving the first research objective, which was to document literature on production management tools, review the identified production factors in previous research and develop a list of production delay factors to understand work flow reliability. In addition, the chapter explained a step by step development of a framework for constructing an SEM to capture the relationship between work flow reliability and production delay factors. The framework was demonstrated using the actual survey instrument to generate hypothetical data. Finally, the chapter discussed strategies to overcome problems in developing the framework.

5.3 Research Goals and Objectives

The overall goal of this research was to understand cause and effect relations related to workflow reliability at the production level in a construction project. In order to achieve this goal, the research focused on developing a method to investigate the causal relationship between production constraints and their impact on workflow reliability as measure by the Percent Plan Complete (PPC) metric. To accomplish this two objectives were proposed in chapter 1, which are:

1. Study production management tools implemented at the site level and document the production delay factors encountered on construction site.

2. Develop a method to study the relationship between production delay factors and work flow reliability.

Objective 1 was achieved by reviewing the literature of conventional and lean production management tools and production delay factors in construction. The literature review provided the essential attributes that were considered for developing a framework to study the production delay factors affecting work flow reliability. These attributes were: production planning metrics (such as PPC), production delay factors that occur on a typical construction site, and classification of the production delay factors based on their impact on start or finish of a construction activity.

Based on the attributes, the research created a survey instrument to collect data on production factors affecting construction site performance. The data would be used to populate models that would be developed using the same production factors in the survey instrument.

Objective 2 was achieved by conducting the literature review on SEM, identifying the essential attributes of SEM model design. Combined with literature on production management, a framework was constructed that allows studying the impact of production delay factors on construction workflow reliability. The primary ingredients in developing this framework were the production delay factors, which were mostly identified by literature review and expert inputs, and specifics of SEM design, as adapted to construction production management. The developed framework suggested number of phases to be performed to (1) develop factors relevant to a construction company's specific sector and methods and (2) to establish a relationship model with these factors and reliable work flow by collecting data empirically and using SEM.

Each phase of the framework was demonstrated it with an example based on a hypothesized model with a randomly generated hypothetical data. Software applications like EQS and Minitab were integral to the development of the framework; therefore, software input/output was an integral component of the framework demonstration. The framework could be applied to build SEM models for testing other relationships in the field of construction management or build a different model based on envisioned relationships (refer section 4.1).

5.4 Conclusions and Inferences

This section discusses the conclusions drawn from the literature review of production management tools and observations made during the development of the framework. The literature of conventional production management tool brought forward the different metrics used to measure construction site performance. Discussion on tools like CPM and

EVM highlighted their limited ability to control the project progress because they do not provide any indication about the status of the upcoming work, which further limit their ability to identify appropriate corrective actions before problems are encountered. The SV and CV metrics implemented in the EVM method were criticized for not being explicitly connected to appropriate management action (Walt 2006). Therefore, the construction managers have to rely on their intuition to take corrective action. It is clear from the implementation of SV and CV that these metrics only consider cost and schedule as performance indicators, meanwhile, no reference is made to production factors that actually impact the site performance. Therefore, these metrics fail to address the root of the problem.

The literature review on lean production management tools revealed the use of PPC as a metric to measure the reliability of production planning as implemented under the Last Planner system. As discussed in chapter 2, PPC is a better indicator of site performance than CPM and EVM, as it gives a better indication of competency of planning the work. The constraints analysis in the Last Planner system provides a window to look at the factors that are affecting the construction site performance. However, it does not work with a standardized and exhaustive list of production factors that affect the construction performance, instead, it records the factors such as, (1) late or defective materials, (2) prerequisite work incomplete, (3) changes in priorities, (4) absenteeism or accident (manpower), (5) failure to accurately estimate the amount of labor time required to execute assignments, etc. These factors come from occurrences as reported by the person conducting constraint analysis. Therefore, it is subject to misinterpretation regarding root causes affecting the construction performance, which further affects selection of a corrective action. As a result, it is necessary to populate a list of factors, which cover most, if not all, aspects of production planning and execution; in a checklist format. Also, no attempt has been made at the production level of construction to study the individual and collective influence of all the production delay factors that affect construction performance vis-a-vis work flow reliability.

The reviewed literature on productivity factors in construction revealed an array of efforts from the researchers to document factors that affect labor productivity; some studied the impact of individual factors on construction productivity (Oglesby et al. 1989). However, this research revealed the importance of studying the collective impact of those factors, because the model estimation revealed different values when three big factors were assessed for their impact on reliable workflow versus the complete set of factors. Consideration of multiple factors will help the production planners to strategize more effectively in a real world complex and dynamic construction site.

In addition, the review revealed that there can be no standard list of production delay factors that can be treated as a finite list, instead, the production factors can change according to the practices of the construction company, type of construction project, size of the construction project, etc. The list of factors should be selected by production planners utilizing industry experiences. The survey instrument designed in this study presents list of production delay factors relevant to most construction settings.

The SEM literature review, applications of SEM, using a framework revealed that having a robust measurement theory is as important as the structural theory itself, i.e., proper care should be taken in deciding directional relationship between latent and measured variables. This research has concluded that the latent factors (Pre Requisite

Work, Directives, Burden, Variation, Waste, and Resources) are mostly subject to constructivist interpretation, i.e., they form as a result of collection of a set of measured variables and represent a collective existence of those variables, therefore, it is recommended that future research consider and test relationships with formative latent variables. This is especially important in a research of this nature because several production factors that are not inter-correlated come together to represent a broad planning category (latent variable), which, if tested for validation for reflective relationships would have to be removed from the construct and affect the nature of the latent variable. Although, from the measurement point of view, it is essential to add a couple of reflective variables to each formative construct to validate the construct. In this regard, the developed framework presents a methodology specific for conducting SEM analysis as it relates to reliable workflow.

5.5 Limitations of the Research

The demonstration of the SEM framework was restricted to randomly generated data. The reason behind this limitation is attributed to the large sample requirements required for SEM analyses (min. sample size 200). Given that the survey instrument required collection of data from construction management professionals based on their past experience and familiarity with Last Planner system, it was impossible to find that number of professionals. Therefore, the proposed structural theory (see section 4.3.1 and 4.3.2) between production factors and work flow reliability remains untested. Also, as a result of using a uniform random variable, 400 realizations of the variable, any likely correlation between the measured variables was not exhibited that could otherwise exist with a real data.

In addition, the research did not discuss handling missing data prior to estimating a measurement model, because the issue of missing data presents a vast discussion in itself and there were no missing data in this case.

Further, the framework development focused on cross-sectional design in SEM. Cross-sectional designs allow only for the evaluation of relationships among variables at one point in time and do not allow for autoregressive effects or time lags, therefore, cause problems in inferring causality or directional influence in cross-sectional studies. To consider such an inference as valid, it would have to be assumed that the time lag during which causal influence operates is essentially instantaneous, thereby justifying concurrent measurement of variables in a cross-sectional design (MacCallum and Austin 2000). Nevertheless, this research has focused on developing the framework to produce cross-sectional equation designs, due to extreme complexities, stronger statistical background, and longer time commitment required to pursue a framework for repeated measures design. Moreover, this research was exploratory, which further justifies the use of cross-sectional design.

5.6 Research Benefits and Contribution

As identified during the literature review of this research, reliable work flow as measured by PPC has been typically low for many types of construction projects (Ballard 1999). This is attributed to lack of understanding amongst the practitioners about the quantity of impact each production factor has on reliable workflow. This research has developed a framework which industry professionals can apply to overcome this overarching problem and design models for their establishments and measure the impact of those factors that affect work flow reliability. Those models can be actively implemented by project planners/ Last Planners on the project to study the impact and improve work flow reliability on the projects.

Although there have been several prior research in construction literature attempting to study the impact of various factors on several issues like labor productivity, performance on international projects, success of joint ventures, and project performance, etc., no study to assess the impact of production delay factors on work flow reliability was found. This research contributes to the Lean Construction practices by developing a list of production delay factors that can be added to the constraint analysis sheet of the Last Planner and used to record the status of production on a quantitative scale, on a regular basis. The use of scale will assist in a more accurate cognition of the presence of factors delaying the work.

In addition, the research delivered a framework that will not only assist in studying work flow reliability, but it will also contribute in developing relationship models for management practices at any organizational level in construction organizations. For example, studying the impact of estimation/ bidding practices over project award success.

Further, in chapter-1, the researcher pointed out the need to study the impact of all factors instead of only a selected few on any phenomenon was pointed out based on prior research (Maloney 1981; Oglesby et al. 1989). To test the validity of the statement, another SEM was created to study the impact on work flow reliability using only 3 latent factors (formative constructs), namely, propensity to reduce waste, burden, and variation. The model was pretested for validity similar to that used for demonstration. The EQS output of the results of the model after estimating with same set of hypothetical data are presented in Table 5.1.

```
  GOODNESS OF FIT SUMMARY FOR METHOD = ML

  INDEPENDENCE MODEL CHI-SQUARE        =      797.425 ON   780 DEGREES
OF FREEDOM

  INDEPENDENCE AIC =    -762.575   INDEPENDENCE CAIC =   -4655.917
         MODEL AIC =    -734.466          MODEL CAIC =   -4433.142

  CHI-SQUARE =      747.534 BASED ON     741 DEGREES OF FREEDOM
  PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS       .42602

  THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS
717.505.

  FIT INDICES
  -----------
  BENTLER-BONETT     NORMED FIT INDEX =       .063
  BENTLER-BONETT NON-NORMED FIT INDEX =       .605
  COMPARATIVE FIT INDEX (CFI)         =       .625
  BOLLEN'S          (IFI) FIT INDEX   =       .884
  MCDONALD'S        (MFI) FIT INDEX   =       .992
  JORESKOG-SORBOM'S  GFI  FIT INDEX   =       .918
  JORESKOG-SORBOM'S AGFI  FIT INDEX   =       .909
  ROOT MEAN-SQUARE RESIDUAL (RMR)     =       .385
  STANDARDIZED RMR                    =       .047
  ROOT MEAN-SQUARE ERROR OF APPROXIMATION (RMSEA)     =       .005
  90% CONFIDENCE INTERVAL OF RMSEA  (        .000,          .016)

  RELIABILITY COEFFICIENTS
  ------------------------
  CRONBACH'S ALPHA                    =     -.015
```

Table 5.1 Goodness-of-fit Results for waste-variation-burden model

The goodness-of-fit results clearly indicate that the model with only waste-variation-burden factors have different fit values for the same data. The RMSEA and CFI values are significantly different, indicating that the model is less likely to be bad (Hypothetically) at the same statistical significance as the full model. Further, a comparison can be drawn by looking at the parameter estimates of a few common variables in both models. The comparison is shown in Table 5.2.

Variable	Demonstration Model result	Waste-variation-burden Model result
BUR20	.205 F6 + .979 E70	.075 F6 + .997 E70
WFR1	.701 F7 + .713 E71	.229 F7 + .973 E71

Table 5.2 Comparison of parameter estimates (Standardized solution) of same variables in two models

Here, F6 represents the latent construct 'Burden' and E70 represents the disturbance error associated with it. And, F7 represents the latent construct 'Workflow Reliability' and E71 represents the disturbance error associated with it.

The results clearly indicate that factor loadings and error variances for both variables differ in the two models, which will lead to different interpretations by production planners regarding the strategy to adopt to control those two production factors. The difference comes about because the collective impact of the universe of indicators differs in both cases. Thus, the experiment confirms the need for studying the impact of all factors together as compared to isolation studies.

In addition, as discussed in previous chapters, it is advisable to study management practices in a formative approach; this framework provides an opportunity to researchers to revisit earlier studies, discussed in chapter 2, and study the impact of factors on the respective end result in a manner more suitable for construction management practices.

This research will primarily benefit construction contractors especially those who implement Last Planner system of production control, with a survey instrument for standardized constraint analysis. Also, the list of production factors is designed in accordance with the principles of lean production control. This framework will aid contractors to bring structure in their evaluation of construction site performance through the lens of production delay factors applicable to their practices.

5.7 Future Areas of Research

The introduction of SEM analysis technique in construction management research is still in a nascent stage and merits a huge potential for implementation in studying cause-and-effect relationships in this field, as was discovered during the literature analysis and framework development and demonstration stage.

Much of the applied SEM literature is characterized by inadequate understanding or acknowledgement of the limitations of single studies. Most often conclusions are limited to the particular sample, variables, and time frame represented by the study. The results are subject to sampling or selection effects with respect to at least three aspects of a study: individuals, measures, and occasions. The choice of individuals has an effect on sampling results, in order to account for such effects researchers may use expected cross-validation index (ECVI), which is computed from a single sample, as an index of how well a solution obtained in one sample is likely to fit an independent sample (MacCallum and Austin 2000). Therefore as a first potential research area, actual data should be collected and the proposed model in this research should be tested for fit. Also, a good fit does not imply a universally true model for a set of factors; therefore, further research is required to produce models with better fit to the data and hence a better prediction capability. In addition, the list of factors may not be entirely applicable to any project and only represent the pool suited to researcher's purpose, hence, more research is required to be done to refine the list of factors to study work flow reliability.

Also, during the development of the model, effort was made to include the entire checklist of important factors that influenced production delay; as mentioned earlier, this checklist was created by reviewing previous research, vetting with Lean experts and researcher's experience. However, a large model indicated the limitations of the computational capabilities of a standard user computer assembly (normally found in construction company offices) and a potential data handling and data processing problem during the data collection phase, therefore, further research can be done to achieve model parsimony (both from a statistical and logistical perspective). Model parsimony can be achieved by field testing the model and performing statistical procedures like Factor Analysis or Analytical Hierarchy Process (AHP).

Secondly, as discussed earlier in SEM literature review, there are two types of equation design. The designed framework assists researchers to study the impact of factors in a cross sectional design format, i.e., studying the factors and their impact at a single moment in time. However, construction production is a dynamic phenomenon; work flow reliability is tested on a weekly basis and is cumulative in nature, therefore, reiterating the point expressed in the limitations section of the research, establishing predictive capability merits further SEM research using the repeated measures design aimed at studying the cumulative impact of factors on work flow reliability and vice versa over the entire duration of the project. Such a study will be especially helpful to create models designed to understand production planning effectiveness for each type of construction project classified according to the building characteristic such as industrial, commercial, healthcare, nuclear, etc. Accordingly, further research is required to modify the framework to assist in developing models with repeated measures of all variables.

Construction is a global activity, and is executed by people from different cultures all across the globe. Since, culture provides a behavioral context especially when there is a huge presence of human interaction, it is important to examine the weighted value of production factors that involve direct human involvement, such as burden, work flow variation in this case. Therefore, a third potential area of research is to investigate the extent to which such factors carry more weightage in overall performance and assign those weights and study the relationship in cultural context as well.

5.8 Chapter Summary

This chapter discussed how the research goal and objectives were achieved, summarized the accomplishments in previous chapters, and presented the final conclusions of the thesis. The chapter also suggests three major areas for further investigation in production management of construction projects.

APPENDICES

APPENDIX A

Survey Instrument - Participant Consent Form

DEVELOPMENT OF METHODOLOGY TO UNDERSTAND CAUSE AND EFFECT RELATIONSHIP BETWEEN PRODUCTION DELAY FACTORS AND CONSTRUCTION SITE PERFORMANCE

Principal Investigator: Tariq Abdelhamid
Secondary Investigator: Samarth Jain

The Michigan State University Center for Construction Project Performance Assessment and Improvement is conducting a research project to explore the relationship between production delay factors and construction site performance. The research will study the current efforts in construction industry to maintain reliable workflow on construction work site and identify the production factors that have an effect on construction performance. The research will develop a method to study the cause and effect relationship that will assist construction professionals to build their company specific models to increase their understanding of their own company construction operations. Funding is being provided by the Construction Project Performance Assessment and Improvement, School of Planning Design and Construction, Michigan State University.
As part of the research we are interviewing professionals who are involved with construction projects as a part of the management team. As an experienced industry participant, your insight into the onsite construction production factors will be very useful to attaining the aims of this research.

As a participant in this research, you will be asked a series of closed ended questions relating to construction onsite management through an online survey. Your participation is voluntary and you may choose to terminate your involvement in this study at any time during this project. If you are uncomfortable at any time during the questioning, you may terminate and withdraw from the interview. You may refuse to answer any particular interview question. Your privacy will be protected to the maximum extent allowable by law. However, your title (e.g. Project Manager) will be reported. The estimated time to complete this survey is approximately 30-40 minutes.

If you have any questions about this project, you may contact Dr. Tariq Abdelhamid, School of Planning, Design and Construction, Michigan State University at (517) 432-6188, or Samarth Jain, School of Planning, Design and Construction, Michigan State University at (517) 203-9010. If you have any questions or concerns about your role and rights as a research participant or would like to obtain information or offer input, or would like to register a complaint about this research study, you may contact, anonymously if you wish, Michigan State University Human Research Protection Program at 517-355-2180, FAX 517-432-4503, or e-mail irb@msu.edu, or regular mail at: 202 Olds Hall, MSU, East Lansing, MI 48824.

You indicate your voluntary participation by completing and returning the survey on questionpro.com.

Survey Instrument – Solicitation Email

DEVELOPMENT OF METHODOLOGY TO UNDERSTAND CAUSE AND EFFECT RELATIONSHIP BETWEEN PRODUCTION DELAY FACTORS AND CONSTRUCTION SITE PERFORMANCE

The Michigan State University Center for Construction Project Performance Assessment and Improvement is conducting a research project to explore the relationship between production delay factors and construction site performance. The research will study the current efforts in construction industry to maintain reliable workflow on construction work site and identify the production factors that have an effect on construction performance. The research will develop a method to study the cause and effect relationship that will assist construction professionals to build their company specific models to increase their understanding of their own company construction operations. Funding is being provided by the Construction Project Performance Assessment and Improvement, School of Planning Design and Construction, Michigan State University. As part of the research we are surveying professionals who are involved with construction projects as a part of the management team. As experienced industry participants, their insight into the onsite construction production factors will be very useful to attaining the aims of this research. The minimum qualification requirements for a participant are:

1. Must have at least 1 year or 1 project experience on construction project functioning as a member/leader of the management team and used Last Planner system.

We, therefore, request you to forward this survey to the list serve that matches our requirements within your company, asking for participation in the survey. As a participant in this research, they will be asked a series of closed ended questions relating to construction onsite management through an online survey. The participation is voluntary and anyone may choose to terminate their involvement in this study at any time during this project. Please note that the research is purely for academic purposes and survey results will not be shared with the company or the participants. A participant if uncomfortable at any time during the survey, may terminate and withdraw from the survey. They may refuse to answer any particular interview question. Their privacy will be protected to the maximum extent allowable by law.

The estimated time to complete this survey is approximately 30-40 minutes. If you have any questions about this project, you may contact Dr. Tariq Abdelhamid, School of Planning, Design and Construction, Michigan State University at (517) 432-6188, or Samarth Jain, School of Planning, Design and Construction, Michigan State University at (517) 203-9010. If you have any questions or concerns about your role and rights as a research participant or would like to obtain information or offer input, or would like to register a complaint about this research study, you may contact, anonymously if you wish, Michigan State University Human Research Protection Program at 517-355-2180, FAX 517-432-4503, or e-mail: irb@msu.edu, or regular mail at: 207 Olds Hall, MSU, East Lansing, MI 48824

Survey Instrument

The survey instrument is a web based questionnaire reproduced in word format for publishing purposes below.

Please enter your job position/title

Please enter no. of years of your working experience

Please enter your experience in Construction Management team/role

Enter an estimated no. of projects you have worked in management role

What is the average duration of projects (in months) that you have worked on?

In the following sections, you will be asked questions from seven categories. The first six categories represent Production delay factors that come into action during the progress of work namely:

1. Completion of Prerequisite Work
2. Availability of Directives (Information)
3. Availability of Resources: Equipment, Labor, Material and Space.
4. Propensity to Reduce Waste
5. Propensity to Reduce Variation
6. Propensity to Reduce Burden

Each category has a list of questions presented as statements of fact representing an aspect of production planning. A scale is provided next to each question. You are requested to select the best value according to your experience. The last category i.e. Work Flow Reliability, contains questions on work performance as result of the six production planning categories encountered during work. Your answers from the most recent project work week will be preferred, otherwise please fill responses based on your cumulative experience.

Completion of Pre Requisite Work (PRE)

PRE1. Prior work is complete with desired quality.

	1	2	3	4	5	6	7	8	9	10
(10-100% Complete)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

PRE2. The pre-requisite work has been verified to meet current work needs (dimensions, locations, etc)

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

PRE3. All regulatory inspections needed were conducted and successfully passed.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

PRE4. The prerequisite work is officially handed over from prior trade.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

PRE5. The weather forecast is favorable for performing work.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	☐	☐	☐	☐	☐	☐	☐	☐

PRE6. Access to the work area (permits, etc) has been obtained and cleared with respective party.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

PRE7. All coordination issues with following trade have been addressed by the project team.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

PRE8. Overall, the prerequisite work is complete.

	1	2	3	4	5	6	7	8	9	10
(10-100% Complete)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Availability of Directives (Information) (DIR)

DIR1. The D&E documents for current work are acceptable.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR2. The D&E documents for current work are available.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR3. All RFIs for current work are addressed satisfactorily.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR4. The owner is agreeable to any design/scope changes, if any.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR5. The standard of work performance is available.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR6. The standard of work performance is clearly expressed.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR7. The submittals are approved.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR8. The submittals are available.

	1	2	3	4	5	6	7	8	9	10
(10-100% Available)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR9. Final design instructions have been confirmed by architect/engineer to avoid change.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR10. All lien waivers are in order.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR11. All permits are available.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR12. All lien waivers are submitted.

	1	2	3	4	5	6	7	8	9	10
(10-100% Complete)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

DIR13. Overall, all the directives are in order.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

Availability of Resources: Equipment, Labor, Material and Space (RES)

RES1. The material is/will be delivered on time.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

RES2. The material specifications match to contract/submittal specs.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

RES3. Space is available for material lay-downs.

	1	2	3	4	5	6	7	8	9	10
(10-100% Available)										

RES4. Space is available for material transport.

	1	2	3	4	5	6	7	8	9	10
(10-100% Available)										

RES5. The labor is informed of all work assignments.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

RES6. The labor needed is available.

	1	2	3	4	5	6	7	8	9	10
(10-100% Available)										

RES7. The tools to be used are in good working condition.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

RES8. Right tools are available in enough quantity for crews to work with.

	1	2	3	4	5	6	7	8	9	10
(10-100% Available)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

RES9. The equipment to be used is in good working condition.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

RES10. Right equipment is available in the desired quantity.

	1	2	3	4	5	6	7	8	9	10
(10-100% Available)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

RES11. Overall, all the required resources are available.

	1	2	3	4	5	6	7	8	9	10
(10-100% Available)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Propensity to Reduce Waste (WTE)

WTE1. The amount of work is sized appropriately to avoid overproduction.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE2. Transportation of raw/processed materials requires single handling (as opposed to more than once).

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE3. Transportation of raw/processed materials is over short distances.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE4.No amount of rework/correction is required for completed work.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE5. No over-processing (unnecessary finishing) is performed for completed work.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE6. Inventory is delivered just-in-time to the production unit.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE7. The production unit makes no unnecessary movements to complete the work.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE8. The production unit is always working to complete the work.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE9. The production crew is consulted on the best way to perform the work.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE10. The production crew is consulted on the safest way to perform the work.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

WTE11. Overall, sufficient steps have been taken to prevent generation of waste.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Propensity to Reduce Variation (VAR)

VAR1. There was no absenteeism in the workforce.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

VAR2. The production crews operate with reserve capacity.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

VAR3. The learning curve effect is realizable for the crews.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

VAR4. Recovery plans from occupational accidents are standard practice.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

VAR5. The production rates of the crew are consistent over time (match Takt).

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

VAR6. The production plan has workable backlog in case of interruptions to current assignment(s).

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

VAR7. The production plan has time buffers to prevent interruptions to project completion.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Propensity to Reduce Burden (BUR)

BUR1. The work environment is free of potential environmental hazards (air-borne pathogens, dust, chemical agents, ultra-violet light, and ionizing radiation).

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

BUR2. The work environment is comfortable to function in (temperature and humidity, lighting, sun exposure, noise levels).

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR3. The work environment is not congested.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR4. Overtime is not needed on our jobs.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR5. The work is adequately paced to avoid physical fatigue.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR6. The workers are equipped with PPEs, as necessary.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR7. The workers are not allowed to engage work involving heavy muscular loads.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR8. The workers have access to material-lifting equipment.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR9. A Job Safety Analysis is performed.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR10. Workers are trained on proper lifting techniques.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR11. Rest cycles are built into the work method.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR12. Workers receive sufficient information regarding the process flow and output.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR13. The rate of information does not exceed the mental capacity of the worker to process.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR14. Identical or very similar signals don't occur for a long time.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR15. Adequate time is allowed for decisions and resulting actions in the normal circumstances.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR16. Adequate time is allowed for decisions and resulting actions in emergencies.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR17. Hand tools used are the correct ones for the task.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)										

BUR18. Hand tools used are adequately maintained.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

BUR19. All safety signs and visuals are correctly located.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

BUR20. Overall, the workers do not feel any kind of burden.

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Reliable Work Flow Achieved (WFR)

WFR1. The PPC is high; 90% or higher

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

WFR2. We are headed to a timely completion of the project

	1	2	3	4	5	6	7	8	9	10
(10-100% Agree)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

APPENDIX B

Output File from EQS for Framework Demonstration Example

```
1
  EQS, A STRUCTURAL EQUATION PROGRAM          MULTIVARIATE SOFTWARE,
INC.
  COPYRIGHT BY P.M. BENTLER                   VERSION 6.1 (C) 1985 -
2009 (B97).


    PROGRAM CONTROL INFORMATION

    /TITLE
    Model built by EQS 6 for Windows
    /SPECIFICATIONS
    DATA='c:\eqs61\support\sam\thesis 400 samples.ess';
    VARIABLES=72; CASES=400;
    METHOD=ML; ANALYSIS=COVARIANCE; MATRIX=RAW;
    /LABELS
    V1=PRE1; V2=PRE2; V3=PRE3; V4=PRE4; V5=PRE5;
    V6=PRE6; V7=PRE7; V8=PRE8; V9=DIR1; V10=DIR2;
    V11=DIR3; V12=DIR4; V13=DIR5; V14=DIR6; V15=DIR7;
    V16=DIR8; V17=DIR9; V18=DIR10; V19=DIR11; V20=DIR12;
    V21=DIR13; V22=RES1; V23=RES2; V24=RES3; V25=RES4;
    V26=RES5; V27=RES6; V28=RES7; V29=RES8; V30=RES9;
    V31=RES10; V32=RES11; V33=WTE1; V34=WTE2; V35=WTE3;
    V36=WTE4; V37=WTE5; V38=WTE6; V39=WTE7; V40=WTE8;
    V41=WTE9; V42=WTE10; V43=WTE11; V44=VAR1; V45=VAR2;
    V46=VAR3; V47=VAR4; V48=VAR5; V49=VAR6; V50=VAR7;
    V51=BUR1; V52=BUR2; V53=BUR3; V54=BUR4; V55=BUR5;
    V56=BUR6; V57=BUR7; V58=BUR8; V59=BUR9; V60=BUR10;
    V61=BUR11; V62=BUR12; V63=BUR13; V64=BUR14; V65=BUR15;
    V66=BUR16; V67=BUR17; V68=BUR18; V69=BUR19; V70=BUR20;
    V71=WFR1; V72=WFR2;
    /EQUATIONS
    V8 =   1F1 + E8;
    V21 =   1F2 + E21;
    V32 =   1F3 + E32;
    V43 =   1F4 + E43;
    V48 =   1F5 + E48;
    V70 =   1F6 + E70;
    V71 =   1F7 + E71;
    V72 =   *F7 + E72;
    F1 =   *V1 + *V2 + *V3 + *V4 + *V5 + *V6 + *V7
    ;
    F2 =   *V9 + *V10 + *V11 + *V12 + *V13 + *V14 + *V15
    + *V16 + *V17 + *V18 + *V19 + *V20 ;
    F3 =   *V22 + *V23 + *V24 + *V25 + *V26 + *V27 + *V28
    + *V29 + *V30 + *V31 ;
    F4 =   *V33 + *V34 + *V35 + *V36 + *V37 + *V38 + *V39
    + *V40 + *V41 + *V42 ;
    F5 =   *V44 + *V45 + *V46 + *V47 + *V49 + *V50 ;
    F6 =   *V51 + *V52 + *V53 + *V54 + *V55 + *V56 + *V57
    + *V58 + *V59 + *V60 + *V61 + *V62 + *V63 + *V64
    + *V65 + *V66 + *V67 + *V68 + *V69 ;
```

```
F7 =    *F1 + *F2 + *F3 + *F4 + *F5 + *F6 + D7;

/VARIANCES
 V1 = *;
 V2 = *;
 V3 = *;
 V4 = *;
 V5 = *;
 V6 = *;
 V7 = *;
 V9 = *;
 V10 = *;
 V11 = *;
 V12 = *;
 V13 = *;
 V14 = *;
 V15 = *;
 V16 = *;
 V17 = *;
 V18 = *;
 V19 = *;
 V20 = *;
 V22 = *;
 V23 = *;
 V24 = *;
 V25 = *;
 V26 = *;
 V27 = *;
 V28 = *;
 V29 = *;
 V30 = *;
 V31 = *;
 V33 = *;
 V34 = *;
 V35 = *;
 V36 = *;
 V37 = *;
 V38 = *;
 V39 = *;
 V40 = *;
 V41 = *;
 V42 = *;
 V44 = *;
 V45 = *;
 V46 = *;
 V47 = *;
 V49 = *;
 V50 = *;
 V51 = *;
 V52 = *;
 V53 = *;
 V54 = *;
 V55 = *;
 V56 = *;
 V57 = *;
 V58 = *;
 V59 = *;
```

```
V60 = *;
V61 = *;
V62 = *;
V63 = *;
V64 = *;
V65 = *;
V66 = *;
V67 = *;
V68 = *;
V69 = *;
E8 = *;
E21 = *;
E32 = *;
E43 = *;
E48 = *;
E70 = *;
E71 = *;
E72 = *;
D7 = *;
/COVARIANCES
/PRINT
EIS;
FIT=ALL;
TABLE=EQUATION;
/END
```

125 RECORDS OF INPUT MODEL FILE WERE READ

DATA IS READ FROM c:\eqs61\support\sam\thesis 400 samples.ess
THERE ARE 72 VARIABLES AND 400 CASES
IT IS A RAW DATA ESS FILE

SAMPLE STATISTICS BASED ON COMPLETE CASES

UNIVARIATE STATISTICS

VARIABLE	PRE1 V1	PRE2 V2	PRE3 V3	PRE4 V4	PRE5 V5
MEAN	5.6050	5.4225	5.5225	5.5125	5.4275
SKEWNESS (G1)	-0.0559	0.0449	0.0847	-0.0354	0.0456
KURTOSIS (G2)	-1.2527	-1.1995	-1.1437	-1.2394	-1.2815
STANDARD DEV.	2.9590	2.7962	2.7980	2.8522	2.9693

VARIABLE	PRE6 V6	PRE7 V7	PRE8 V8	DIR1 V9	DIR2 V10

MEAN	5.4425	5.6250	5.6400	5.7425	5.4200
SKEWNESS (G1)	0.0492	-0.0470	-0.1050	-0.1880	0.0592
KURTOSIS (G2)	-1.1765	-1.2906	-1.3034	-1.0715	-1.2823
STANDARD DEV.	2.8190	2.8513	2.9097	2.7587	2.9750

VARIABLE	DIR3 V11	DIR4 V12	DIR5 V13	DIR6 V14	DIR7 V15
MEAN	5.8775	5.4400	5.6875	5.4575	5.7275
SKEWNESS (G1)	-0.1820	-0.0620	-0.0578	0.0455	-0.0941
KURTOSIS (G2)	-1.1785	-1.3308	-1.1933	-1.2002	-1.2906
STANDARD DEV.	2.8377	2.9390	2.7927	2.8192	2.9504

VARIABLE	DIR8 V16	DIR9 V17	DIR10 V18	DIR11 V19	DIR12 V20
MEAN	5.4250	5.4150	5.6125	5.6625	5.4900
SKEWNESS (G1)	0.0351	0.0183	-0.1208	-0.0616	-0.0178
KURTOSIS (G2)	-1.3000	-1.3349	-1.2143	-1.1993	-1.2484
STANDARD DEV.	2.9455	3.0017	2.8693	2.8485	2.8522

VARIABLE	DIR13 V21	RES1 V22	RES2 V23	RES3 V24	RES4 V25
MEAN	5.4450	5.3325	5.2775	5.7375	5.5225
SKEWNESS (G1)	-0.0198	0.0655	0.1023	-0.0916	-0.0614
KURTOSIS (G2)	-1.2661	-1.2017	-1.2449	-1.2384	-1.2615

STANDARD DEV.	2.9255	2.8464	2.8977	2.8791	2.9693

VARIABLE	RES5 V26	RES6 V27	RES7 V28	RES8 V29	RES9 V30
MEAN	5.4175	5.4875	5.5375	5.6200	5.7450
SKEWNESS (G1)	0.0118	-0.0590	-0.0699	-0.0463	-0.1148
KURTOSIS (G2)	-1.2422	-1.2011	-1.2200	-1.1774	-1.2390
STANDARD DEV.	2.8729	2.9456	2.8458	2.8847	2.9165

VARIABLE	RES10 V31	RES11 V32	WTE1 V33	WTE2 V34	WTE3 V35
MEAN	5.4925	5.6300	5.6525	5.5050	5.4075
SKEWNESS (G1)	-0.0027	-0.1134	-0.0903	-0.0478	0.0790
KURTOSIS (G2)	-1.2519	-1.2217	-1.2088	-1.2060	-1.3481
STANDARD DEV.	2.8408	2.8589	2.8136	2.8443	3.0569

VARIABLE	WTE4 V36	WTE5 V37	WTE6 V38	WTE7 V39	WTE8 V40
MEAN	5.4700	5.5625	5.6300	5.3025	5.3825
SKEWNESS (G1)	0.0182	-0.0197	-0.0549	0.1134	0.0321
KURTOSIS (G2)	-1.2081	-1.2311	-1.2067	-1.2356	-1.1150
STANDARD DEV.	2.8371	2.9012	2.8721	2.9167	2.7930

VARIABLE	WTE9 V41	WTE10 V42	WTE11 V43	VAR1 V44	VAR2 V45
MEAN	5.4675	5.5825	5.7350	5.8675	5.4200

SKEWNESS (G1) 0.0451 -0.0571 -0.0713 -0.1781 -
0.0426

KURTOSIS (G2) -1.2126 -1.2442 -1.2214 -1.2646 -
1.2305

STANDARD DEV. 2.8853 2.8493 2.8724 2.9062
2.9008

VARIABLE VAR3 VAR4 VAR5 VAR6 VAR7
V46 V47 V48 V49 V50

MEAN 5.4725 5.3100 5.3175 5.7825
5.4925

SKEWNESS (G1) -0.0363 0.0642 0.0883 -0.0516
0.0630

KURTOSIS (G2) -1.2349 -1.2882 -1.3367 -1.2658 -
1.2022

STANDARD DEV. 2.8949 2.9437 2.9974 2.9157
2.8408

VARIABLE BUR1 BUR2 BUR3 BUR4 BUR5
V51 V52 V53 V54 V55

MEAN 5.6800 5.6500 5.6375 5.4875
5.2500

SKEWNESS (G1) -0.1307 -0.0547 -0.1472 -0.0175
0.0669

KURTOSIS (G2) -1.2364 -1.2203 -1.1913 -1.2685 -
1.1011

STANDARD DEV. 2.8597 2.8789 2.8735 2.9096
2.7869

VARIABLE BUR6 BUR7 BUR8 BUR9 BUR10
V56 V57 V58 V59 V60

MEAN 5.6700 5.6425 5.3900 5.5100
5.2775

SKEWNESS (G1) -0.1095 -0.0880 0.1009 -0.0049
0.1121

KURTOSIS (G2) -1.1905 -1.2582 -1.2133 -1.1897 -
1.2973

STANDARD DEV. 2.8144 2.9345 2.8448 2.8275
2.8620

VARIABLE	BUR11 V61	BUR12 V62	BUR13 V63	BUR14 V64	BUR15 V65
MEAN	5.4850	5.1225	5.4625	5.4750	5.4050
SKEWNESS (G1)	-0.0554	0.1228	0.0192	0.0176	0.0516
KURTOSIS (G2)	-1.2191	-1.1768	-1.2231	-1.2234	-1.1508
STANDARD DEV.	2.8715	2.8492	2.7997	2.8740	2.7677

VARIABLE	BUR16 V66	BUR17 V67	BUR18 V68	BUR19 V69	BUR20 V70
MEAN	5.4225	5.0925	5.5075	5.6125	5.3975
SKEWNESS (G1)	0.0102	0.1576	0.0323	-0.0419	0.0902
KURTOSIS (G2)	-1.1897	-1.2600	-1.2306	-1.1769	-1.2226
STANDARD DEV.	2.7908	2.8800	2.8628	2.8315	2.8442

VARIABLE	WFR1 V71	WFR2 V72
MEAN	5.4150	5.5275
SKEWNESS (G1)	0.0436	-0.0189
KURTOSIS (G2)	-1.2777	-1.2742
STANDARD DEV.	2.8746	2.8600

MULTIVARIATE KURTOSIS

MARDIA'S COEFFICIENT (G2,P) = -86.9022
NORMALIZED ESTIMATE = -8.4185

ELLIPTICAL THEORY KURTOSIS ESTIMATES

MARDIA-BASED KAPPA = -0.0163 MEAN SCALED UNIVARIATE KURTOSIS = -0.4100

MARDIA-BASED KAPPA IS USED IN COMPUTATION. KAPPA= -0.0163

CASE NUMBERS WITH LARGEST CONTRIBUTION TO NORMALIZED MULTIVARIATE KURTOSIS:

CASE NUMBER	6	13	16	133	229
ESTIMATE	239.9667	286.1542	288.7188	231.1765	296.4353

COVARIANCE MATRIX TO BE ANALYZED: 72 VARIABLES (SELECTED FROM 72 VARIABLES)
BASED ON 400 CASES.

		PRE1	PRE2	PRE3	PRE4	PRE5
		V1	V2	V3	V4	V5
PRE1	V1	8.756				
PRE2	V2	-0.372	7.819			
PRE3	V3	0.079	-0.620	7.829		
PRE4	V4	-0.363	0.126	-0.131	8.135	
PRE5	V5	1.227	-0.592	1.014	0.289	8.817
PRE6	V6	0.050	-0.716	-0.708	0.204	0.763
PRE7	V7	-0.061	0.800	0.773	-0.291	-0.366
PRE8	V8	0.211	0.516	-0.661	-0.512	-0.781
DIR1	V9	0.016	-0.139	-0.091	0.260	-0.353
DIR2	V10	-0.380	-0.506	-0.716	0.501	0.765
DIR3	V11	-0.226	0.220	-0.384	-0.040	0.657
DIR4	V12	0.560	0.533	-0.025	-0.444	-0.153
DIR5	V13	-0.124	0.263	0.236	0.724	0.131
DIR6	V14	-0.566	0.345	-0.367	0.001	-0.326
DIR7	V15	1.286	0.103	0.223	0.323	-0.254
DIR8	V16	-0.225	0.336	-0.025	-0.103	-0.355
DIR9	V17	-0.204	-0.464	0.091	-0.456	-0.491

DIR10	V18	0.117	0.194	-0.216	0.565	-0.754
DIR11	V19	0.067	-0.521	0.949	0.198	0.212
DIR12	V20	-0.530	-0.265	0.623	0.089	-0.759
DIR13	V21	0.011	-0.467	0.712	-0.176	0.293
RES1	V22	0.337	-0.216	-0.242	-0.148	0.336
RES2	V23	0.909	0.035	0.393	0.311	0.518
RES3	V24	-0.670	-0.415	-0.304	-0.437	-0.289
RES4	V25	0.219	0.197	0.070	0.090	0.202
RES5	V26	-0.093	-0.112	0.110	0.242	0.280
RES6	V27	0.652	-0.044	0.710	0.218	-0.161
RES7	V28	0.163	0.597	0.024	0.032	-0.333
RES8	V29	-0.103	0.038	0.194	-0.439	0.261
RES9	V30	0.729	-0.386	0.753	1.221	1.037
RES10	V31	0.032	-0.356	-0.007	0.043	-0.838
RES11	V32	-0.510	-0.480	-0.007	0.669	-0.240
WTE1	V33	-0.639	0.034	0.220	-0.253	0.056
WTE2	V34	-0.216	-0.602	-0.057	-0.708	-0.452
WTE3	V35	0.001	0.509	0.561	0.430	-0.089
WTE4	V36	-0.100	0.047	-0.667	0.540	-0.264
WTE5	V37	0.175	0.145	1.036	-0.191	-0.414
WTE6	V38	0.204	-0.134	0.758	0.110	0.379
WTE7	V39	-0.304	0.148	0.190	0.644	0.241
WTE8	V40	-0.302	-0.357	0.333	-0.948	0.162
WTE9	V41	-0.141	-0.035	0.359	0.206	-0.233
WTE10	V42	0.744	-0.354	-0.049	-0.267	-0.408
WTE11	V43	0.599	-0.371	-0.039	-0.814	0.429
VAR1	V44	0.273	0.247	-0.043	-0.040	0.530
VAR2	V45	-0.097	-0.890	0.141	0.666	-0.829

VAR3	V46	-0.106	0.502	-0.155	-0.335	-0.328
VAR4	V47	-0.278	-0.322	0.036	-0.475	0.326
VAR5	V48	0.101	-0.155	0.227	-0.491	0.290
VAR6	V49	0.044	0.140	-0.307	-0.307	-0.456
VAR7	V50	-0.186	-0.254	-0.509	0.201	0.476
BUR1	V51	-0.708	-0.168	0.686	0.240	0.270
BUR2	V52	0.611	0.176	0.000	0.127	0.844
BUR3	V53	-0.758	0.056	-0.657	-0.047	-0.514
BUR4	V54	-0.153	-0.522	-0.343	-0.601	-0.675
BUR5	V55	0.254	0.185	0.268	-0.346	-0.425
BUR6	V56	0.040	-0.301	-0.163	-0.512	-0.325
BUR7	V57	0.046	0.477	-0.570	-0.220	0.103
BUR8	V58	0.475	0.682	0.981	0.281	0.234
BUR9	V59	-0.001	0.483	-0.052	0.126	0.383
BUR10	V60	0.975	-0.095	0.060	0.316	0.154
BUR11	V61	0.420	-0.326	-0.334	0.402	0.349
BUR12	V62	-0.648	0.146	0.893	0.757	1.128
BUR13	V63	0.198	-0.113	0.104	0.003	-0.970
BUR14	V64	0.103	-0.487	0.305	-0.665	-0.757
BUR15	V65	-0.263	-0.633	-0.252	0.073	0.674
BUR16	V66	0.092	0.102	0.603	0.412	-0.314
BUR17	V67	0.237	0.028	0.210	-0.085	-0.533
BUR18	V68	0.126	0.141	0.812	0.516	-0.446
BUR19	V69	0.979	0.094	-0.727	0.119	-0.177
BUR20	V70	-0.549	0.243	0.040	-0.390	0.020
WFR1	V71	-0.337	4.977	-0.320	-0.008	-0.413
WFR2	V72	-0.525	0.383	-0.640	-0.554	-0.818

		PRE6	PRE7	PRE8	DIR1	DIR2
		V6	V7	V8	V9	V10
PRE6	V6	7.947				
PRE7	V7	0.094	8.130			
PRE8	V8	0.706	0.188	8.467		
DIR1	V9	-0.397	0.179	0.311	7.610	
DIR2	V10	0.300	-0.173	-0.508	0.106	8.851
DIR3	V11	0.465	-0.141	0.026	-0.320	0.016
DIR4	V12	-0.696	0.830	-0.445	0.166	-1.153
DIR5	V13	0.161	-0.819	-0.338	0.373	0.264
DIR6	V14	-0.276	-0.242	0.315	0.203	-0.599
DIR7	V15	-0.147	0.411	0.187	0.120	-0.394
DIR8	V16	-0.279	0.466	-0.922	0.022	-0.535
DIR9	V17	0.252	-0.210	-0.051	0.528	0.201
DIR10	V18	-0.585	0.170	0.617	0.579	-0.153
DIR11	V19	-0.118	0.502	0.081	-0.120	0.027
DIR12	V20	0.041	0.623	0.094	0.099	0.769
DIR13	V21	-0.130	0.353	0.078	-0.514	-0.704
RES1	V22	-0.351	-0.579	-0.306	-0.536	0.196
RES2	V23	0.684	-0.329	0.413	-0.778	0.008
RES3	V24	-0.059	-0.081	0.231	0.000	-0.223
RES4	V25	-0.294	-0.716	0.083	-0.203	-0.265
RES5	V26	-0.356	-0.199	-0.461	0.140	-0.682
RES6	V27	-0.417	0.329	0.522	-0.082	-0.769
RES7	V28	0.037	0.357	0.470	-0.149	0.127
RES8	V29	-0.355	-0.855	-0.561	-0.324	-1.259
RES9	V30	-0.305	-0.259	-0.764	0.057	0.092
RES10	V31	0.398	-0.421	0.511	0.368	-0.167
RES11	V32	1.004	-0.177	0.403	0.067	-0.313
WTE1	V33	0.608	1.000	-0.276	0.259	0.071

WTE2	V34	-0.515	0.543	-0.369	0.236	-1.235
WTE3	V35	-0.081	-0.478	0.152	0.130	-0.598
WTE4	V36	-0.537	0.695	-0.282	-0.265	-0.461
WTE5	V37	-0.260	-0.470	-0.298	-0.075	0.668
WTE6	V38	-0.440	0.177	0.663	0.361	-0.130
WTE7	V39	0.164	-0.024	-0.189	0.619	-0.265
WTE8	V40	0.018	0.690	0.008	-0.064	0.044
WTE9	V41	-0.115	-0.709	-0.345	0.040	0.560
WTE10	V42	0.240	0.129	0.716	0.070	-0.087
WTE11	V43	0.368	-0.017	-0.236	-0.114	0.177
VAR1	V44	-0.508	-0.975	-0.053	-0.134	-0.202
VAR2	V45	0.029	-1.178	0.064	-0.187	-0.357
VAR3	V46	0.046	-0.602	-0.030	-0.284	0.568
VAR4	V47	0.005	-0.427	0.468	-0.722	0.772
VAR5	V48	-0.146	0.470	0.413	0.413	0.270
VAR6	V49	-0.497	0.259	0.323	-0.099	-0.615
VAR7	V50	0.173	0.072	-0.261	0.059	0.434
BUR1	V51	-0.076	0.266	0.697	-0.729	0.009
BUR2	V52	-0.421	-0.342	0.162	-0.822	0.092
BUR3	V53	1.143	-0.018	-0.612	-0.134	0.639
BUR4	V54	-0.126	0.534	-0.110	-0.348	0.085
BUR5	V55	0.250	0.410	-0.223	-0.073	0.108
BUR6	V56	0.645	0.287	0.084	-0.253	-0.470
BUR7	V57	-0.400	-0.533	0.149	0.281	-0.313
BUR8	V58	0.017	0.352	0.632	0.351	-0.149
BUR9	V59	-0.434	0.432	0.234	-0.217	-0.125
BUR10	V60	0.336	0.423	0.178	-0.014	0.267
BUR11	V61	-0.240	-0.555	-0.098	-0.025	0.635

BUR12	V62	0.121	0.016	-0.487	-0.314	0.161
BUR13	V63	-0.263	0.194	-0.031	0.159	-0.393
BUR14	V64	0.163	0.903	-0.092	0.245	-0.107
BUR15	V65	0.229	0.496	-0.212	0.598	0.381
BUR16	V66	-0.621	-0.748	0.586	0.412	-0.002
BUR17	V67	-0.352	0.561	0.542	0.054	0.189
BUR18	V68	-0.634	0.163	-0.709	0.048	0.315
BUR19	V69	-0.232	0.117	0.249	0.186	-0.862
BUR20	V70	-0.154	-0.460	0.158	0.491	0.051
WFR1	V71	-0.279	0.271	0.100	-0.459	-0.262
WFR2	V72	0.405	0.193	4.769	0.144	-0.603

		DIR3	DIR4	DIR5	DIR6	DIR7
		V11	V12	V13	V14	V15
DIR3	V11	8.053				
DIR4	V12	-0.187	8.638			
DIR5	V13	0.207	0.168	7.799		
DIR6	V14	0.247	-0.169	-0.428	7.948	
DIR7	V15	0.177	0.248	-0.098	-0.035	8.705
DIR8	V16	-0.028	0.221	-0.932	-0.420	-0.914
DIR9	V17	-0.693	0.293	-0.572	-0.321	-0.476
DIR10	V18	-0.990	-0.260	-0.081	-0.213	0.360
DIR11	V19	0.162	-0.257	-0.291	-0.610	0.449
DIR12	V20	-0.073	-0.138	-0.162	0.264	0.259
DIR13	V21	0.137	-0.429	-0.196	0.458	-1.024
RES1	V22	0.439	0.021	-0.156	0.151	0.379
RES2	V23	-0.257	0.374	0.593	-0.531	0.126
RES3	V24	0.071	0.311	0.394	0.386	-0.300
RES4	V25	0.801	-0.554	-0.027	-0.433	-0.095
RES5	V26	0.004	-1.104	-0.007	0.402	-0.157

RES6	V27	0.331	-0.273	0.218	-0.016	-0.005
RES7	V28	-0.252	-0.425	-1.145	-0.693	-0.287
RES8	V29	-0.217	0.321	-0.182	0.342	0.079
RES9	V30	0.455	-0.111	0.404	0.405	0.161
RES10	V31	-0.403	-0.082	-0.006	-0.261	0.092
RES11	V32	0.967	-0.681	0.461	-0.522	-0.577
WTE1	V33	0.689	0.208	0.317	-0.369	-0.393
WTE2	V34	-0.580	-0.052	-0.208	-0.059	0.183
WTE3	V35	-0.556	0.324	0.198	0.056	1.565
WTE4	V36	0.436	0.023	0.308	-0.221	0.595
WTE5	V37	0.300	-0.303	-0.160	0.055	0.083
WTE6	V38	-0.243	0.173	0.771	0.491	-0.432
WTE7	V39	-0.968	-0.888	-0.319	0.029	-0.466
WTE8	V40	0.162	0.177	-0.206	-0.206	0.217
WTE9	V41	0.323	-0.585	0.094	0.247	0.529
WTE10	V42	-0.264	0.061	-0.334	0.417	-0.044
WTE11	V43	-0.298	0.180	-0.243	-0.528	0.101
VAR1	V44	-0.039	0.550	0.638	0.053	0.377
VAR2	V45	-0.465	0.018	0.553	-0.045	-0.011
VAR3	V46	0.341	0.230	0.414	-0.232	-0.455
VAR4	V47	0.314	-0.362	0.044	-0.130	-0.078
VAR5	V48	-0.141	0.281	0.338	-0.689	-0.465
VAR6	V49	0.041	-0.425	-0.963	0.819	-0.415
VAR7	V50	0.261	0.357	-0.026	0.025	-0.199
BUR1	V51	0.106	-0.538	0.170	-0.299	-0.601
BUR2	V52	0.368	0.761	-0.145	-0.381	-0.121
BUR3	V53	0.647	-0.291	0.297	-0.779	-0.061
BUR4	V54	-0.567	0.517	0.055	-0.219	0.577

BUR5	V55	-0.676	0.409	0.026	-0.012	0.073
BUR6	V56	0.486	0.830	-0.061	-0.109	0.145
BUR7	V57	-0.049	0.015	0.284	0.239	-0.163
BUR8	V58	-0.105	0.284	0.283	0.596	-0.507
BUR9	V59	0.278	0.605	-0.204	-0.933	0.079
BUR10	V60	0.357	-0.163	0.428	0.186	-0.145
BUR11	V61	0.125	0.342	0.347	-0.135	-0.098
BUR12	V62	0.276	-0.212	0.304	-0.141	-0.385
BUR13	V63	0.039	0.538	0.240	0.006	-0.575
BUR14	V64	-0.007	-0.034	0.141	-0.616	0.806
BUR15	V65	-0.574	0.746	-0.267	-0.171	0.025
BUR16	V66	-0.324	0.087	0.318	-0.256	-0.368
BUR17	V67	-0.713	0.323	-0.239	-0.265	-0.060
BUR18	V68	-0.286	-0.229	0.738	-0.423	0.580
BUR19	V69	0.115	0.489	0.064	0.193	1.308
BUR20	V70	0.129	-0.689	0.683	-0.298	0.294
WFR1	V71	-0.017	0.601	3.551	-0.276	0.101
WFR2	V72	0.476	-0.037	-0.644	3.718	0.365

		DIR8	DIR9	DIR10	DIR11	DIR12
		V16	V17	V18	V19	V20
DIR8	V16	8.676				
DIR9	V17	0.214	9.010			
DIR10	V18	-0.674	0.349	8.233		
DIR11	V19	-0.553	-0.669	-0.637	8.114	
DIR12	V20	-0.768	0.435	0.271	0.051	8.135
DIR13	V21	-0.177	-0.255	-0.739	-0.802	0.248
RES1	V22	-0.179	-0.281	-0.412	-0.148	0.381
RES2	V23	-0.033	0.093	-0.055	-0.109	0.084
RES3	V24	0.756	0.157	-0.187	0.307	-0.721

RES4	V25	0.356	0.083	-0.273	-0.011	0.986
RES5	V26	0.088	0.007	-0.013	0.159	0.033
RES6	V27	0.078	0.085	-0.292	0.428	0.217
RES7	V28	0.059	0.616	0.048	-0.788	0.147
RES8	V29	0.475	-0.163	-0.097	-0.028	-0.254
RES9	V30	0.389	-0.571	-0.192	0.475	0.421
RES10	V31	0.291	0.324	0.344	-0.287	-0.097
RES11	V32	-0.116	0.146	-0.344	-1.108	0.117
WTE1	V33	0.389	0.205	-0.077	0.005	-0.376
WTE2	V34	0.449	0.008	0.026	-0.265	0.546
WTE3	V35	0.122	-0.611	-0.531	0.401	0.802
WTE4	V36	-0.190	-0.103	0.280	0.046	-0.073
WTE5	V37	-0.435	-0.740	0.103	0.446	0.207
WTE6	V38	-0.471	-0.225	-0.174	0.619	-0.302
WTE7	V39	0.250	0.486	0.308	-0.030	0.934
WTE8	V40	0.025	0.603	-0.172	-0.136	-0.323
WTE9	V41	-0.159	-0.292	0.886	-0.408	-0.926
WTE10	V42	-0.714	0.099	0.061	-0.297	-0.722
WTE11	V43	0.306	0.301	0.115	-0.273	0.163
VAR1	V44	-0.307	0.313	-0.508	0.238	-0.103
VAR2	V45	0.207	0.454	-0.133	-0.096	0.137
VAR3	V46	0.265	-0.723	-0.090	-0.509	-0.144
VAR4	V47	-0.017	-0.139	-1.266	0.408	-0.473
VAR5	V48	-0.596	-0.440	0.412	0.448	0.067
VAR6	V49	0.125	0.644	0.126	-0.124	0.395
VAR7	V50	0.043	0.066	0.161	-0.036	0.039
BUR1	V51	-0.322	0.008	0.124	-0.792	-0.016
BUR2	V52	0.540	0.296	0.405	-0.690	-0.317

BUR3	V53	-0.006	-0.250	-0.096	-0.118	0.637
BUR4	V54	0.161	-0.090	0.024	-0.655	-0.087
BUR5	V55	-0.460	-0.254	0.280	0.598	0.877
BUR6	V56	0.529	0.578	0.323	-0.495	0.217
BUR7	V57	-0.133	-0.172	-0.272	-0.527	-0.062
BUR8	V58	0.187	0.106	0.129	-0.206	0.127
BUR9	V59	0.023	0.058	-0.195	0.471	0.176
BUR10	V60	0.155	-0.549	0.444	0.114	-0.480
BUR11	V61	-0.367	-0.081	0.838	0.232	0.250
BUR12	V62	0.005	0.217	-0.486	0.693	0.098
BUR13	V63	0.161	-0.423	0.215	0.204	-0.129
BUR14	V64	0.076	0.655	0.638	0.188	-0.108
BUR15	V65	-0.180	0.150	-1.186	0.119	0.217
BUR16	V66	0.394	0.213	-0.264	-0.017	0.527
BUR17	V67	0.577	0.267	-0.215	-0.129	-0.106
BUR18	V68	0.470	-0.928	-0.176	-0.244	0.046
BUR19	V69	-0.076	-0.270	-0.694	-0.424	-0.153
BUR20	V70	0.595	0.198	-0.129	-0.640	0.156
WFR1	V71	0.287	-0.879	0.121	-0.190	-0.369
WFR2	V72	-0.292	-0.791	0.340	-0.611	0.505

		DIR13	RES1	RES2	RES3	RES4
		V21	V22	V23	V24	V25
DIR13	V21	8.558				
RES1	V22	0.290	8.102			
RES2	V23	0.608	0.885	8.396		
RES3	V24	0.007	0.035	0.301	8.289	
RES4	V25	0.005	0.001	-0.070	-0.449	8.817
RES5	V26	-0.191	-0.079	0.069	-0.168	0.147
RES6	V27	-0.220	-0.235	0.448	0.427	0.186

RES7	V28	-0.237	0.691	-0.515	-0.282	-0.322
RES8	V29	0.533	0.342	0.828	-0.195	0.507
RES9	V30	-0.004	0.190	-0.335	0.229	0.269
RES10	V31	-0.265	0.595	-0.282	-0.474	-0.208
RES11	V32	0.448	-0.172	0.281	-0.132	0.480
WTE1	V33	0.260	-0.744	-0.352	0.149	-0.252
WTE2	V34	0.429	-0.401	0.366	0.108	-0.468
WTE3	V35	-0.300	0.403	-0.001	-0.943	0.659
WTE4	V36	1.008	0.099	0.223	0.144	0.268
WTE5	V37	0.937	0.589	0.468	-0.526	0.252
WTE6	V38	1.075	0.632	0.669	1.181	0.021
WTE7	V39	0.534	0.280	0.555	-0.630	0.481
WTE8	V40	-0.221	0.346	-0.410	-0.333	-0.283
WTE9	V41	-0.096	0.526	0.153	-0.341	0.169
WTE10	V42	0.274	-0.442	-0.370	0.093	0.722
WTE11	V43	0.111	0.409	0.550	0.920	0.121
VAR1	V44	0.011	0.019	-0.109	-0.316	0.744
VAR2	V45	0.324	-0.747	0.655	0.549	-0.065
VAR3	V46	-0.060	-0.361	0.247	0.342	-0.077
VAR4	V47	0.278	0.348	0.230	1.057	0.191
VAR5	V48	-0.327	-0.394	0.456	-1.009	0.127
VAR6	V49	0.007	-0.070	-0.007	0.457	-0.247
VAR7	V50	-0.370	0.282	-0.245	-0.387	0.146
BUR1	V51	0.353	-0.334	-0.893	-0.012	-0.065
BUR2	V52	-0.663	0.149	0.333	-0.022	-0.448
BUR3	V53	0.199	0.108	0.016	-0.118	0.656
BUR4	V54	-0.135	0.088	-0.847	-0.681	0.263
BUR5	V55	-0.004	-0.174	0.073	-0.097	0.270

BUR6	V56	-0.026	0.130	0.027	-0.571	0.038
BUR7	V57	-0.470	-0.981	-0.452	-0.630	0.155
BUR8	V58	0.558	-0.015	0.245	-0.218	-0.172
BUR9	V59	0.314	-0.115	-0.598	-0.182	0.841
BUR10	V60	1.002	0.411	0.073	0.324	0.366
BUR11	V61	0.122	-0.628	-0.047	-0.391	0.032
BUR12	V62	-0.441	-0.141	-0.382	-0.116	0.738
BUR13	V63	0.633	-0.450	0.222	0.282	-0.681
BUR14	V64	-0.415	-0.236	-0.651	0.168	0.047
BUR15	V65	-0.384	-0.453	-0.135	0.222	0.159
BUR16	V66	0.303	-0.048	-0.002	-0.159	-0.073
BUR17	V67	-0.204	0.110	-0.324	0.393	-0.146
BUR18	V68	-0.525	-0.099	0.052	-0.573	-0.374
BUR19	V69	-0.030	-0.297	-0.622	-0.746	0.073
BUR20	V70	-0.037	0.371	0.772	0.393	-0.246
WFR1	V71	-0.554	0.328	0.661	-0.064	0.261
WFR2	V72	0.481	-0.266	-0.082	0.650	-0.231

		RES5	RES6	RES7	RES8	RES9
		V26	V27	V28	V29	V30
RES5	V26	8.254				
RES6	V27	-0.131	8.677			
RES7	V28	0.472	-0.198	8.099		
RES8	V29	-0.014	-0.403	-0.733	8.321	
RES9	V30	0.390	0.210	0.263	-0.553	8.506
RES10	V31	-0.234	0.035	0.481	-0.642	0.372
RES11	V32	-0.326	-0.268	0.179	-0.041	0.306
WTE1	V33	-0.027	0.120	-0.467	0.171	-0.104
WTE2	V34	0.393	-0.340	-0.641	0.090	-0.259
WTE3	V35	-0.145	0.084	-0.154	0.940	0.260

WTE4	V36	0.209	-1.180	-0.311	0.257	-0.093
WTE5	V37	-0.271	-0.210	0.085	0.204	0.477
WTE6	V38	0.543	0.286	0.430	0.654	0.296
WTE7	V39	0.705	-0.023	0.266	0.238	-0.206
WTE8	V40	0.213	0.294	0.042	0.183	0.043
WTE9	V41	0.025	0.646	-0.252	0.023	0.019
WTE10	V42	0.478	-0.776	-0.424	0.009	-0.059
WTE11	V43	0.008	0.413	0.068	0.257	-0.484
VAR1	V44	1.018	-0.091	0.247	-0.163	0.179
VAR2	V45	0.075	0.111	-0.708	0.082	-0.123
VAR3	V46	0.128	0.087	0.139	-0.416	0.231
VAR4	V47	0.660	0.067	-0.355	0.416	-0.206
VAR5	V48	0.000	0.253	0.049	0.043	-0.465
VAR6	V49	0.442	0.613	1.160	0.804	-0.078
VAR7	V50	-0.043	-0.338	-0.519	-0.617	-0.330
BUR1	V51	0.081	0.608	-0.306	0.139	-0.322
BUR2	V52	-0.142	0.359	-0.162	0.446	0.542
BUR3	V53	-0.314	0.104	0.160	-0.404	-0.366
BUR4	V54	-0.610	-0.161	-0.165	0.356	-0.068
BUR5	V55	-0.122	0.209	-0.458	-0.083	-0.365
BUR6	V56	0.148	0.439	-0.494	0.050	-0.736
BUR7	V57	-0.307	-0.595	-0.359	1.165	0.204
BUR8	V58	-0.364	-0.451	0.416	-0.257	0.410
BUR9	V59	0.323	-0.039	0.166	-0.006	0.546
BUR10	V60	0.681	0.376	0.282	-0.308	0.494
BUR11	V61	-0.303	-0.317	0.147	-0.076	0.162
BUR12	V62	0.184	-0.255	-0.231	0.763	1.162
BUR13	V63	-0.662	0.443	-1.074	0.031	0.261

BUR14	V64	0.220	0.382	0.057	-0.310	-0.089
BUR15	V65	-0.079	-0.173	0.356	-1.184	0.324
BUR16	V66	0.116	-0.176	-0.157	0.304	-0.183
BUR17	V67	0.046	0.125	0.141	-0.338	0.167
BUR18	V68	-0.541	0.341	-0.945	0.446	0.167
BUR19	V69	0.636	-0.071	-0.267	-0.120	-0.237
BUR20	V70	0.508	0.104	0.049	0.214	0.079
WFR1	V71	-0.502	0.193	-0.494	0.484	0.046
WFR2	V72	0.213	-0.092	0.082	-0.057	-0.396

		RES10	RES11	WTE1	WTE2	WTE3
		V31	V32	V33	V34	V35
RES10	V31	8.070				
RES11	V32	1.075	8.174			
WTE1	V33	0.064	0.540	7.917		
WTE2	V34	-0.086	0.521	0.391	8.090	
WTE3	V35	-0.038	-0.215	-0.903	-0.314	9.345
WTE4	V36	0.435	0.525	0.161	-0.068	-0.230
WTE5	V37	-0.844	-0.009	0.186	-0.084	-0.059
WTE6	V38	-0.564	-0.385	-0.116	-0.016	-0.132
WTE7	V39	0.377	0.142	-0.025	0.762	-0.317
WTE8	V40	-0.540	-0.179	0.795	0.440	-0.224
WTE9	V41	0.057	-0.220	-0.429	-0.069	-0.524
WTE10	V42	0.154	-0.646	-0.396	-0.345	0.276
WTE11	V43	0.041	-0.209	0.058	0.214	-0.330
VAR1	V44	-0.110	0.003	-0.217	0.227	0.320
VAR2	V45	0.537	0.121	-0.302	0.211	0.452
VAR3	V46	0.163	-0.166	-0.487	-0.159	0.353
VAR4	V47	-0.236	-0.126	0.534	-0.082	-0.325
VAR5	V48	-0.147	-0.085	0.399	0.193	0.091

VAR6	V49	0.015	-0.406	0.087	-0.281	-1.079
VAR7	V50	0.108	-0.093	-0.137	-0.447	0.290
BUR1	V51	-0.235	0.400	-0.274	-0.018	-0.107
BUR2	V52	0.090	0.314	-0.450	0.891	0.356
BUR3	V53	-0.530	0.449	-0.161	-0.400	-0.624
BUR4	V54	-0.654	-1.055	-0.111	0.430	0.197
BUR5	V55	0.608	-0.471	-0.825	-0.199	0.234
BUR6	V56	-0.303	-0.438	0.301	-0.505	0.313
BUR7	V57	-0.631	0.404	0.382	0.234	-0.458
BUR8	V58	0.665	-0.096	0.183	-0.030	0.507
BUR9	V59	-0.214	-0.031	0.456	-0.173	0.010
BUR10	V60	-0.114	-0.040	-0.131	0.022	0.486
BUR11	V61	0.131	0.598	0.297	-0.664	-0.043
BUR12	V62	-0.208	0.216	0.399	-0.172	-0.243
BUR13	V63	0.446	0.061	-0.561	0.450	-0.257
BUR14	V64	0.209	-0.130	-0.017	0.236	0.004
BUR15	V65	-0.333	-0.143	-0.290	0.181	0.363
BUR16	V66	0.654	0.187	-0.778	0.277	0.221
BUR17	V67	-0.031	0.330	-0.389	-0.373	-0.030
BUR18	V68	-0.068	0.384	-0.116	0.673	0.432
BUR19	V69	-0.252	-0.800	0.299	-0.080	-0.155
BUR20	V70	0.678	0.318	0.056	0.636	1.086
WFR1	V71	-0.222	-0.252	0.069	-0.135	0.269
WFR2	V72	0.246	-0.088	-0.057	0.009	-0.135

		WTE4	WTE5	WTE6	WTE7	WTE8
		V36	V37	V38	V39	V40
WTE4	V36	8.049				
WTE5	V37	0.567	8.417			
WTE6	V38	0.237	0.389	8.249		

WTE7	V39	0.148	-0.424	0.012	8.507	
WTE8	V40	-0.045	0.586	-0.141	0.165	7.801
WTE9	V41	-0.062	0.696	-0.090	-0.743	-0.069
WTE10	V42	-0.284	-0.491	-0.290	-0.259	0.090
WTE11	V43	0.218	-0.302	0.263	-0.654	0.583
VAR1	V44	-0.105	0.198	-0.332	-0.130	0.339
VAR2	V45	0.150	-0.360	0.238	0.720	-0.159
VAR3	V46	-0.468	0.047	-0.306	-0.895	-0.697
VAR4	V47	-0.552	0.986	-0.171	0.355	-0.450
VAR5	V48	0.161	-0.049	-0.409	-0.753	0.051
VAR6	V49	-0.346	-0.379	-0.818	0.129	0.785
VAR7	V50	0.758	-0.646	0.097	0.194	-0.472
BUR1	V51	0.043	-0.429	-0.121	-0.028	-0.276
BUR2	V52	0.641	0.087	-0.137	0.106	0.260
BUR3	V53	-0.140	-0.064	-0.661	0.604	0.723
BUR4	V54	0.013	-0.313	0.093	0.120	-0.463
BUR5	V55	0.296	-0.093	-0.266	0.611	-0.732
BUR6	V56	-0.609	-0.024	0.158	0.108	0.650
BUR7	V57	0.444	0.016	0.083	0.341	0.180
BUR8	V58	0.310	0.003	0.581	-0.396	-0.237
BUR9	V59	0.053	-0.553	0.244	0.241	0.662
BUR10	V60	-0.587	-0.653	-0.203	-0.049	0.054
BUR11	V61	-0.351	0.188	0.488	0.051	-0.527
BUR12	V62	-0.449	-0.372	-0.115	0.138	0.920
BUR13	V63	-0.153	0.456	-0.267	0.366	-0.250
BUR14	V64	0.004	-0.867	0.329	-0.447	0.605
BUR15	V65	-0.497	-0.151	0.022	0.238	0.845
BUR16	V66	-0.089	0.015	-0.046	0.757	-0.165
BUR17	V67	-0.800	0.893	-0.304	0.406	-0.336

BUR18	V68	-0.369	0.170	0.065	0.743	-0.004
BUR19	V69	-0.264	0.081	-0.084	-0.634	-0.100
BUR20	V70	-0.626	-0.798	0.704	0.215	0.620
WFR1	V71	-0.193	-0.039	0.272	0.042	-0.199
WFR2	V72	0.007	-0.135	0.699	-0.112	-0.037

		WTE9	WTE10	WTE11	VAR1	VAR2
		V41	V42	V43	V44	V45
WTE9	V41	8.325				
WTE10	V42	0.594	8.118			
WTE11	V43	0.310	-0.843	8.250		
VAR1	V44	0.711	-0.113	-0.567	8.446	
VAR2	V45	0.064	0.527	-0.214	0.808	8.415
VAR3	V46	0.127	-0.191	-0.321	-0.160	-0.272
VAR4	V47	0.160	-0.096	-0.281	0.174	-0.637
VAR5	V48	0.195	-0.842	0.520	0.807	-0.114
VAR6	V49	-0.860	0.312	0.218	0.227	0.077
VAR7	V50	0.646	0.570	-0.185	-0.148	-0.440
BUR1	V51	0.225	0.560	-0.007	-0.674	0.022
BUR2	V52	0.673	-0.061	-0.406	0.289	0.383
BUR3	V53	0.275	-0.034	-0.011	-0.830	-0.068
BUR4	V54	0.471	0.487	0.355	-0.717	-0.531
BUR5	V55	-0.019	0.716	-0.435	-0.566	0.213
BUR6	V56	0.117	0.739	-0.266	-0.307	0.272
BUR7	V57	0.541	-0.292	-0.461	0.148	-0.471
BUR8	V58	0.351	-0.536	0.091	0.350	-0.202
BUR9	V59	-0.036	-0.711	0.349	0.353	0.106
BUR10	V60	0.238	0.038	0.011	0.097	-0.260
BUR11	V61	0.359	0.033	-0.037	-0.527	-0.452
BUR12	V62	0.241	0.111	-0.875	0.608	-0.312

BUR13	V63	-0.086	-0.107	0.276	-0.738	-0.473
BUR14	V64	-0.373	1.287	-0.513	-0.766	-0.293
BUR15	V65	0.482	0.154	0.499	-0.061	0.145
BUR16	V66	-0.238	0.031	-0.046	0.074	-0.048
BUR17	V67	-0.199	0.089	0.022	-0.191	-0.370
BUR18	V68	-0.220	-0.179	-0.667	-0.324	0.105
BUR19	V69	0.257	-0.320	-0.584	0.500	0.872
BUR20	V70	-0.294	-0.859	0.436	-0.363	-0.155
WFR1	V71	0.339	-0.323	-0.476	0.338	-0.205
WFR2	V72	0.201	0.118	-0.208	-0.085	0.114

		VAR3	VAR4	VAR5	VAR6	VAR7
		V46	V47	V48	V49	V50
VAR3	V46	8.380				
VAR4	V47	0.347	8.666			
VAR5	V48	0.812	0.237	8.984		
VAR6	V49	-0.679	0.288	-0.003	8.501	
VAR7	V50	-0.301	0.052	0.229	-0.176	8.070
BUR1	V51	-0.029	0.197	-0.041	-0.087	0.569
BUR2	V52	0.517	-0.220	0.445	-0.244	0.757
BUR3	V53	0.485	0.621	-0.243	0.272	0.723
BUR4	V54	-0.038	0.345	-0.589	-0.889	-0.181
BUR5	V55	0.052	-0.383	-0.024	-0.186	0.388
BUR6	V56	-0.022	-0.745	0.333	0.209	-0.509
BUR7	V57	-0.578	-0.779	-0.302	0.456	0.618
BUR8	V58	-0.227	-0.394	-0.287	0.200	0.444
BUR9	V59	-0.683	-0.111	0.722	-0.139	0.054
BUR10	V60	-0.179	0.212	-0.271	-0.586	-0.140
BUR11	V61	-0.523	-0.612	0.470	-0.769	1.086
BUR12	V62	-0.920	0.235	-0.026	0.350	-0.371

BUR13	V63	0.342	-0.151	-0.541	-0.531	-0.241
BUR14	V64	0.269	0.010	-0.224	-0.225	0.312
BUR15	V65	-0.513	-0.306	-1.079	-0.679	0.537
BUR16	V66	-0.574	0.686	-0.225	-0.497	0.764
BUR17	V67	0.204	0.648	-0.380	0.108	-0.334
BUR18	V68	-0.353	0.243	0.157	-0.290	-0.564
BUR19	V69	0.284	-0.025	-0.057	0.141	0.221
BUR20	V70	0.601	0.105	0.197	0.001	0.242
WFR1	V71	0.515	0.257	-0.187	-0.331	-0.528
WFR2	V72	0.302	0.062	0.083	0.280	-0.022

		BUR1	BUR2	BUR3	BUR4	BUR5
		V51	V52	V53	V54	V55
BUR1	V51	8.178				
BUR2	V52	0.454	8.288			
BUR3	V53	0.505	-0.087	8.257		
BUR4	V54	-0.089	-0.049	0.280	8.466	
BUR5	V55	-0.023	0.747	0.527	0.251	7.767
BUR6	V56	-0.860	-0.564	0.196	0.700	-0.048
BUR7	V57	-0.461	-0.792	-0.335	-0.289	-0.236
BUR8	V58	0.639	0.074	-0.507	-0.201	-0.807
BUR9	V59	-0.047	-0.458	0.268	0.107	-0.253
BUR10	V60	0.222	-0.013	-0.430	-0.557	0.169
BUR11	V61	0.138	0.100	0.246	-0.267	-0.084
BUR12	V62	0.734	0.156	-0.068	-0.514	0.358
BUR13	V63	-0.037	0.019	-0.130	0.002	0.481
BUR14	V64	0.441	-0.660	0.694	1.061	-0.006
BUR15	V65	0.335	0.140	0.039	0.013	0.450
BUR16	V66	0.261	-0.042	-0.080	-0.144	-0.316
BUR17	V67	0.431	-0.258	-0.235	0.346	0.335

BUR18	V68	-0.441	-0.078	-0.016	0.246	-0.468
BUR19	V69	0.131	0.230	-0.341	0.390	-0.128
BUR20	V70	-0.176	0.072	0.656	-0.472	-0.706
WFR1	V71	0.078	-0.045	0.421	0.008	0.490
WFR2	V72	-0.132	-0.143	-0.974	0.344	0.098

		BUR6	BUR7	BUR8	BUR9	BUR10
		V56	V57	V58	V59	V60
BUR6	V56	7.921				
BUR7	V57	-0.469	8.611			
BUR8	V58	0.347	-0.098	8.093		
BUR9	V59	0.194	-0.100	-0.237	7.995	
BUR10	V60	0.139	-0.434	0.463	-0.144	8.191
BUR11	V61	0.216	0.470	-0.904	0.156	0.211
BUR12	V62	-0.453	0.533	-0.126	0.820	0.600
BUR13	V63	-0.504	-0.002	0.290	-0.557	0.195
BUR14	V64	0.480	0.123	0.381	0.266	-0.648
BUR15	V65	0.575	-0.634	-0.246	-0.250	-0.634
BUR16	V66	-0.449	-0.590	0.339	-0.477	0.143
BUR17	V67	-0.516	-0.453	-0.041	0.775	0.059
BUR18	V68	0.128	-0.359	-0.592	-0.350	0.483
BUR19	V69	-0.436	0.189	-0.177	-0.353	-0.183
BUR20	V70	0.487	-0.424	0.481	0.248	0.178
WFR1	V71	0.117	-0.024	0.457	0.161	0.323
WFR2	V72	0.159	0.452	0.305	0.054	0.292

		BUR11	BUR12	BUR13	BUR14	BUR15
		V61	V62	V63	V64	V65
BUR11	V61	8.245				
BUR12	V62	0.735	8.118			
BUR13	V63	0.379	-0.400	7.838		
BUR14	V64	-0.023	-0.129	-0.466	8.260	

```
     BUR15     V65          0.380       -0.584        0.251       -0.313
7.660
     BUR16     V66          0.261       -0.180        0.080       -0.369
0.420
     BUR17     V67         -0.125        0.061        0.747       -0.027
0.526
     BUR18     V68          0.149        0.321        0.384       -0.079      -
0.086
     BUR19     V69          0.183       -0.459        0.478       -0.515      -
0.048
     BUR20     V70         -0.008       -0.299        0.390        0.207
0.069
       WFR1    V71         -0.302        0.708        0.888       -0.571      -
0.660
       WFR2    V72          0.358       -0.393       -0.320       -0.173      -
0.169


                          BUR16        BUR17        BUR18        BUR19
BUR20
                             V66          V67          V68          V69
V70
     BUR16     V66          7.788
     BUR17     V67          0.424        8.295
     BUR18     V68          0.507        0.294        8.195
     BUR19     V69         -0.377        0.194        0.155        8.017
     BUR20     V70         -0.341       -0.145       -0.215        0.142
8.090
       WFR1    V71          0.050        0.042        0.739        0.379
0.258
       WFR2    V72          0.228       -0.267       -0.797        0.175
0.346


                            WFR1         WFR2
                             V71          V72
       WFR1    V71          8.263
       WFR2    V72         -0.237        8.180


  BENTLER-WEEKS STRUCTURAL REPRESENTATION:

        NUMBER OF DEPENDENT VARIABLES = 15
            DEPENDENT V'S :      8    21    32    43    48    70    71    72
            DEPENDENT F'S :      1     2     3     4     5     6     7

        NUMBER OF INDEPENDENT VARIABLES = 73
            INDEPENDENT V'S :      1     2     3     4     5     6     7     9
10   11
            INDEPENDENT V'S :     12    13    14    15    16    17    18    19
20   22
            INDEPENDENT V'S :     23    24    25    26    27    28    29    30
31   33
            INDEPENDENT V'S :     34    35    36    37    38    39    40    41
42   44
```

```
            INDEPENDENT V'S :     45    46    47    49    50    51    52    53
54    55
            INDEPENDENT V'S :     56    57    58    59    60    61    62    63
64    65
            INDEPENDENT V'S :     66    67    68    69
            INDEPENDENT E'S :      8    21    32    43    48    70    71    72
            INDEPENDENT D'S :      7

        NUMBER OF FREE PARAMETERS = 144
        NUMBER OF FIXED NONZERO PARAMETERS =  16

 *** WARNING MESSAGES ABOVE, IF ANY, REFER TO THE MODEL PROVIDED.
     CALCULATIONS FOR INDEPENDENCE MODEL NOW BEGIN.

 *** WARNING MESSAGES ABOVE, IF ANY, REFER TO INDEPENDENCE MODEL.
     CALCULATIONS FOR USER'S MODEL NOW BEGIN.


  3RD STAGE OF COMPUTATION REQUIRED    957288 WORDS OF MEMORY.
  PROGRAM ALLOCATED  40000000 WORDS

  DETERMINANT OF INPUT MATRIX IS   0.20969D+63

  PARAMETER        CONDITION CODE
    D7,D7          LINEARLY DEPENDENT ON OTHER PARAMETERS


  MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)



  RESIDUAL COVARIANCE MATRIX  (S-SIGMA) :


                            PRE1        PRE2        PRE3        PRE4
PRE5
                             V1          V2          V3          V4
V5
       PRE1   V1            0.000
       PRE2   V2           -0.372       0.000
       PRE3   V3            0.079      -0.620       0.000
       PRE4   V4           -0.363       0.126      -0.131       0.000
       PRE5   V5            1.227      -0.592       1.014       0.289
0.000
       PRE6   V6            0.050      -0.716      -0.708       0.204
0.763
       PRE7   V7           -0.061       0.800       0.773      -0.291      -
0.366
       PRE8   V8            0.221      -0.101      -0.653      -0.475      -
0.757
       DIR1   V9            0.016      -0.139      -0.091       0.260      -
0.353
       DIR2   V10          -0.380      -0.506      -0.716       0.501
0.765
       DIR3   V11          -0.226       0.220      -0.384      -0.040
0.657
```

DIR4	V12	0.560	0.533	-0.025	-0.444	-0.153
DIR5	V13	-0.124	0.263	0.236	0.724	0.131
DIR6	V14	-0.566	0.345	-0.367	0.001	-0.326
DIR7	V15	1.286	0.103	0.223	0.323	-0.254
DIR8	V16	-0.225	0.336	-0.025	-0.103	-0.355
DIR9	V17	-0.204	-0.464	0.091	-0.456	-0.491
DIR10	V18	0.117	0.194	-0.216	0.565	-0.754
DIR11	V19	0.067	-0.521	0.949	0.198	0.212
DIR12	V20	-0.530	-0.265	0.623	0.089	-0.759
DIR13	V21	0.011	-0.467	0.712	-0.176	0.293
RES1	V22	0.337	-0.216	-0.242	-0.148	0.336
RES2	V23	0.909	0.035	0.393	0.311	0.518
RES3	V24	-0.670	-0.415	-0.304	-0.437	-0.289
RES4	V25	0.219	0.197	0.070	0.090	0.202
RES5	V26	-0.093	-0.112	0.110	0.242	0.280
RES6	V27	0.652	-0.044	0.710	0.218	-0.161
RES7	V28	0.163	0.597	0.024	0.032	-0.333
RES8	V29	-0.103	0.038	0.194	-0.439	0.261
RES9	V30	0.729	-0.386	0.753	1.221	1.037
RES10	V31	0.032	-0.356	-0.007	0.043	-0.838
RES11	V32	-0.510	-0.480	-0.007	0.669	-0.240
WTE1	V33	-0.639	0.034	0.220	-0.253	0.056
WTE2	V34	-0.216	-0.602	-0.057	-0.708	-0.452
WTE3	V35	0.001	0.509	0.561	0.430	-0.089
WTE4	V36	-0.100	0.047	-0.667	0.540	-0.264
WTE5	V37	0.175	0.145	1.036	-0.191	-0.414
WTE6	V38	0.204	-0.134	0.758	0.110	0.379
WTE7	V39	-0.304	0.148	0.190	0.644	0.241

WTE8	V40	-0.302	-0.357	0.333	-0.948	0.162
WTE9	V41	-0.141	-0.035	0.359	0.206	-0.233
WTE10	V42	0.744	-0.354	-0.049	-0.267	-0.408
WTE11	V43	0.599	-0.371	-0.039	-0.814	0.429
VAR1	V44	0.273	0.247	-0.043	-0.040	0.530
VAR2	V45	-0.097	-0.890	0.141	0.666	-0.829
VAR3	V46	-0.106	0.502	-0.155	-0.335	-0.328
VAR4	V47	-0.278	-0.322	0.036	-0.475	0.326
VAR5	V48	0.101	-0.155	0.227	-0.491	0.290
VAR6	V49	0.044	0.140	-0.307	-0.307	-0.456
VAR7	V50	-0.186	-0.254	-0.509	0.201	0.476
BUR1	V51	-0.708	-0.168	0.686	0.240	0.270
BUR2	V52	0.611	0.176	0.000	0.127	0.844
BUR3	V53	-0.758	0.056	-0.657	-0.047	-0.514
BUR4	V54	-0.153	-0.522	-0.343	-0.601	-0.675
BUR5	V55	0.254	0.185	0.268	-0.346	-0.425
BUR6	V56	0.040	-0.301	-0.163	-0.512	-0.325
BUR7	V57	0.046	0.477	-0.570	-0.220	0.103
BUR8	V58	0.475	0.682	0.981	0.281	0.234
BUR9	V59	-0.001	0.483	-0.052	0.126	0.383
BUR10	V60	0.975	-0.095	0.060	0.316	0.154
BUR11	V61	0.420	-0.326	-0.334	0.402	0.349
BUR12	V62	-0.648	0.146	0.893	0.757	1.128
BUR13	V63	0.198	-0.113	0.104	0.003	-0.970
BUR14	V64	0.103	-0.487	0.305	-0.665	-0.757
BUR15	V65	-0.263	-0.633	-0.252	0.073	0.674
BUR16	V66	0.092	0.102	0.603	0.412	-0.314
BUR17	V67	0.237	0.028	0.210	-0.085	-0.533

BUR18	V68	0.126	0.141	0.812	0.516	-0.446
BUR19	V69	0.979	0.094	-0.727	0.119	-0.177
BUR20	V70	-0.549	0.243	0.040	-0.390	0.020
WFR1	V71	-0.260	0.146	-0.260	0.284	-0.228
WFR2	V72	-0.523	0.238	-0.638	-0.545	-0.812

		PRE6	PRE7	PRE8	DIR1	DIR2
		V6	V7	V8	V9	V10
PRE6	V6	0.000				
PRE7	V7	0.094	0.000			
PRE8	V8	0.682	0.181	0.000		
DIR1	V9	-0.397	0.179	0.311	0.000	
DIR2	V10	0.300	-0.173	-0.508	0.106	0.000
DIR3	V11	0.465	-0.141	0.026	-0.320	0.016
DIR4	V12	-0.696	0.830	-0.445	0.166	-1.153
DIR5	V13	0.161	-0.819	-0.338	0.373	0.264
DIR6	V14	-0.276	-0.242	0.315	0.203	-0.599
DIR7	V15	-0.147	0.411	0.187	0.120	-0.394
DIR8	V16	-0.279	0.466	-0.922	0.022	-0.535
DIR9	V17	0.252	-0.210	-0.051	0.528	0.201
DIR10	V18	-0.585	0.170	0.617	0.579	-0.153
DIR11	V19	-0.118	0.502	0.081	-0.120	0.027
DIR12	V20	0.041	0.623	0.094	0.099	0.769
DIR13	V21	-0.130	0.353	0.078	-0.510	-0.703
RES1	V22	-0.351	-0.579	-0.306	-0.536	0.196
RES2	V23	0.684	-0.329	0.413	-0.778	0.008
RES3	V24	-0.059	-0.081	0.231	0.000	-0.223
RES4	V25	-0.294	-0.716	0.083	-0.203	-0.265
RES5	V26	-0.356	-0.199	-0.461	0.140	-0.682
RES6	V27	-0.417	0.329	0.522	-0.082	-0.769

RES7	V28	0.037	0.357	0.470	-0.149	0.127
RES8	V29	-0.355	-0.855	-0.561	-0.324	-1.259
RES9	V30	-0.305	-0.259	-0.764	0.057	0.092
RES10	V31	0.398	-0.421	0.511	0.368	-0.167
RES11	V32	1.004	-0.177	0.403	0.067	-0.313
WTE1	V33	0.608	1.000	-0.276	0.259	0.071
WTE2	V34	-0.515	0.543	-0.369	0.236	-1.235
WTE3	V35	-0.081	-0.478	0.152	0.130	-0.598
WTE4	V36	-0.537	0.695	-0.282	-0.265	-0.461
WTE5	V37	-0.260	-0.470	-0.298	-0.075	0.668
WTE6	V38	-0.440	0.177	0.663	0.361	-0.130
WTE7	V39	0.164	-0.024	-0.189	0.619	-0.265
WTE8	V40	0.018	0.690	0.008	-0.064	0.044
WTE9	V41	-0.115	-0.709	-0.345	0.040	0.560
WTE10	V42	0.240	0.129	0.716	0.070	-0.087
WTE11	V43	0.368	-0.017	-0.236	-0.114	0.177
VAR1	V44	-0.508	-0.975	-0.053	-0.134	-0.202
VAR2	V45	0.029	-1.178	0.064	-0.187	-0.357
VAR3	V46	0.046	-0.602	-0.030	-0.284	0.568
VAR4	V47	0.005	-0.427	0.468	-0.722	0.772
VAR5	V48	-0.146	0.470	0.413	0.413	0.270
VAR6	V49	-0.497	0.259	0.323	-0.099	-0.615
VAR7	V50	0.173	0.072	-0.261	0.059	0.434
BUR1	V51	-0.076	0.266	0.697	-0.729	0.009
BUR2	V52	-0.421	-0.342	0.162	-0.822	0.092
BUR3	V53	1.143	-0.018	-0.612	-0.134	0.639
BUR4	V54	-0.126	0.534	-0.110	-0.348	0.085
BUR5	V55	0.250	0.410	-0.223	-0.073	0.108

BUR6	V56	0.645	0.287	0.084	-0.253	-0.470
BUR7	V57	-0.400	-0.533	0.149	0.281	-0.313
BUR8	V58	0.017	0.352	0.632	0.351	-0.149
BUR9	V59	-0.434	0.432	0.234	-0.217	-0.125
BUR10	V60	0.336	0.423	0.178	-0.014	0.267
BUR11	V61	-0.240	-0.555	-0.098	-0.025	0.635
BUR12	V62	0.121	0.016	-0.487	-0.314	0.161
BUR13	V63	-0.263	0.194	-0.031	0.159	-0.393
BUR14	V64	0.163	0.903	-0.092	0.245	-0.107
BUR15	V65	0.229	0.496	-0.212	0.598	0.381
BUR16	V66	-0.621	-0.748	0.586	0.412	-0.002
BUR17	V67	-0.352	0.561	0.542	0.054	0.189
BUR18	V68	-0.634	0.163	-0.709	0.048	0.315
BUR19	V69	-0.232	0.117	0.249	0.186	-0.862
BUR20	V70	-0.154	-0.460	0.158	0.491	0.051
WFR1	V71	-0.472	0.213	-0.284	-0.172	-0.243
WFR2	V72	0.399	0.192	4.758	0.152	-0.602

		DIR3	DIR4	DIR5	DIR6	DIR7
		V11	V12	V13	V14	V15
DIR3	V11	0.000				
DIR4	V12	-0.187	0.000			
DIR5	V13	0.207	0.168	0.000		
DIR6	V14	0.247	-0.169	-0.428	0.000	
DIR7	V15	0.177	0.248	-0.098	-0.035	0.000
DIR8	V16	-0.028	0.221	-0.932	-0.420	-0.914
DIR9	V17	-0.693	0.293	-0.572	-0.321	-0.476
DIR10	V18	-0.990	-0.260	-0.081	-0.213	0.360
DIR11	V19	0.162	-0.257	-0.291	-0.610	0.449
DIR12	V20	-0.073	-0.138	-0.162	0.264	0.259

DIR13	V21	0.140	-0.431	-0.227	0.460	-1.024
RES1	V22	0.439	0.021	-0.156	0.151	0.379
RES2	V23	-0.257	0.374	0.593	-0.531	0.126
RES3	V24	0.071	0.311	0.394	0.386	-0.300
RES4	V25	0.801	-0.554	-0.027	-0.433	-0.095
RES5	V26	0.004	-1.104	-0.007	0.402	-0.157
RES6	V27	0.331	-0.273	0.218	-0.016	-0.005
RES7	V28	-0.252	-0.425	-1.145	-0.693	-0.287
RES8	V29	-0.217	0.321	-0.182	0.342	0.079
RES9	V30	0.455	-0.111	0.404	0.405	0.161
RES10	V31	-0.403	-0.082	-0.006	-0.261	0.092
RES11	V32	0.967	-0.681	0.461	-0.522	-0.577
WTE1	V33	0.689	0.208	0.317	-0.369	-0.393
WTE2	V34	-0.580	-0.052	-0.208	-0.059	0.183
WTE3	V35	-0.556	0.324	0.198	0.056	1.565
WTE4	V36	0.436	0.023	0.308	-0.221	0.595
WTE5	V37	0.300	-0.303	-0.160	0.055	0.083
WTE6	V38	-0.243	0.173	0.771	0.491	-0.432
WTE7	V39	-0.968	-0.888	-0.319	0.029	-0.466
WTE8	V40	0.162	0.177	-0.206	-0.206	0.217
WTE9	V41	0.323	-0.585	0.094	0.247	0.529
WTE10	V42	-0.264	0.061	-0.334	0.417	-0.044
WTE11	V43	-0.298	0.180	-0.243	-0.528	0.101
VAR1	V44	-0.039	0.550	0.638	0.053	0.377
VAR2	V45	-0.465	0.018	0.553	-0.045	-0.011
VAR3	V46	0.341	0.230	0.414	-0.232	-0.455
VAR4	V47	0.314	-0.362	0.044	-0.130	-0.078
VAR5	V48	-0.141	0.281	0.338	-0.689	-0.465

VAR6	V49	0.041	-0.425	-0.963	0.819	-0.415
VAR7	V50	0.261	0.357	-0.026	0.025	-0.199
BUR1	V51	0.106	-0.538	0.170	-0.299	-0.601
BUR2	V52	0.368	0.761	-0.145	-0.381	-0.121
BUR3	V53	0.647	-0.291	0.297	-0.779	-0.061
BUR4	V54	-0.567	0.517	0.055	-0.219	0.577
BUR5	V55	-0.676	0.409	0.026	-0.012	0.073
BUR6	V56	0.486	0.830	-0.061	-0.109	0.145
BUR7	V57	-0.049	0.015	0.284	0.239	-0.163
BUR8	V58	-0.105	0.284	0.283	0.596	-0.507
BUR9	V59	0.278	0.605	-0.204	-0.933	0.079
BUR10	V60	0.357	-0.163	0.428	0.186	-0.145
BUR11	V61	0.125	0.342	0.347	-0.135	-0.098
BUR12	V62	0.276	-0.212	0.304	-0.141	-0.385
BUR13	V63	0.039	0.538	0.240	0.006	-0.575
BUR14	V64	-0.007	-0.034	0.141	-0.616	0.806
BUR15	V65	-0.574	0.746	-0.267	-0.171	0.025
BUR16	V66	-0.324	0.087	0.318	-0.256	-0.368
BUR17	V67	-0.713	0.323	-0.239	-0.265	-0.060
BUR18	V68	-0.286	-0.229	0.738	-0.423	0.580
BUR19	V69	0.115	0.489	0.064	0.193	1.308
BUR20	V70	0.129	-0.689	0.683	-0.298	0.294
WFR1	V71	0.157	0.496	1.364	-0.129	0.083
WFR2	V72	0.481	-0.040	-0.710	3.722	0.364

		DIR8	DIR9	DIR10	DIR11	DIR12
		V16	V17	V18	V19	V20
DIR8	V16	0.000				
DIR9	V17	0.214	0.000			
DIR10	V18	-0.674	0.349	0.000		

DIR11	V19	-0.553	-0.669	-0.637	0.000	
DIR12	V20	-0.768	0.435	0.271	0.051	0.000
DIR13	V21	-0.179	-0.251	-0.740	-0.803	0.249
RES1	V22	-0.179	-0.281	-0.412	-0.148	0.381
RES2	V23	-0.033	0.093	-0.055	-0.109	0.084
RES3	V24	0.756	0.157	-0.187	0.307	-0.721
RES4	V25	0.356	0.083	-0.273	-0.011	0.986
RES5	V26	0.088	0.007	-0.013	0.159	0.033
RES6	V27	0.078	0.085	-0.292	0.428	0.217
RES7	V28	0.059	0.616	0.048	-0.788	0.147
RES8	V29	0.475	-0.163	-0.097	-0.028	-0.254
RES9	V30	0.389	-0.571	-0.192	0.475	0.421
RES10	V31	0.291	0.324	0.344	-0.287	-0.097
RES11	V32	-0.116	0.146	-0.344	-1.108	0.117
WTE1	V33	0.389	0.205	-0.077	0.005	-0.376
WTE2	V34	0.449	0.008	0.026	-0.265	0.546
WTE3	V35	0.122	-0.611	-0.531	0.401	0.802
WTE4	V36	-0.190	-0.103	0.280	0.046	-0.073
WTE5	V37	-0.435	-0.740	0.103	0.446	0.207
WTE6	V38	-0.471	-0.225	-0.174	0.619	-0.302
WTE7	V39	0.250	0.486	0.308	-0.030	0.934
WTE8	V40	0.025	0.603	-0.172	-0.136	-0.323
WTE9	V41	-0.159	-0.292	0.886	-0.408	-0.926
WTE10	V42	-0.714	0.099	0.061	-0.297	-0.722
WTE11	V43	0.306	0.301	0.115	-0.273	0.163
VAR1	V44	-0.307	0.313	-0.508	0.238	-0.103
VAR2	V45	0.207	0.454	-0.133	-0.096	0.137
VAR3	V46	0.265	-0.723	-0.090	-0.509	-0.144
VAR4	V47	-0.017	-0.139	-1.266	0.408	-0.473

VAR5	V48	-0.596	-0.440	0.412	0.448	0.067
VAR6	V49	0.125	0.644	0.126	-0.124	0.395
VAR7	V50	0.043	0.066	0.161	-0.036	0.039
BUR1	V51	-0.322	0.008	0.124	-0.792	-0.016
BUR2	V52	0.540	0.296	0.405	-0.690	-0.317
BUR3	V53	-0.006	-0.250	-0.096	-0.118	0.637
BUR4	V54	0.161	-0.090	0.024	-0.655	-0.087
BUR5	V55	-0.460	-0.254	0.280	0.598	0.877
BUR6	V56	0.529	0.578	0.323	-0.495	0.217
BUR7	V57	-0.133	-0.172	-0.272	-0.527	-0.062
BUR8	V58	0.187	0.106	0.129	-0.206	0.127
BUR9	V59	0.023	0.058	-0.195	0.471	0.176
BUR10	V60	0.155	-0.549	0.444	0.114	-0.480
BUR11	V61	-0.367	-0.081	0.838	0.232	0.250
BUR12	V62	0.005	0.217	-0.486	0.693	0.098
BUR13	V63	0.161	-0.423	0.215	0.204	-0.129
BUR14	V64	0.076	0.655	0.638	0.188	-0.108
BUR15	V65	-0.180	0.150	-1.186	0.119	0.217
BUR16	V66	0.394	0.213	-0.264	-0.017	0.527
BUR17	V67	0.577	0.267	-0.215	-0.129	-0.106
BUR18	V68	0.470	-0.928	-0.176	-0.244	0.046
BUR19	V69	-0.076	-0.270	-0.694	-0.424	-0.153
BUR20	V70	0.595	0.198	-0.129	-0.640	0.156
WFR1	V71	0.118	-0.552	0.084	-0.305	-0.301
WFR2	V72	-0.297	-0.781	0.339	-0.614	0.507

		DIR13	RES1	RES2	RES3	RES4
		V21	V22	V23	V24	V25
DIR13	V21	-0.027				

RES1	V22	0.290	0.000			
RES2	V23	0.608	0.885	0.000		
RES3	V24	0.007	0.035	0.301	0.000	
RES4	V25	0.005	0.001	-0.070	-0.449	0.000
RES5	V26	-0.191	-0.079	0.069	-0.168	0.147
RES6	V27	-0.220	-0.235	0.448	0.427	0.186
RES7	V28	-0.237	0.691	-0.515	-0.282	-0.322
RES8	V29	0.533	0.342	0.828	-0.195	0.507
RES9	V30	-0.004	0.190	-0.335	0.229	0.269
RES10	V31	-0.265	0.595	-0.282	-0.474	-0.208
RES11	V32	0.448	-0.128	-0.239	-0.099	-0.024
WTE1	V33	0.260	-0.744	-0.352	0.149	-0.252
WTE2	V34	0.429	-0.401	0.366	0.108	-0.468
WTE3	V35	-0.300	0.403	-0.001	-0.943	0.659
WTE4	V36	1.008	0.099	0.223	0.144	0.268
WTE5	V37	0.937	0.589	0.468	-0.526	0.252
WTE6	V38	1.075	0.632	0.669	1.181	0.021
WTE7	V39	0.534	0.280	0.555	-0.630	0.481
WTE8	V40	-0.221	0.346	-0.410	-0.333	-0.283
WTE9	V41	-0.096	0.526	0.153	-0.341	0.169
WTE10	V42	0.274	-0.442	-0.370	0.093	0.722
WTE11	V43	0.111	0.409	0.550	0.920	0.121
VAR1	V44	0.011	0.019	-0.109	-0.316	0.744
VAR2	V45	0.324	-0.747	0.655	0.549	-0.065
VAR3	V46	-0.060	-0.361	0.247	0.342	-0.077
VAR4	V47	0.278	0.348	0.230	1.057	0.191
VAR5	V48	-0.327	-0.394	0.456	-1.009	0.127
VAR6	V49	0.007	-0.070	-0.007	0.457	-0.247
VAR7	V50	-0.370	0.282	-0.245	-0.387	0.146
BUR1	V51	0.353	-0.334	-0.893	-0.012	-0.065

BUR2	V52	-0.663	0.149	0.333	-0.022	-0.448
BUR3	V53	0.199	0.108	0.016	-0.118	0.656
BUR4	V54	-0.135	0.088	-0.847	-0.681	0.263
BUR5	V55	-0.004	-0.174	0.073	-0.097	0.270
BUR6	V56	-0.026	0.130	0.027	-0.571	0.038
BUR7	V57	-0.470	-0.981	-0.452	-0.630	0.155
BUR8	V58	0.558	-0.015	0.245	-0.218	-0.172
BUR9	V59	0.314	-0.115	-0.598	-0.182	0.841
BUR10	V60	1.002	0.411	0.073	0.324	0.366
BUR11	V61	0.122	-0.628	-0.047	-0.391	0.032
BUR12	V62	-0.441	-0.141	-0.382	-0.116	0.738
BUR13	V63	0.633	-0.450	0.222	0.282	-0.681
BUR14	V64	-0.415	-0.236	-0.651	0.168	0.047
BUR15	V65	-0.384	-0.453	-0.135	0.222	0.159
BUR16	V66	0.303	-0.048	-0.002	-0.159	-0.073
BUR17	V67	-0.204	0.110	-0.324	0.393	-0.146
BUR18	V68	-0.525	-0.099	0.052	-0.573	-0.374
BUR19	V69	-0.030	-0.297	-0.622	-0.746	0.073
BUR20	V70	-0.037	0.371	0.772	0.393	-0.246
WFR1	V71	-0.563	0.344	0.470	-0.051	0.076
WFR2	V72	0.481	-0.266	-0.087	0.650	-0.237

		RES5	RES6	RES7	RES8	RES9
		V26	V27	V28	V29	V30
RES5	V26	0.000				
RES6	V27	-0.131	0.000			
RES7	V28	0.472	-0.198	0.000		
RES8	V29	-0.014	-0.403	-0.733	0.000	
RES9	V30	0.390	0.210	0.263	-0.553	0.000
RES10	V31	-0.234	0.035	0.481	-0.642	0.372

RES11	V32	0.151	-0.069	0.287	-0.259	-0.065
WTE1	V33	-0.027	0.120	-0.467	0.171	-0.104
WTE2	V34	0.393	-0.340	-0.641	0.090	-0.259
WTE3	V35	-0.145	0.084	-0.154	0.940	0.260
WTE4	V36	0.209	-1.180	-0.311	0.257	-0.093
WTE5	V37	-0.271	-0.210	0.085	0.204	0.477
WTE6	V38	0.543	0.286	0.430	0.654	0.296
WTE7	V39	0.705	-0.023	0.266	0.238	-0.206
WTE8	V40	0.213	0.294	0.042	0.183	0.043
WTE9	V41	0.025	0.646	-0.252	0.023	0.019
WTE10	V42	0.478	-0.776	-0.424	0.009	-0.059
WTE11	V43	0.008	0.413	0.068	0.257	-0.484
VAR1	V44	1.018	-0.091	0.247	-0.163	0.179
VAR2	V45	0.075	0.111	-0.708	0.082	-0.123
VAR3	V46	0.128	0.087	0.139	-0.416	0.231
VAR4	V47	0.660	0.067	-0.355	0.416	-0.206
VAR5	V48	0.000	0.253	0.049	0.043	-0.465
VAR6	V49	0.442	0.613	1.160	0.804	-0.078
VAR7	V50	-0.043	-0.338	-0.519	-0.617	-0.330
BUR1	V51	0.081	0.608	-0.306	0.139	-0.322
BUR2	V52	-0.142	0.359	-0.162	0.446	0.542
BUR3	V53	-0.314	0.104	0.160	-0.404	-0.366
BUR4	V54	-0.610	-0.161	-0.165	0.356	-0.068
BUR5	V55	-0.122	0.209	-0.458	-0.083	-0.365
BUR6	V56	0.148	0.439	-0.494	0.050	-0.736
BUR7	V57	-0.307	-0.595	-0.359	1.165	0.204
BUR8	V58	-0.364	-0.451	0.416	-0.257	0.410
BUR9	V59	0.323	-0.039	0.166	-0.006	0.546

BUR10	V60	0.681	0.376	0.282	-0.308	0.494
BUR11	V61	-0.303	-0.317	0.147	-0.076	0.162
BUR12	V62	0.184	-0.255	-0.231	0.763	1.162
BUR13	V63	-0.662	0.443	-1.074	0.031	0.261
BUR14	V64	0.220	0.382	0.057	-0.310	-0.089
BUR15	V65	-0.079	-0.173	0.356	-1.184	0.324
BUR16	V66	0.116	-0.176	-0.157	0.304	-0.183
BUR17	V67	0.046	0.125	0.141	-0.338	0.167
BUR18	V68	-0.541	0.341	-0.945	0.446	0.167
BUR19	V69	0.636	-0.071	-0.267	-0.120	-0.237
BUR20	V70	0.508	0.104	0.049	0.214	0.079
WFR1	V71	-0.326	0.267	-0.454	0.404	-0.091
WFR2	V72	0.218	-0.090	0.083	-0.060	-0.401

		RES10	RES11	WTE1	WTE2	WTE3
		V31	V32	V33	V34	V35
RES10	V31	0.000				
RES11	V32	0.174	-0.012			
WTE1	V33	0.064	0.540	0.000		
WTE2	V34	-0.086	0.521	0.391	0.000	
WTE3	V35	-0.038	-0.215	-0.903	-0.314	0.000
WTE4	V36	0.435	0.525	0.161	-0.068	-0.230
WTE5	V37	-0.844	-0.009	0.186	-0.084	-0.059
WTE6	V38	-0.564	-0.385	-0.116	-0.016	-0.132
WTE7	V39	0.377	0.142	-0.025	0.762	-0.317
WTE8	V40	-0.540	-0.179	0.795	0.440	-0.224
WTE9	V41	0.057	-0.220	-0.429	-0.069	-0.524
WTE10	V42	0.154	-0.646	-0.396	-0.345	0.276
WTE11	V43	0.041	-0.209	0.126	-0.055	-0.043
VAR1	V44	-0.110	0.003	-0.217	0.227	0.320

VAR2	V45	0.537	0.121	-0.302	0.211	0.452
VAR3	V46	0.163	-0.166	-0.487	-0.159	0.353
VAR4	V47	-0.236	-0.126	0.534	-0.082	-0.325
VAR5	V48	-0.147	-0.085	0.399	0.193	0.091
VAR6	V49	0.015	-0.406	0.087	-0.281	-1.079
VAR7	V50	0.108	-0.093	-0.137	-0.447	0.290
BUR1	V51	-0.235	0.400	-0.274	-0.018	-0.107
BUR2	V52	0.090	0.314	-0.450	0.891	0.356
BUR3	V53	-0.530	0.449	-0.161	-0.400	-0.624
BUR4	V54	-0.654	-1.055	-0.111	0.430	0.197
BUR5	V55	0.608	-0.471	-0.825	-0.199	0.234
BUR6	V56	-0.303	-0.438	0.301	-0.505	0.313
BUR7	V57	-0.631	0.404	0.382	0.234	-0.458
BUR8	V58	0.665	-0.096	0.183	-0.030	0.507
BUR9	V59	-0.214	-0.031	0.456	-0.173	0.010
BUR10	V60	-0.114	-0.040	-0.131	0.022	0.486
BUR11	V61	0.131	0.598	0.297	-0.664	-0.043
BUR12	V62	-0.208	0.216	0.399	-0.172	-0.243
BUR13	V63	0.446	0.061	-0.561	0.450	-0.257
BUR14	V64	0.209	-0.130	-0.017	0.236	0.004
BUR15	V65	-0.333	-0.143	-0.290	0.181	0.363
BUR16	V66	0.654	0.187	-0.778	0.277	0.221
BUR17	V67	-0.031	0.330	-0.389	-0.373	-0.030
BUR18	V68	-0.068	0.384	-0.116	0.673	0.432
BUR19	V69	-0.252	-0.800	0.299	-0.080	-0.155
BUR20	V70	0.678	0.318	0.056	0.636	1.086
WFR1	V71	-0.555	-0.332	0.084	-0.192	0.330
WFR2	V72	0.236	-0.090	-0.056	0.007	-0.133

		WTE4	WTE5	WTE6	WTE7	WTE8
		V36	V37	V38	V39	V40
WTE4	V36	0.000				
WTE5	V37	0.567	0.000			
WTE6	V38	0.237	0.389	0.000		
WTE7	V39	0.148	-0.424	0.012	0.000	
WTE8	V40	-0.045	0.586	-0.141	0.165	0.000
WTE9	V41	-0.062	0.696	-0.090	-0.743	-0.069
WTE10	V42	-0.284	-0.491	-0.290	-0.259	0.090
WTE11	V43	0.141	0.208	-0.088	-0.034	-0.044
VAR1	V44	-0.105	0.198	-0.332	-0.130	0.339
VAR2	V45	0.150	-0.360	0.238	0.720	-0.159
VAR3	V46	-0.468	0.047	-0.306	-0.895	-0.697
VAR4	V47	-0.552	0.986	-0.171	0.355	-0.450
VAR5	V48	0.161	-0.049	-0.409	-0.753	0.051
VAR6	V49	-0.346	-0.379	-0.818	0.129	0.785
VAR7	V50	0.758	-0.646	0.097	0.194	-0.472
BUR1	V51	0.043	-0.429	-0.121	-0.028	-0.276
BUR2	V52	0.641	0.087	-0.137	0.106	0.260
BUR3	V53	-0.140	-0.064	-0.661	0.604	0.723
BUR4	V54	0.013	-0.313	0.093	0.120	-0.463
BUR5	V55	0.296	-0.093	-0.266	0.611	-0.732
BUR6	V56	-0.609	-0.024	0.158	0.108	0.650
BUR7	V57	0.444	0.016	0.083	0.341	0.180
BUR8	V58	0.310	0.003	0.581	-0.396	-0.237
BUR9	V59	0.053	-0.553	0.244	0.241	0.662
BUR10	V60	-0.587	-0.653	-0.203	-0.049	0.054
BUR11	V61	-0.351	0.188	0.488	0.051	-0.527
BUR12	V62	-0.449	-0.372	-0.115	0.138	0.920
BUR13	V63	-0.153	0.456	-0.267	0.366	-0.250

BUR14	V64	0.004	-0.867	0.329	-0.447	0.605
BUR15	V65	-0.497	-0.151	0.022	0.238	0.845
BUR16	V66	-0.089	0.015	-0.046	0.757	-0.165
BUR17	V67	-0.800	0.893	-0.304	0.406	-0.336
BUR18	V68	-0.369	0.170	0.065	0.743	-0.004
BUR19	V69	-0.264	0.081	-0.084	-0.634	-0.100
BUR20	V70	-0.626	-0.798	0.704	0.215	0.620
WFR1	V71	-0.209	0.070	0.197	0.174	-0.332
WFR2	V72	0.007	-0.131	0.697	-0.108	-0.041

		WTE9	WTE10	WTE11	VAR1	VAR2
		V41	V42	V43	V44	V45
WTE9	V41	0.000				
WTE10	V42	0.594	0.000			
WTE11	V43	-0.166	0.002	-0.028		
VAR1	V44	0.711	-0.113	-0.567	0.000	
VAR2	V45	0.064	0.527	-0.214	0.808	0.000
VAR3	V46	0.127	-0.191	-0.321	-0.160	-0.272
VAR4	V47	0.160	-0.096	-0.281	0.174	-0.637
VAR5	V48	0.195	-0.842	0.520	0.016	-0.070
VAR6	V49	-0.860	0.312	0.218	0.227	0.077
VAR7	V50	0.646	0.570	-0.185	-0.148	-0.440
BUR1	V51	0.225	0.560	-0.007	-0.674	0.022
BUR2	V52	0.673	-0.061	-0.406	0.289	0.383
BUR3	V53	0.275	-0.034	-0.011	-0.830	-0.068
BUR4	V54	0.471	0.487	0.355	-0.717	-0.531
BUR5	V55	-0.019	0.716	-0.435	-0.566	0.213
BUR6	V56	0.117	0.739	-0.266	-0.307	0.272
BUR7	V57	0.541	-0.292	-0.461	0.148	-0.471
BUR8	V58	0.351	-0.536	0.091	0.350	-0.202

BUR9	V59	-0.036	-0.711	0.349	0.353	0.106
BUR10	V60	0.238	0.038	0.011	0.097	-0.260
BUR11	V61	0.359	0.033	-0.037	-0.527	-0.452
BUR12	V62	0.241	0.111	-0.875	0.608	-0.312
BUR13	V63	-0.086	-0.107	0.276	-0.738	-0.473
BUR14	V64	-0.373	1.287	-0.513	-0.766	-0.293
BUR15	V65	0.482	0.154	0.499	-0.061	0.145
BUR16	V66	-0.238	0.031	-0.046	0.074	-0.048
BUR17	V67	-0.199	0.089	0.022	-0.191	-0.370
BUR18	V68	-0.220	-0.179	-0.667	-0.324	0.105
BUR19	V69	0.257	-0.320	-0.584	0.500	0.872
BUR20	V70	-0.294	-0.859	0.436	-0.363	-0.155
WFR1	V71	0.238	-0.143	-0.535	0.201	-0.197
WFR2	V72	0.198	0.123	-0.210	-0.089	0.114

		VAR3	VAR4	VAR5	VAR6	VAR7
		V46	V47	V48	V49	V50
VAR3	V46	0.000				
VAR4	V47	0.347	0.000			
VAR5	V48	0.038	-0.130	0.001		
VAR6	V49	-0.679	0.288	0.034	0.000	
VAR7	V50	-0.301	0.052	0.130	-0.176	0.000
BUR1	V51	-0.029	0.197	-0.041	-0.087	0.569
BUR2	V52	0.517	-0.220	0.445	-0.244	0.757
BUR3	V53	0.485	0.621	-0.243	0.272	0.723
BUR4	V54	-0.038	0.345	-0.589	-0.889	-0.181
BUR5	V55	0.052	-0.383	-0.024	-0.186	0.388
BUR6	V56	-0.022	-0.745	0.333	0.209	-0.509
BUR7	V57	-0.578	-0.779	-0.302	0.456	0.618
BUR8	V58	-0.227	-0.394	-0.287	0.200	0.444

BUR9	V59	-0.683	-0.111	0.722	-0.139	0.054
BUR10	V60	-0.179	0.212	-0.271	-0.586	-0.140
BUR11	V61	-0.523	-0.612	0.470	-0.769	1.086
BUR12	V62	-0.920	0.235	-0.026	0.350	-0.371
BUR13	V63	0.342	-0.151	-0.541	-0.531	-0.241
BUR14	V64	0.269	0.010	-0.224	-0.225	0.312
BUR15	V65	-0.513	-0.306	-1.079	-0.679	0.537
BUR16	V66	-0.574	0.686	-0.225	-0.497	0.764
BUR17	V67	0.204	0.648	-0.380	0.108	-0.334
BUR18	V68	-0.353	0.243	0.157	-0.290	-0.564
BUR19	V69	0.284	-0.025	-0.057	0.141	0.221
BUR20	V70	0.601	0.105	0.197	0.001	0.242
WFR1	V71	0.380	0.193	-0.216	-0.324	-0.545
WFR2	V72	0.297	0.060	0.082	0.281	-0.023

		BUR1	BUR2	BUR3	BUR4	BUR5
		V51	V52	V53	V54	V55
BUR1	V51	0.000				
BUR2	V52	0.454	0.000			
BUR3	V53	0.505	-0.087	0.000		
BUR4	V54	-0.089	-0.049	0.280	0.000	
BUR5	V55	-0.023	0.747	0.527	0.251	0.000
BUR6	V56	-0.860	-0.564	0.196	0.700	-0.048
BUR7	V57	-0.461	-0.792	-0.335	-0.289	-0.236
BUR8	V58	0.639	0.074	-0.507	-0.201	-0.807
BUR9	V59	-0.047	-0.458	0.268	0.107	-0.253
BUR10	V60	0.222	-0.013	-0.430	-0.557	0.169
BUR11	V61	0.138	0.100	0.246	-0.267	-0.084
BUR12	V62	0.734	0.156	-0.068	-0.514	0.358
BUR13	V63	-0.037	0.019	-0.130	0.002	0.481

BUR14	V64	0.441	-0.660	0.694	1.061	-0.006
BUR15	V65	0.335	0.140	0.039	0.013	0.450
BUR16	V66	0.261	-0.042	-0.080	-0.144	-0.316
BUR17	V67	0.431	-0.258	-0.235	0.346	0.335
BUR18	V68	-0.441	-0.078	-0.016	0.246	-0.468
BUR19	V69	0.131	0.230	-0.341	0.390	-0.128
BUR20	V70	0.058	-0.095	-0.090	0.067	0.038
WFR1	V71	0.093	-0.056	0.373	0.043	0.538
WFR2	V72	-0.131	-0.144	-0.975	0.345	0.100

		BUR6 V56	BUR7 V57	BUR8 V58	BUR9 V59	BUR10 V60
BUR6	V56	0.000				
BUR7	V57	-0.469	0.000			
BUR8	V58	0.347	-0.098	0.000		
BUR9	V59	0.194	-0.100	-0.237	0.000	
BUR10	V60	0.139	-0.434	0.463	-0.144	0.000
BUR11	V61	0.216	0.470	-0.904	0.156	0.211
BUR12	V62	-0.453	0.533	-0.126	0.820	0.600
BUR13	V63	-0.504	-0.002	0.290	-0.557	0.195
BUR14	V64	0.480	0.123	0.381	0.266	-0.648
BUR15	V65	0.575	-0.634	-0.246	-0.250	-0.634
BUR16	V66	-0.449	-0.590	0.339	-0.477	0.143
BUR17	V67	-0.516	-0.453	-0.041	0.775	0.059
BUR18	V68	0.128	-0.359	-0.592	-0.350	0.483
BUR19	V69	-0.436	0.189	-0.177	-0.353	-0.183
BUR20	V70	0.030	0.012	0.090	-0.002	-0.050
WFR1	V71	0.088	0.004	0.431	0.145	0.308
WFR2	V72	0.159	0.453	0.304	0.053	0.291

		BUR11 V61	BUR12 V62	BUR13 V63	BUR14 V64	BUR15 V65
BUR11	V61	0.000				
BUR12	V62	0.735	0.000			
BUR13	V63	0.379	-0.400	0.000		
BUR14	V64	-0.023	-0.129	-0.466	0.000	
BUR15	V65	0.380	-0.584	0.251	-0.313	0.000
BUR16	V66	0.261	-0.180	0.080	-0.369	0.420
BUR17	V67	-0.125	0.061	0.747	-0.027	0.526
BUR18	V68	0.149	0.321	0.384	-0.079	-0.086
BUR19	V69	0.183	-0.459	0.478	-0.515	-0.048
BUR20	V70	0.010	-0.126	-0.146	-0.012	-0.014
WFR1	V71	-0.301	0.720	0.853	-0.585	-0.665
WFR2	V72	0.358	-0.393	-0.321	-0.174	-0.169

		BUR16 V66	BUR17 V67	BUR18 V68	BUR19 V69	BUR20 V70
BUR16	V66	0.000				
BUR17	V67	0.424	0.000			
BUR18	V68	0.507	0.294	0.000		
BUR19	V69	-0.377	0.194	0.155	0.000	
BUR20	V70	0.009	-0.053	0.001	-0.084	-0.029
WFR1	V71	0.072	0.048	0.753	0.365	0.236
WFR2	V72	0.228	-0.267	-0.797	0.174	0.346

		WFR1 V71	WFR2 V72
WFR1	V71	0.719	
WFR2	V72	-0.348	0.006

AVERAGE ABSOLUTE RESIDUAL = 0.3211

AVERAGE OFF-DIAGONAL ABSOLUTE RESIDUAL = 0.3298

MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)

STANDARDIZED RESIDUAL MATRIX:

		PRE1 V1	PRE2 V2	PRE3 V3	PRE4 V4	PRE5 V5
PRE1	V1	0.000				
PRE2	V2	-0.045	0.000			
PRE3	V3	0.010	-0.079	0.000		
PRE4	V4	-0.043	0.016	-0.016	0.000	
PRE5	V5	0.140	-0.071	0.122	0.034	0.000
PRE6	V6	0.006	-0.091	-0.090	0.025	0.091
PRE7	V7	-0.007	0.100	0.097	-0.036	-0.043
PRE8	V8	0.026	-0.012	-0.080	-0.057	-0.088
DIR1	V9	0.002	-0.018	-0.012	0.033	-0.043
DIR2	V10	-0.043	-0.061	-0.086	0.059	0.087
DIR3	V11	-0.027	0.028	-0.048	-0.005	0.078
DIR4	V12	0.064	0.065	-0.003	-0.053	-0.018
DIR5	V13	-0.015	0.034	0.030	0.091	0.016
DIR6	V14	-0.068	0.044	-0.047	0.000	-0.039
DIR7	V15	0.147	0.012	0.027	0.038	-0.029
DIR8	V16	-0.026	0.041	-0.003	-0.012	-0.041
DIR9	V17	-0.023	-0.055	0.011	-0.053	-0.055
DIR10	V18	0.014	0.024	-0.027	0.069	-0.088
DIR11	V19	0.008	-0.065	0.119	0.024	0.025
DIR12	V20	-0.063	-0.033	0.078	0.011	-0.090
DIR13	V21	0.001	-0.057	0.087	-0.021	0.034
RES1	V22	0.040	-0.027	-0.030	-0.018	0.040
RES2	V23	0.106	0.004	0.049	0.038	0.060
RES3	V24	-0.079	-0.052	-0.038	-0.053	-0.034
RES4	V25	0.025	0.024	0.008	0.011	0.023
RES5	V26	-0.011	-0.014	0.014	0.029	0.033
RES6	V27	0.075	-0.005	0.086	0.026	-0.018

RES7	V28	0.019	0.075	0.003	0.004	-0.039
RES8	V29	-0.012	0.005	0.024	-0.053	0.030
RES9	V30	0.084	-0.047	0.092	0.147	0.120
RES10	V31	0.004	-0.045	-0.001	0.005	-0.099
RES11	V32	-0.060	-0.060	-0.001	0.082	-0.028
WTE1	V33	-0.077	0.004	0.028	-0.031	0.007
WTE2	V34	-0.026	-0.076	-0.007	-0.087	-0.054
WTE3	V35	0.000	0.060	0.066	0.049	-0.010
WTE4	V36	-0.012	0.006	-0.084	0.067	-0.031
WTE5	V37	0.020	0.018	0.128	-0.023	-0.048
WTE6	V38	0.024	-0.017	0.094	0.013	0.044
WTE7	V39	-0.035	0.018	0.023	0.077	0.028
WTE8	V40	-0.037	-0.046	0.043	-0.119	0.020
WTE9	V41	-0.016	-0.004	0.044	0.025	-0.027
WTE10	V42	0.088	-0.044	-0.006	-0.033	-0.048
WTE11	V43	0.071	-0.046	-0.005	-0.099	0.050
VAR1	V44	0.032	0.030	-0.005	-0.005	0.061
VAR2	V45	-0.011	-0.110	0.017	0.081	-0.096
VAR3	V46	-0.012	0.062	-0.019	-0.041	-0.038
VAR4	V47	-0.032	-0.039	0.004	-0.057	0.037
VAR5	V48	0.011	-0.018	0.027	-0.057	0.033
VAR6	V49	0.005	0.017	-0.038	-0.037	-0.053
VAR7	V50	-0.022	-0.032	-0.064	0.025	0.056
BUR1	V51	-0.084	-0.021	0.086	0.029	0.032
BUR2	V52	0.072	0.022	0.000	0.015	0.099
BUR3	V53	-0.089	0.007	-0.082	-0.006	-0.060
BUR4	V54	-0.018	-0.064	-0.042	-0.072	-0.078
BUR5	V55	0.031	0.024	0.034	-0.044	-0.051

BUR6	V56	0.005	-0.038	-0.021	-0.064	-0.039
BUR7	V57	0.005	0.058	-0.069	-0.026	0.012
BUR8	V58	0.056	0.086	0.123	0.035	0.028
BUR9	V59	0.000	0.061	-0.007	0.016	0.046
BUR10	V60	0.115	-0.012	0.008	0.039	0.018
BUR11	V61	0.049	-0.041	-0.042	0.049	0.041
BUR12	V62	-0.077	0.018	0.112	0.093	0.133
BUR13	V63	0.024	-0.014	0.013	0.000	-0.117
BUR14	V64	0.012	-0.061	0.038	-0.081	-0.089
BUR15	V65	-0.032	-0.082	-0.033	0.009	0.082
BUR16	V66	0.011	0.013	0.077	0.052	-0.038
BUR17	V67	0.028	0.004	0.026	-0.010	-0.062
BUR18	V68	0.015	0.018	0.101	0.063	-0.052
BUR19	V69	0.117	0.012	-0.092	0.015	-0.021
BUR20	V70	-0.065	0.031	0.005	-0.048	0.002
WFR1	V71	-0.031	0.018	-0.032	0.035	-0.027
WFR2	V72	-0.062	0.030	-0.080	-0.067	-0.096

		PRE6	PRE7	PRE8	DIR1	DIR2
		V6	V7	V8	V9	V10
PRE6	V6	0.000				
PRE7	V7	0.012	0.000			
PRE8	V8	0.083	0.022	0.000		
DIR1	V9	-0.051	0.023	0.039	0.000	
DIR2	V10	0.036	-0.020	-0.059	0.013	0.000
DIR3	V11	0.058	-0.017	0.003	-0.041	0.002
DIR4	V12	-0.084	0.099	-0.052	0.021	-0.132
DIR5	V13	0.020	-0.103	-0.042	0.048	0.032
DIR6	V14	-0.035	-0.030	0.038	0.026	-0.071
DIR7	V15	-0.018	0.049	0.022	0.015	-0.045

DIR8	V16	-0.034	0.055	-0.108	0.003	-0.061
DIR9	V17	0.030	-0.025	-0.006	0.064	0.023
DIR10	V18	-0.072	0.021	0.074	0.073	-0.018
DIR11	V19	-0.015	0.062	0.010	-0.015	0.003
DIR12	V20	0.005	0.077	0.011	0.013	0.091
DIR13	V21	-0.016	0.042	0.009	-0.063	-0.081
RES1	V22	-0.044	-0.071	-0.037	-0.068	0.023
RES2	V23	0.084	-0.040	0.049	-0.097	0.001
RES3	V24	-0.007	-0.010	0.028	0.000	-0.026
RES4	V25	-0.035	-0.085	0.010	-0.025	-0.030
RES5	V26	-0.044	-0.024	-0.055	0.018	-0.080
RES6	V27	-0.050	0.039	0.061	-0.010	-0.088
RES7	V28	0.005	0.044	0.057	-0.019	0.015
RES8	V29	-0.044	-0.104	-0.067	-0.041	-0.147
RES9	V30	-0.037	-0.031	-0.090	0.007	0.011
RES10	V31	0.050	-0.052	0.062	0.047	-0.020
RES11	V32	0.125	-0.022	0.048	0.009	-0.037
WTE1	V33	0.077	0.125	-0.034	0.033	0.008
WTE2	V34	-0.064	0.067	-0.045	0.030	-0.146
WTE3	V35	-0.009	-0.055	0.017	0.015	-0.066
WTE4	V36	-0.067	0.086	-0.034	-0.034	-0.055
WTE5	V37	-0.032	-0.057	-0.035	-0.009	0.077
WTE6	V38	-0.054	0.022	0.079	0.046	-0.015
WTE7	V39	0.020	-0.003	-0.022	0.077	-0.031
WTE8	V40	0.002	0.087	0.001	-0.008	0.005
WTE9	V41	-0.014	-0.086	-0.041	0.005	0.065
WTE10	V42	0.030	0.016	0.086	0.009	-0.010
WTE11	V43	0.045	-0.002	-0.028	-0.014	0.021

VAR1	V44	-0.062	-0.118	-0.006	-0.017	-0.023
VAR2	V45	0.004	-0.142	0.008	-0.023	-0.041
VAR3	V46	0.006	-0.073	-0.004	-0.036	0.066
VAR4	V47	0.001	-0.051	0.055	-0.089	0.088
VAR5	V48	-0.017	0.055	0.047	0.050	0.030
VAR6	V49	-0.061	0.031	0.038	-0.012	-0.071
VAR7	V50	0.022	0.009	-0.032	0.008	0.051
BUR1	V51	-0.009	0.033	0.084	-0.092	0.001
BUR2	V52	-0.052	-0.042	0.019	-0.104	0.011
BUR3	V53	0.141	-0.002	-0.073	-0.017	0.075
BUR4	V54	-0.015	0.064	-0.013	-0.043	0.010
BUR5	V55	0.032	0.052	-0.028	-0.010	0.013
BUR6	V56	0.081	0.036	0.010	-0.033	-0.056
BUR7	V57	-0.048	-0.064	0.017	0.035	-0.036
BUR8	V58	0.002	0.043	0.076	0.045	-0.018
BUR9	V59	-0.054	0.054	0.028	-0.028	-0.015
BUR10	V60	0.042	0.052	0.021	-0.002	0.031
BUR11	V61	-0.030	-0.068	-0.012	-0.003	0.074
BUR12	V62	0.015	0.002	-0.059	-0.040	0.019
BUR13	V63	-0.033	0.024	-0.004	0.021	-0.047
BUR14	V64	0.020	0.110	-0.011	0.031	-0.013
BUR15	V65	0.029	0.063	-0.026	0.078	0.046
BUR16	V66	-0.079	-0.094	0.072	0.054	0.000
BUR17	V67	-0.043	0.068	0.065	0.007	0.022
BUR18	V68	-0.079	0.020	-0.085	0.006	0.037
BUR19	V69	-0.029	0.015	0.030	0.024	-0.102
BUR20	V70	-0.019	-0.057	0.019	0.063	0.006
WFR1	V71	-0.058	0.026	-0.034	-0.022	-0.028

WFR2	V72	0.050	0.023	0.572	0.019	-0.071

		DIR3	DIR4	DIR5	DIR6	DIR7
		V11	V12	V13	V14	V15
DIR3	V11	0.000				
DIR4	V12	-0.022	0.000			
DIR5	V13	0.026	0.020	0.000		
DIR6	V14	0.031	-0.020	-0.054	0.000	
DIR7	V15	0.021	0.029	-0.012	-0.004	0.000
DIR8	V16	-0.003	0.026	-0.113	-0.051	-0.105
DIR9	V17	-0.081	0.033	-0.068	-0.038	-0.054
DIR10	V18	-0.122	-0.031	-0.010	-0.026	0.043
DIR11	V19	0.020	-0.031	-0.037	-0.076	0.053
DIR12	V20	-0.009	-0.017	-0.020	0.033	0.031
DIR13	V21	0.017	-0.050	-0.028	0.056	-0.119
RES1	V22	0.054	0.003	-0.020	0.019	0.045
RES2	V23	-0.031	0.044	0.073	-0.065	0.015
RES3	V24	0.009	0.037	0.049	0.048	-0.035
RES4	V25	0.095	-0.063	-0.003	-0.052	-0.011
RES5	V26	0.000	-0.131	-0.001	0.050	-0.018
RES6	V27	0.040	-0.031	0.026	-0.002	-0.001
RES7	V28	-0.031	-0.051	-0.144	-0.086	-0.034
RES8	V29	-0.027	0.038	-0.023	0.042	0.009
RES9	V30	0.055	-0.013	0.050	0.049	0.019
RES10	V31	-0.050	-0.010	-0.001	-0.033	0.011
RES11	V32	0.119	-0.081	0.058	-0.065	-0.068
WTE1	V33	0.086	0.025	0.040	-0.047	-0.047
WTE2	V34	-0.072	-0.006	-0.026	-0.007	0.022
WTE3	V35	-0.064	0.036	0.023	0.007	0.174
WTE4	V36	0.054	0.003	0.039	-0.028	0.071

WTE5	V37	0.036	-0.036	-0.020	0.007	0.010
WTE6	V38	-0.030	0.021	0.096	0.061	-0.051
WTE7	V39	-0.117	-0.104	-0.039	0.004	-0.054
WTE8	V40	0.020	0.022	-0.026	-0.026	0.026
WTE9	V41	0.039	-0.069	0.012	0.030	0.062
WTE10	V42	-0.033	0.007	-0.042	0.052	-0.005
WTE11	V43	-0.037	0.021	-0.030	-0.065	0.012
VAR1	V44	-0.005	0.064	0.079	0.006	0.044
VAR2	V45	-0.056	0.002	0.068	-0.005	-0.001
VAR3	V46	0.042	0.027	0.051	-0.028	-0.053
VAR4	V47	0.038	-0.042	0.005	-0.016	-0.009
VAR5	V48	-0.017	0.032	0.040	-0.082	-0.053
VAR6	V49	0.005	-0.050	-0.118	0.100	-0.048
VAR7	V50	0.032	0.043	-0.003	0.003	-0.024
BUR1	V51	0.013	-0.064	0.021	-0.037	-0.071
BUR2	V52	0.045	0.090	-0.018	-0.047	-0.014
BUR3	V53	0.079	-0.034	0.037	-0.096	-0.007
BUR4	V54	-0.069	0.060	0.007	-0.027	0.067
BUR5	V55	-0.085	0.050	0.003	-0.002	0.009
BUR6	V56	0.061	0.100	-0.008	-0.014	0.018
BUR7	V57	-0.006	0.002	0.035	0.029	-0.019
BUR8	V58	-0.013	0.034	0.036	0.074	-0.060
BUR9	V59	0.035	0.073	-0.026	-0.117	0.009
BUR10	V60	0.044	-0.019	0.054	0.023	-0.017
BUR11	V61	0.015	0.041	0.043	-0.017	-0.012
BUR12	V62	0.034	-0.025	0.038	-0.018	-0.046
BUR13	V63	0.005	0.065	0.031	0.001	-0.070
BUR14	V64	-0.001	-0.004	0.018	-0.076	0.095

BUR15	V65	-0.073	0.092	-0.034	-0.022	0.003
BUR16	V66	-0.041	0.011	0.041	-0.033	-0.045
BUR17	V67	-0.087	0.038	-0.030	-0.033	-0.007
BUR18	V68	-0.035	-0.027	0.092	-0.052	0.069
BUR19	V69	0.014	0.059	0.008	0.024	0.157
BUR20	V70	0.016	-0.082	0.086	-0.037	0.035
WFR1	V71	0.019	0.059	0.170	-0.016	0.010
WFR2	V72	0.059	-0.005	-0.089	0.462	0.043

		DIR8	DIR9	DIR10	DIR11	DIR12
		V16	V17	V18	V19	V20
DIR8	V16	0.000				
DIR9	V17	0.024	0.000			
DIR10	V18	-0.080	0.041	0.000		
DIR11	V19	-0.066	-0.078	-0.078	0.000	
DIR12	V20	-0.091	0.051	0.033	0.006	0.000
DIR13	V21	-0.021	-0.029	-0.088	-0.096	0.030
RES1	V22	-0.021	-0.033	-0.050	-0.018	0.047
RES2	V23	-0.004	0.011	-0.007	-0.013	0.010
RES3	V24	0.089	0.018	-0.023	0.037	-0.088
RES4	V25	0.041	0.009	-0.032	-0.001	0.116
RES5	V26	0.010	0.001	-0.002	0.019	0.004
RES6	V27	0.009	0.010	-0.035	0.051	0.026
RES7	V28	0.007	0.072	0.006	-0.097	0.018
RES8	V29	0.056	-0.019	-0.012	-0.003	-0.031
RES9	V30	0.045	-0.065	-0.023	0.057	0.051
RES10	V31	0.035	0.038	0.042	-0.035	-0.012
RES11	V32	-0.014	0.017	-0.042	-0.136	0.014
WTE1	V33	0.047	0.024	-0.010	0.001	-0.047
WTE2	V34	0.054	0.001	0.003	-0.033	0.067

WTE3	V35	0.014	-0.067	-0.061	0.046	0.092
WTE4	V36	-0.023	-0.012	0.034	0.006	-0.009
WTE5	V37	-0.051	-0.085	0.012	0.054	0.025
WTE6	V38	-0.056	-0.026	-0.021	0.076	-0.037
WTE7	V39	0.029	0.055	0.037	-0.004	0.112
WTE8	V40	0.003	0.072	-0.021	-0.017	-0.041
WTE9	V41	-0.019	-0.034	0.107	-0.050	-0.113
WTE10	V42	-0.085	0.012	0.007	-0.037	-0.089
WTE11	V43	0.036	0.035	0.014	-0.033	0.020
VAR1	V44	-0.036	0.036	-0.061	0.029	-0.012
VAR2	V45	0.024	0.052	-0.016	-0.012	0.017
VAR3	V46	0.031	-0.083	-0.011	-0.062	-0.017
VAR4	V47	-0.002	-0.016	-0.150	0.049	-0.056
VAR5	V48	-0.068	-0.049	0.048	0.053	0.008
VAR6	V49	0.015	0.074	0.015	-0.015	0.048
VAR7	V50	0.005	0.008	0.020	-0.004	0.005
BUR1	V51	-0.038	0.001	0.015	-0.097	-0.002
BUR2	V52	0.064	0.034	0.049	-0.084	-0.039
BUR3	V53	-0.001	-0.029	-0.012	-0.014	0.078
BUR4	V54	0.019	-0.010	0.003	-0.079	-0.010
BUR5	V55	-0.056	-0.030	0.035	0.075	0.110
BUR6	V56	0.064	0.068	0.040	-0.062	0.027
BUR7	V57	-0.015	-0.020	-0.032	-0.063	-0.007
BUR8	V58	0.022	0.012	0.016	-0.025	0.016
BUR9	V59	0.003	0.007	-0.024	0.058	0.022
BUR10	V60	0.018	-0.064	0.054	0.014	-0.059
BUR11	V61	-0.043	-0.009	0.102	0.028	0.031
BUR12	V62	0.001	0.025	-0.059	0.085	0.012

BUR13	V63	0.020	-0.050	0.027	0.026	-0.016
BUR14	V64	0.009	0.076	0.077	0.023	-0.013
BUR15	V65	-0.022	0.018	-0.149	0.015	0.028
BUR16	V66	0.048	0.025	-0.033	-0.002	0.066
BUR17	V67	0.068	0.031	-0.026	-0.016	-0.013
BUR18	V68	0.056	-0.108	-0.021	-0.030	0.006
BUR19	V69	-0.009	-0.032	-0.085	-0.053	-0.019
BUR20	V70	0.071	0.023	-0.016	-0.079	0.019
WFR1	V71	0.014	-0.064	0.010	-0.037	-0.037
WFR2	V72	-0.035	-0.091	0.041	-0.075	0.062

		DIR13 V21	RES1 V22	RES2 V23	RES3 V24	RES4 V25
DIR13	V21	-0.003				
RES1	V22	0.035	0.000			
RES2	V23	0.072	0.107	0.000		
RES3	V24	0.001	0.004	0.036	0.000	
RES4	V25	0.001	0.000	-0.008	-0.053	0.000
RES5	V26	-0.023	-0.010	0.008	-0.020	0.017
RES6	V27	-0.026	-0.028	0.053	0.050	0.021
RES7	V28	-0.029	0.085	-0.063	-0.034	-0.038
RES8	V29	0.063	0.042	0.099	-0.024	0.059
RES9	V30	0.000	0.023	-0.040	0.027	0.031
RES10	V31	-0.032	0.074	-0.034	-0.058	-0.025
RES11	V32	0.054	-0.016	-0.029	-0.012	-0.003
WTE1	V33	0.032	-0.093	-0.043	0.018	-0.030
WTE2	V34	0.052	-0.050	0.044	0.013	-0.055
WTE3	V35	-0.033	0.046	0.000	-0.107	0.073
WTE4	V36	0.121	0.012	0.027	0.018	0.032
WTE5	V37	0.110	0.071	0.056	-0.063	0.029

WTE6	V38	0.128	0.077	0.080	0.143	0.002
WTE7	V39	0.063	0.034	0.066	-0.075	0.055
WTE8	V40	-0.027	0.044	-0.051	-0.041	-0.034
WTE9	V41	-0.011	0.064	0.018	-0.041	0.020
WTE10	V42	0.033	-0.055	-0.045	0.011	0.085
WTE11	V43	0.013	0.050	0.066	0.111	0.014
VAR1	V44	0.001	0.002	-0.013	-0.038	0.086
VAR2	V45	0.038	-0.090	0.078	0.066	-0.008
VAR3	V46	-0.007	-0.044	0.029	0.041	-0.009
VAR4	V47	0.032	0.042	0.027	0.125	0.022
VAR5	V48	-0.037	-0.046	0.052	-0.117	0.014
VAR6	V49	0.001	-0.008	-0.001	0.054	-0.029
VAR7	V50	-0.045	0.035	-0.030	-0.047	0.017
BUR1	V51	0.042	-0.041	-0.108	-0.001	-0.008
BUR2	V52	-0.079	0.018	0.040	-0.003	-0.052
BUR3	V53	0.024	0.013	0.002	-0.014	0.077
BUR4	V54	-0.016	0.011	-0.101	-0.081	0.030
BUR5	V55	0.000	-0.022	0.009	-0.012	0.033
BUR6	V56	-0.003	0.016	0.003	-0.070	0.004
BUR7	V57	-0.055	-0.117	-0.053	-0.075	0.018
BUR8	V58	0.067	-0.002	0.030	-0.027	-0.020
BUR9	V59	0.038	-0.014	-0.073	-0.022	0.100
BUR10	V60	0.120	0.050	0.009	0.039	0.043
BUR11	V61	0.015	-0.077	-0.006	-0.047	0.004
BUR12	V62	-0.053	-0.017	-0.046	-0.014	0.087
BUR13	V63	0.077	-0.056	0.027	0.035	-0.082
BUR14	V64	-0.049	-0.029	-0.078	0.020	0.005
BUR15	V65	-0.047	-0.058	-0.017	0.028	0.019

BUR16	V66	0.037	-0.006	0.000	-0.020	-0.009
BUR17	V67	-0.024	0.013	-0.039	0.047	-0.017
BUR18	V68	-0.063	-0.012	0.006	-0.070	-0.044
BUR19	V69	-0.004	-0.037	-0.076	-0.092	0.009
BUR20	V70	-0.004	0.046	0.094	0.048	-0.029
WFR1	V71	-0.067	0.042	0.056	-0.006	0.009
WFR2	V72	0.058	-0.033	-0.011	0.079	-0.028

		RES5	RES6	RES7	RES8	RES9
		V26	V27	V28	V29	V30
RES5	V26	0.000				
RES6	V27	-0.016	0.000			
RES7	V28	0.058	-0.024	0.000		
RES8	V29	-0.002	-0.047	-0.089	0.000	
RES9	V30	0.047	0.024	0.032	-0.066	0.000
RES10	V31	-0.029	0.004	0.060	-0.078	0.045
RES11	V32	0.018	-0.008	0.035	-0.031	-0.008
WTE1	V33	-0.003	0.014	-0.058	0.021	-0.013
WTE2	V34	0.048	-0.041	-0.079	0.011	-0.031
WTE3	V35	-0.017	0.009	-0.018	0.107	0.029
WTE4	V36	0.026	-0.141	-0.039	0.031	-0.011
WTE5	V37	-0.032	-0.025	0.010	0.024	0.056
WTE6	V38	0.066	0.034	0.053	0.079	0.035
WTE7	V39	0.084	-0.003	0.032	0.028	-0.024
WTE8	V40	0.027	0.036	0.005	0.023	0.005
WTE9	V41	0.003	0.076	-0.031	0.003	0.002
WTE10	V42	0.058	-0.092	-0.052	0.001	-0.007
WTE11	V43	0.001	0.049	0.008	0.031	-0.058
VAR1	V44	0.122	-0.011	0.030	-0.019	0.021
VAR2	V45	0.009	0.013	-0.086	0.010	-0.015

VAR3	V46	0.015	0.010	0.017	-0.050	0.027
VAR4	V47	0.078	0.008	-0.042	0.049	-0.024
VAR5	V48	0.000	0.029	0.006	0.005	-0.053
VAR6	V49	0.053	0.071	0.140	0.096	-0.009
VAR7	V50	-0.005	-0.040	-0.064	-0.075	-0.040
BUR1	V51	0.010	0.072	-0.038	0.017	-0.039
BUR2	V52	-0.017	0.042	-0.020	0.054	0.065
BUR3	V53	-0.038	0.012	0.020	-0.049	-0.044
BUR4	V54	-0.073	-0.019	-0.020	0.042	-0.008
BUR5	V55	-0.015	0.025	-0.058	-0.010	-0.045
BUR6	V56	0.018	0.053	-0.062	0.006	-0.090
BUR7	V57	-0.036	-0.069	-0.043	0.138	0.024
BUR8	V58	-0.045	-0.054	0.051	-0.031	0.049
BUR9	V59	0.040	-0.005	0.021	-0.001	0.066
BUR10	V60	0.083	0.045	0.035	-0.037	0.059
BUR11	V61	-0.037	-0.038	0.018	-0.009	0.019
BUR12	V62	0.023	-0.030	-0.029	0.093	0.140
BUR13	V63	-0.082	0.054	-0.135	0.004	0.032
BUR14	V64	0.027	0.045	0.007	-0.037	-0.011
BUR15	V65	-0.010	-0.021	0.045	-0.148	0.040
BUR16	V66	0.015	-0.021	-0.020	0.038	-0.022
BUR17	V67	0.006	0.015	0.017	-0.041	0.020
BUR18	V68	-0.066	0.040	-0.116	0.054	0.020
BUR19	V69	0.078	-0.009	-0.033	-0.015	-0.029
BUR20	V70	0.062	0.012	0.006	0.026	0.010
WFR1	V71	-0.039	0.031	-0.056	0.049	-0.011
WFR2	V72	0.027	-0.011	0.010	-0.007	-0.048

		RES10	RES11	WTE1	WTE2	WTE3
		V31	V32	V33	V34	V35
RES10	V31	0.000				
RES11	V32	0.021	-0.002			
WTE1	V33	0.008	0.067	0.000		
WTE2	V34	-0.011	0.064	0.049	0.000	
WTE3	V35	-0.004	-0.025	-0.105	-0.036	0.000
WTE4	V36	0.054	0.065	0.020	-0.008	-0.026
WTE5	V37	-0.102	-0.001	0.023	-0.010	-0.007
WTE6	V38	-0.069	-0.047	-0.014	-0.002	-0.015
WTE7	V39	0.045	0.017	-0.003	0.092	-0.036
WTE8	V40	-0.068	-0.022	0.101	0.055	-0.026
WTE9	V41	0.007	-0.027	-0.053	-0.008	-0.059
WTE10	V42	0.019	-0.079	-0.049	-0.043	0.032
WTE11	V43	0.005	-0.025	0.016	-0.007	-0.005
VAR1	V44	-0.013	0.000	-0.026	0.028	0.036
VAR2	V45	0.065	0.015	-0.037	0.026	0.051
VAR3	V46	0.020	-0.020	-0.060	-0.019	0.040
VAR4	V47	-0.028	-0.015	0.064	-0.010	-0.036
VAR5	V48	-0.017	-0.010	0.047	0.023	0.010
VAR6	V49	0.002	-0.049	0.011	-0.034	-0.121
VAR7	V50	0.013	-0.011	-0.017	-0.055	0.033
BUR1	V51	-0.029	0.049	-0.034	-0.002	-0.012
BUR2	V52	0.011	0.038	-0.056	0.109	0.040
BUR3	V53	-0.065	0.055	-0.020	-0.049	-0.071
BUR4	V54	-0.079	-0.127	-0.014	0.052	0.022
BUR5	V55	0.077	-0.059	-0.105	-0.025	0.027
BUR6	V56	-0.038	-0.054	0.038	-0.063	0.036
BUR7	V57	-0.076	0.048	0.046	0.028	-0.051
BUR8	V58	0.082	-0.012	0.023	-0.004	0.058

BUR9	V59	-0.027	-0.004	0.057	-0.022	0.001
BUR10	V60	-0.014	-0.005	-0.016	0.003	0.056
BUR11	V61	0.016	0.073	0.037	-0.081	-0.005
BUR12	V62	-0.026	0.027	0.050	-0.021	-0.028
BUR13	V63	0.056	0.008	-0.071	0.057	-0.030
BUR14	V64	0.026	-0.016	-0.002	0.029	0.000
BUR15	V65	-0.042	-0.018	-0.037	0.023	0.043
BUR16	V66	0.082	0.023	-0.099	0.035	0.026
BUR17	V67	-0.004	0.040	-0.048	-0.045	-0.003
BUR18	V68	-0.008	0.047	-0.014	0.083	0.049
BUR19	V69	-0.031	-0.099	0.037	-0.010	-0.018
BUR20	V70	0.084	0.039	0.007	0.079	0.125
WFR1	V71	-0.068	-0.040	0.010	-0.023	0.038
WFR2	V72	0.029	-0.011	-0.007	0.001	-0.015

		WTE4	WTE5	WTE6	WTE7	WTE8
		V36	V37	V38	V39	V40
WTE4	V36	0.000				
WTE5	V37	0.069	0.000			
WTE6	V38	0.029	0.047	0.000		
WTE7	V39	0.018	-0.050	0.001	0.000	
WTE8	V40	-0.006	0.072	-0.018	0.020	0.000
WTE9	V41	-0.008	0.083	-0.011	-0.088	-0.009
WTE10	V42	-0.035	-0.059	-0.035	-0.031	0.011
WTE11	V43	0.017	0.025	-0.011	-0.004	-0.006
VAR1	V44	-0.013	0.023	-0.040	-0.015	0.042
VAR2	V45	0.018	-0.043	0.029	0.085	-0.020
VAR3	V46	-0.057	0.006	-0.037	-0.106	-0.086
VAR4	V47	-0.066	0.115	-0.020	0.041	-0.055
VAR5	V48	0.019	-0.006	-0.047	-0.086	0.006

VAR6	V49	-0.042	-0.045	-0.098	0.015	0.096
VAR7	V50	0.094	-0.078	0.012	0.023	-0.059
BUR1	V51	0.005	-0.052	-0.015	-0.003	-0.035
BUR2	V52	0.078	0.010	-0.017	0.013	0.032
BUR3	V53	-0.017	-0.008	-0.080	0.072	0.090
BUR4	V54	0.002	-0.037	0.011	0.014	-0.057
BUR5	V55	0.037	-0.012	-0.033	0.075	-0.094
BUR6	V56	-0.076	-0.003	0.020	0.013	0.083
BUR7	V57	0.053	0.002	0.010	0.040	0.022
BUR8	V58	0.038	0.000	0.071	-0.048	-0.030
BUR9	V59	0.007	-0.067	0.030	0.029	0.084
BUR10	V60	-0.072	-0.079	-0.025	-0.006	0.007
BUR11	V61	-0.043	0.023	0.059	0.006	-0.066
BUR12	V62	-0.056	-0.045	-0.014	0.017	0.116
BUR13	V63	-0.019	0.056	-0.033	0.045	-0.032
BUR14	V64	0.001	-0.104	0.040	-0.053	0.075
BUR15	V65	-0.063	-0.019	0.003	0.029	0.109
BUR16	V66	-0.011	0.002	-0.006	0.093	-0.021
BUR17	V67	-0.098	0.107	-0.037	0.048	-0.042
BUR18	V68	-0.045	0.020	0.008	0.089	-0.001
BUR19	V69	-0.033	0.010	-0.010	-0.077	-0.013
BUR20	V70	-0.078	-0.097	0.086	0.026	0.078
WFR1	V71	-0.026	0.008	0.024	0.021	-0.041
WFR2	V72	0.001	-0.016	0.085	-0.013	-0.005

		WTE9	WTE10	WTE11	VAR1	VAR2
		V41	V42	V43	V44	V45
WTE9	V41	0.000				
WTE10	V42	0.072	0.000			
WTE11	V43	-0.020	0.000	-0.003		

VAR1	V44	0.085	-0.014	-0.068	0.000	
VAR2	V45	0.008	0.064	-0.026	0.096	0.000
VAR3	V46	0.015	-0.023	-0.039	-0.019	-0.032
VAR4	V47	0.019	-0.011	-0.033	0.020	-0.075
VAR5	V48	0.022	-0.099	0.060	0.002	-0.008
VAR6	V49	-0.102	0.038	0.026	0.027	0.009
VAR7	V50	0.079	0.070	-0.023	-0.018	-0.053
BUR1	V51	0.027	0.069	-0.001	-0.081	0.003
BUR2	V52	0.081	-0.007	-0.049	0.035	0.046
BUR3	V53	0.033	-0.004	-0.001	-0.099	-0.008
BUR4	V54	0.056	0.059	0.042	-0.085	-0.063
BUR5	V55	-0.002	0.090	-0.054	-0.070	0.026
BUR6	V56	0.014	0.092	-0.033	-0.038	0.033
BUR7	V57	0.064	-0.035	-0.055	0.017	-0.055
BUR8	V58	0.043	-0.066	0.011	0.042	-0.024
BUR9	V59	-0.004	-0.088	0.043	0.043	0.013
BUR10	V60	0.029	0.005	0.001	0.012	-0.031
BUR11	V61	0.043	0.004	-0.004	-0.063	-0.054
BUR12	V62	0.029	0.014	-0.107	0.073	-0.038
BUR13	V63	-0.011	-0.013	0.034	-0.091	-0.058
BUR14	V64	-0.045	0.157	-0.062	-0.092	-0.035
BUR15	V65	0.060	0.020	0.063	-0.008	0.018
BUR16	V66	-0.030	0.004	-0.006	0.009	-0.006
BUR17	V67	-0.024	0.011	0.003	-0.023	-0.044
BUR18	V68	-0.027	-0.022	-0.081	-0.039	0.013
BUR19	V69	0.031	-0.040	-0.072	0.061	0.106
BUR20	V70	-0.036	-0.106	0.053	-0.044	-0.019
WFR1	V71	0.029	-0.018	-0.065	0.024	-0.024
WFR2	V72	0.024	0.015	-0.026	-0.011	0.014

		VAR3 V46	VAR4 V47	VAR5 V48	VAR6 V49	VAR7 V50
VAR3	V46	0.000				
VAR4	V47	0.041	0.000			
VAR5	V48	0.004	-0.015	0.000		
VAR6	V49	-0.080	0.034	0.004	0.000	
VAR7	V50	-0.037	0.006	0.015	-0.021	0.000
BUR1	V51	-0.003	0.023	-0.005	-0.010	0.070
BUR2	V52	0.062	-0.026	0.052	-0.029	0.093
BUR3	V53	0.058	0.073	-0.028	0.032	0.089
BUR4	V54	-0.005	0.040	-0.068	-0.105	-0.022
BUR5	V55	0.006	-0.047	-0.003	-0.023	0.049
BUR6	V56	-0.003	-0.090	0.039	0.025	-0.064
BUR7	V57	-0.068	-0.090	-0.034	0.053	0.074
BUR8	V58	-0.028	-0.047	-0.034	0.024	0.055
BUR9	V59	-0.083	-0.013	0.085	-0.017	0.007
BUR10	V60	-0.022	0.025	-0.032	-0.070	-0.017
BUR11	V61	-0.063	-0.072	0.055	-0.092	0.133
BUR12	V62	-0.112	0.028	-0.003	0.042	-0.046
BUR13	V63	0.042	-0.018	-0.064	-0.065	-0.030
BUR14	V64	0.032	0.001	-0.026	-0.027	0.038
BUR15	V65	-0.064	-0.038	-0.130	-0.084	0.068
BUR16	V66	-0.071	0.083	-0.027	-0.061	0.096
BUR17	V67	0.025	0.076	-0.044	0.013	-0.041
BUR18	V68	-0.043	0.029	0.018	-0.035	-0.069
BUR19	V69	0.035	-0.003	-0.007	0.017	0.028
BUR20	V70	0.073	0.012	0.023	0.000	0.030
WFR1	V71	0.046	0.023	-0.025	-0.039	-0.067
WFR2	V72	0.036	0.007	0.010	0.034	-0.003

		BUR1 V51	BUR2 V52	BUR3 V53	BUR4 V54	BUR5 V55
BUR1	V51	0.000				
BUR2	V52	0.055	0.000			
BUR3	V53	0.061	-0.011	0.000		
BUR4	V54	-0.011	-0.006	0.033	0.000	
BUR5	V55	-0.003	0.093	0.066	0.031	0.000
BUR6	V56	-0.107	-0.070	0.024	0.085	-0.006
BUR7	V57	-0.055	-0.094	-0.040	-0.034	-0.029
BUR8	V58	0.079	0.009	-0.062	-0.024	-0.102
BUR9	V59	-0.006	-0.056	0.033	0.013	-0.032
BUR10	V60	0.027	-0.002	-0.052	-0.067	0.021
BUR11	V61	0.017	0.012	0.030	-0.032	-0.010
BUR12	V62	0.090	0.019	-0.008	-0.062	0.045
BUR13	V63	-0.005	0.002	-0.016	0.000	0.062
BUR14	V64	0.054	-0.080	0.084	0.127	-0.001
BUR15	V65	0.042	0.018	0.005	0.002	0.058
BUR16	V66	0.033	-0.005	-0.010	-0.018	-0.041
BUR17	V67	0.052	-0.031	-0.028	0.041	0.042
BUR18	V68	-0.054	-0.009	-0.002	0.029	-0.059
BUR19	V69	0.016	0.028	-0.042	0.047	-0.016
BUR20	V70	0.007	-0.012	-0.011	0.008	0.005
WFR1	V71	0.011	-0.007	0.045	0.005	0.067
WFR2	V72	-0.016	-0.017	-0.119	0.041	0.013

		BUR6 V56	BUR7 V57	BUR8 V58	BUR9 V59	BUR10 V60
BUR6	V56	0.000				
BUR7	V57	-0.057	0.000			
BUR8	V58	0.043	-0.012	0.000		
BUR9	V59	0.024	-0.012	-0.029	0.000	
BUR10	V60	0.017	-0.052	0.057	-0.018	0.000

BUR11	V61	0.027	0.056	-0.111	0.019	0.026
BUR12	V62	-0.057	0.064	-0.015	0.102	0.074
BUR13	V63	-0.064	0.000	0.036	-0.070	0.024
BUR14	V64	0.059	0.015	0.047	0.033	-0.079
BUR15	V65	0.074	-0.078	-0.031	-0.032	-0.080
BUR16	V66	-0.057	-0.072	0.043	-0.060	0.018
BUR17	V67	-0.064	-0.054	-0.005	0.095	0.007
BUR18	V68	0.016	-0.043	-0.073	-0.043	0.059
BUR19	V69	-0.055	0.023	-0.022	-0.044	-0.023
BUR20	V70	0.004	0.001	0.011	0.000	-0.006
WFR1	V71	0.011	0.000	0.053	0.018	0.037
WFR2	V72	0.020	0.054	0.037	0.007	0.036

		BUR11	BUR12	BUR13	BUR14	BUR15
		V61	V62	V63	V64	V65
BUR11	V61	0.000				
BUR12	V62	0.090	0.000			
BUR13	V63	0.047	-0.050	0.000		
BUR14	V64	-0.003	-0.016	-0.058	0.000	
BUR15	V65	0.048	-0.074	0.032	-0.039	0.000
BUR16	V66	0.033	-0.023	0.010	-0.046	0.054
BUR17	V67	-0.015	0.007	0.093	-0.003	0.066
BUR18	V68	0.018	0.039	0.048	-0.010	-0.011
BUR19	V69	0.023	-0.057	0.060	-0.063	-0.006
BUR20	V70	0.001	-0.016	-0.018	-0.001	-0.002
WFR1	V71	-0.036	0.088	0.106	-0.071	-0.084
WFR2	V72	0.044	-0.048	-0.040	-0.021	-0.021

		BUR16	BUR17	BUR18	BUR19	BUR20
		V66	V67	V68	V69	V70
BUR16	V66	0.000				

```
    BUR17     V67          0.053       0.000
    BUR18     V68          0.063       0.036       0.000
    BUR19     V69         -0.048       0.024       0.019       0.000
    BUR20     V70          0.001      -0.006       0.000      -0.010       -
0.004
      WFR1    V71          0.009       0.006       0.091       0.045
0.029
      WFR2    V72          0.029      -0.032      -0.097       0.022
0.042


                           WFR1        WFR2
                            V71         V72
      WFR1    V71          0.087
      WFR2    V72         -0.042       0.001

                   AVERAGE ABSOLUTE STANDARDIZED RESIDUAL =
0.0389
       AVERAGE OFF-DIAGONAL ABSOLUTE STANDARDIZED RESIDUAL =
0.0399
```

LARGEST STANDARDIZED RESIDUALS:

NO.	PARAMETER	ESTIMATE	NO.	PARAMETER	ESTIMATE
1	V72, V8	0.572	11	V30, V4	0.147
2	V72, V14	0.462	12	V29, V10	-0.147
3	V35, V15	0.174	13	V34, V10	-0.146
4	V71, V13	0.170	14	V28, V13	-0.144
5	V64, V42	0.157	15	V38, V24	0.143
6	V69, V15	0.157	16	V45, V7	-0.142
7	V47, V18	-0.150	17	V36, V27	-0.141
8	V65, V18	-0.149	18	V53, V6	0.141
9	V65, V29	-0.148	19	V62, V30	0.140
10	V15, V1	0.147	20	V49, V28	0.140

MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)

DISTRIBUTION OF STANDARDIZED RESIDUALS

```
     ----------------------------------------
     !                                      !
   00-                     *                -
     !                  *  *                !
     !                  *  *                !
     !                  *  *                !
     !                  *  *                !              RANGE
FREQ PERCENT
  975-                  *  *                -
     !                  *  *                !     1    -0.5   -   --
0    0.00%
     !                  *  *                !     2    -0.4   -   -0.5
0    0.00%
```

```
     !                  *  *                  !    3    -0.3   -   -0.4
0   0.00%
     !                  *  *                  !    4    -0.2   -   -0.3
0   0.00%
   650-                 *  *                  -    5    -0.1   -   -0.2
54   2.05%
     !                  *  *                  !    6     0.0   -   -0.1
1211  46.08%
     !                  *  *                  !    7     0.1   -    0.0
1305  49.66%
     !                  *  *                  !    8     0.2   -    0.1
56   2.13%
     !                  *  *                  !    9     0.3   -    0.2
0   0.00%
   325-                 *  *                  -    A     0.4   -    0.3
0   0.00%
     !                  *  *                  !    B     0.5   -    0.4
1   0.04%
     !                  *  *                  !    C      ++   -    0.5
1   0.04%
     !                  *  *                  !    ----------------------
---------
     !               *  *  *  *               !          TOTAL
2628 100.00%
     ----------------------------------------
        1  2  3  4  5  6  7  8  9  A  B  C    EACH "*" REPRESENTS   65
RESIDUALS
```

MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)

***** WARNING *** TEST RESULTS MAY NOT BE APPROPRIATE DUE TO CONDITION CODE**

```
GOODNESS OF FIT SUMMARY FOR METHOD = ML

INDEPENDENCE MODEL CHI-SQUARE        =    3399.033 ON   2556 DEGREES
OF FREEDOM

INDEPENDENCE AIC =   -1712.967   INDEPENDENCE CAIC =  -14471.151
       MODEL AIC =   -1939.475          MODEL CAIC =  -14338.273

CHI-SQUARE =     3028.525 BASED ON    2484 DEGREES OF FREEDOM
PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS      0.00000

THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS
2755.168.

FIT INDICES
-----------
BENTLER-BONETT     NORMED FIT INDEX =     0.109
BENTLER-BONETT NON-NORMED FIT INDEX =     0.335
COMPARATIVE FIT INDEX (CFI)         =     0.354
BOLLEN'S          (IFI) FIT INDEX   =     0.405
MCDONALD'S        (MFI) FIT INDEX   =     0.506
```

```
JORESKOG-SORBOM'S  GFI  FIT INDEX    =      0.839
JORESKOG-SORBOM'S AGFI  FIT INDEX    =      0.830
ROOT MEAN-SQUARE RESIDUAL (RMR)      =      0.423
STANDARDIZED RMR                     =      0.051
ROOT MEAN-SQUARE ERROR OF APPROXIMATION (RMSEA)    =      0.023
90% CONFIDENCE INTERVAL OF RMSEA  (       0.020,          0.026)

RELIABILITY COEFFICIENTS
------------------------
CRONBACH'S ALPHA                     =      0.058
```

ITERATIVE SUMMARY

ITERATION	PARAMETER ABS CHANGE	ALPHA	FUNCTION
1	7.926075	1.00000	20.95421
2	7.547451	1.00000	10.74106
3	0.857517	1.00000	8.80036
4	0.099451	1.00000	8.32817
5	0.100135	0.50000	8.00445
6	0.048024	1.00000	7.80307
7	0.040574	1.00000	7.66367
8	0.040231	0.50000	7.62924
9	0.047112	0.50000	7.62249
10	0.099768	0.20282	7.61732
11	0.153860	0.09412	7.61072
12	0.197208	0.08483	7.60591
13	0.255429	0.07994	7.60271
14	0.339163	0.07819	7.60138
15	0.470522	0.03517	7.59930
16	0.558555	0.03173	7.59760
17	0.661758	0.02944	7.59621
18	0.786112	0.02805	7.59514
19	0.941073	0.02740	7.59443
20	1.142138	0.02740	7.59419
21	1.416052	0.01240	7.59351
22	1.577285	0.01143	7.59290
23	1.752013	0.01065	7.59236
24	1.942707	0.01003	7.59188
25	2.152681	0.00955	7.59146
26	2.386397	0.00920	7.59109
27	2.649861	0.00897	7.59077
28	2.951232	0.00884	7.59053
29	3.301947	0.00882	7.59036
30	3.718169	0.00890	7.59029

```
*************************************************************************
************************************************
 ** NOTE: DO NOT TRUST THIS OUTPUT.  ITERATIVE PROCESS HAS NOT
CONVERGED.  MAXIMUM NUMBER OF ITERATIONS WAS REACHED.[3] **
```

[3] In Maximum Likelihood Estimation (MLE) method, such warning is typical. The results shown provide the best estimate based on the amount of convergence that is reached. When the iterative process does not

```
 **
**
 **  30 ITERATIONS HAVE BEEN COMPLETED AND THE PROGRAM STOPPED. CHECK
PARAMETER IDENTIFICATION.                           **


**  IF IDENTIFIED, USE THE UPDATED PARAMETERS TO START AGAIN.
**
 **
**
 **  SUBSEQUENT METHODS WILL NOT BE COMPUTED DUE TO ITERATIVE FAILURE.
**

***********************************************************************
***********************************************

 MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)


  MEASUREMENT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS
  STATISTICS SIGNIFICANT AT THE 5% LEVEL ARE MARKED WITH @.



   PRE8  =V8  =    1.000 F1    +  1.000 E8


 DIR13   =V21 =    1.000 F2    +  1.000 E21


 RES11   =V32 =    1.000 F3    +  1.000 E32



 WTE11   =V43 =    1.000 F4    +  1.000 E43

 VAR5  =V48 =    1.000 F5    +  1.000 E48

 BUR20   =V70 =    1.000 F6    +  1.000 E70

 WFR1  =V71 =    1.000 F7    +  1.000 E71

 WFR2  =V72 =     .030*F7    +  1.000 E72
                   .074
                   .403


  MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)


  CONSTRUCT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS
  STATISTICS SIGNIFICANT AT THE 5% LEVEL ARE MARKED WITH @.
```

---

converged, the results are not accurate but are sensitive to the amount of convergence that has reached. In order to reach the full convergence, the number of iterations at the time of running the model have to be increased, which in turn requires higher computational power (not available for this research).

```
 F1    =F1   =    -.001*V1    +   .079*V2    -   .001*V3    -
.005*V4
                    .004          .052          .005          .005
                  -.262         1.523         -.219         -.863

             -      .003*V5   +    .003*V6   +   .001*V7
                    .005          .005          .004
                  -.591           .635          .207

 F2    =F2   =    -.001*V9    -   .000*V10   -   .000*V11   +
.000*V12
                    .007          .001          .004          .002
                  -.077         -.050         -.077           .075

             +      .004*V13  -   .000*V14   +   .000*V15   +
.000*V16
                    .051          .003          .001          .004
                    .077        -.076           .048          .076

             -      .001*V17  +   .000*V18   +   .000*V19   -
.000*V20
                    .007          .001          .003          .002
                  -.077           .067          .076        -.074

 F3    =F3   =    -.006*V22   +   .062*V23   -   .004*V24   +
.057*V25
                    .044          .044          .043          .043
                  -.126         1.409         -.093          1.333

             -      .058*V26  -   .023*V27   -   .013*V28   +
.026*V29
                    .044          .042          .044          .043
                 -1.307         -.540         -.304           .603

             +      .044*V30  +   .112*V31
                    .043          .047
                  1.009         2.391@

 F4    =F4   =    -.009*V33   +   .033*V34   -   .031*V35   +
.010*V36
                    .048          .048          .044          .048
                  -.179           .697        -.694           .200

             -      .061*V37  +   .042*V38   -   .073*V39   +
.080*V40
                    .047          .047          .047          .049
                 -1.290           .898       -1.558          1.644

             +      .057*V41  -   .104*V42
                    .047          .048
                  1.211        -2.156@

 F5    =F5   =      .094*V44  -   .005*V45   +   .092*V46   +
.042*V47
```

```
                  .050          .050          .050          .049
                 1.863         -.105         1.832          .865

              -   .004*V49  +   .012*V50
                  .049          .051
                 -.089          .242


 CONSTRUCT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS
(CONTINUED)


 MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)

   F6   =F6  =     -.029*V51  +   .020*V52  +   .090*V53   -
.064*V54
                  .049          .048          .048          .048
                 -.588          .417         1.864        -1.334

              -   .096*V55  +   .058*V56  -   .051*V57   +
.048*V58
                  .050          .049          .047          .049
                -1.919         1.168        -1.068          .990

              +   .031*V59  +   .028*V60  -   .002*V61   -
.021*V62
                  .049          .049          .048          .049
                  .635          .572         -.044         -.438

              +   .068*V63  +   .026*V64  +   .011*V65   -
.045*V66
                  .050          .048          .050          .050
                 1.375          .547          .216         -.902

              -   .011*V67  -   .026*V68  +   .028*V69
                  .048          .049          .049
                 -.229         -.543          .575

   F7   =F7  =     7.836*F1   + 71.241*F2   +   .369*F3    +
.212*F4
                 5.163        923.632         .238          .195
                 1.518          .077         1.548         1.085

              +   .174*F5   +   .065*F6   + 1.000 D7
                  .252          .169
                  .693          .384



 MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)

 VARIANCES OF INDEPENDENT VARIABLES
 ----------------------------------
 STATISTICS SIGNIFICANT AT THE 5% LEVEL ARE MARKED WITH @.
```

```
                          V                                  F
                         ---                                ---
V1   -   PRE1                     8.756*I                             I
                                   .620 I                             I
                                 14.124@I                             I
                                        I                             I
V2   -   PRE2                     7.819*I                             I
                                   .554 I                             I
                                 14.124@I                             I
                                        I                             I
V3   -   PRE3                     7.829*I                             I
                                   .554 I                             I
                                 14.124@I                             I
                                        I                             I
V4   -   PRE4                     8.135*I                             I
                                   .576 I                             I
                                 14.124@I                             I
                                        I                             I
V5   -   PRE5                     8.817*I                             I
                                   .624 I                             I
                                 14.124@I                             I
                                        I                             I
V6   -   PRE6                     7.947*I                             I
                                   .563 I                             I
                                 14.124@I                             I
                                        I                             I
V7   -   PRE7                     8.130*I                             I
                                   .576 I                             I
                                 14.124@I                             I
                                        I                             I
V9   -   DIR1                     7.610*I                             I
                                   .539 I                             I
                                 14.124@I                             I
                                        I                             I
V10 -   DIR2                      8.851*I                             I
                                   .627 I                             I
                                 14.124@I                             I
                                        I                             I
V11 -   DIR3                      8.053*I                             I
                                   .570 I                             I
                                 14.124@I                             I
                                        I                             I
V12 -   DIR4                      8.638*I                             I
                                   .612 I                             I
                                 14.124@I                             I
                                        I                             I
V13 -   DIR5                      7.799*I                             I
                                   .552 I                             I
                                 14.124@I                             I
                                        I                             I

V14 -   DIR6                      7.948*I                             I
                                   .563 I                             I
                                 14.124@I                             I
                                        I                             I
V15 -   DIR7                      8.705*I                             I
```

```
                              .616 I                           I
                            14.124@I                           I
                                   I                           I
   V16 -  DIR8               8.676*I                           I
                              .614 I                           I
                            14.124@I                           I
                                   I                           I
   V17 -  DIR9               9.010*I                           I
                              .638 I                           I
                            14.124@I                           I
                                   I                           I
   V18 -DIR10                8.233*I                           I
                              .583 I                           I
                            14.124@I                           I
                                   I                           I
   V19 -DIR11                8.114*I                           I
                              .574 I                           I
                            14.124@I                           I
                                   I                           I
   V20 -DIR12                8.135*I                           I
                              .576 I                           I
                            14.124@I                           I
                                   I                           I
   V22 -  RES1               8.102*I                           I
                              .574 I                           I
                            14.124@I                           I
                                   I                           I
   V23 -  RES2               8.396*I                           I
                              .594 I                           I
                            14.124@I                           I
                                   I                           I
   V24 -  RES3               8.289*I                           I
                              .587 I                           I
                            14.124@I                           I
                                   I                           I
   V25 -  RES4               8.817*I                           I
                              .624 I                           I
                            14.124@I                           I
                                   I                           I
   V26 -  RES5               8.254*I                           I
                              .584 I                           I
                            14.124@I                           I
                                   I                           I
  27 -  RES6               8.677*I                           I
                              .614 I                           I
                            14.124@I                           I
                                   I                           I
   V28 -  RES7               8.099*I                           I
                              .573 I                           I
                            14.124@I                           I
                                   I                           I
   V29 -  RES8               8.321*I                           I
                              .589 I                           I
                            14.124@I                           I
                                   I                           I
   V30 -  RES9               8.506*I                           I
                              .602 I                           I
```

```
                      14.124@I                        I
                            I                         I
V31 -RES10             8.070*I                        I
                         .571 I                       I
                      14.124@I                        I
                            I                         I
V33 -   WTE1           7.917*I                        I
                         .560 I                       I
                      14.124@I                        I
                            I                         I
V34 -   WTE2           8.090*I                        I
                         .573 I                       I
                      14.124@I                        I
                            I                         I
V35 -   WTE3           9.345*I                        I
                         .662 I                       I
                      14.124@I                        I
                            I                         I
V36 -   WTE4           8.049*I                        I
                         .570 I                       I
                      14.124@I                        I
                            I                         I
V37 -   WTE5           8.417*I                        I
                         .596 I                       I
                      14.124@I                        I
                            I                         I
V38 -   WTE6           8.249*I                        I
                         .584 I                       I
                      14.124@I                        I
                            I                         I
V39 -   WTE7           8.507*I                        I
                         .602 I                       I
                      14.124@I                        I
                            I                         I


 MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)

 VARIANCES OF INDEPENDENT VARIABLES (CONTINUED)
 ----------------------------------------------

V40 -   WTE8           7.801*I                        I
                         .552 I                       I
                      14.124@I                        I
                            I                         I
V41 -   WTE9           8.325*I                        I
                         .589 I                       I
                      14.124@I                        I
                            I                         I
V42 -WTE10             8.118*I                        I
                         .575 I                       I
                      14.124@I                        I
                            I                         I
V44 -   VAR1           8.446*I                        I
                         .598 I                       I
```

```
                               14.124@I                         I
                                      I                         I
 V45 -  VAR2                    8.415*I                         I
                                 .596 I                         I
                               14.124@I                         I
                                      I                         I
 V46 -  VAR3                    8.380*I                         I
                                 .593 I                         I
                               14.124@I                         I
                                      I                         I
 V47 -  VAR4                    8.666*I                         I
                                 .614 I                         I
                               14.124@I                         I
                                      I                         I
 V49 -  VAR6                    8.501*I                         I
                                 .602 I                         I
                               14.124@I                         I
                                      I                         I
 V50 -  VAR7                    8.070*I                         I
                                 .571 I                         I
                               14.124@I                         I
                                      I                         I
 V51 -  BUR1                    8.178*I                         I
                                 .579 I                         I
                               14.124@I                         I
                                      I                         I
 V52 -  BUR2                    8.288*I                         I
                                 .587 I                         I
                               14.124@I                         I
                                      I                         I
 V53 -  BUR3                    8.257*I                         I
                                 .585 I                         I
                               14.124@I                         I
                                      I                         I
 V54 -  BUR4                    8.466*I                         I
                                 .599 I                         I
                               14.124@I                         I
                                      I                         I
 V55 -  BUR5                    7.767*I                         I
                                 .550 I                         I
                               14.124@I                         I
                                      I                         I
 V56 -  BUR6                    7.921*I                         I
                                 .561 I                         I
                               14.124@I                         I
                                      I                         I
 V57 -  BUR7                    8.611*I                         I
                                 .610 I                         I
                               14.124@I                         I
                                      I                         I
 V58 -  BUR8                    8.093*I                         I
                                 .573 I                         I
                               14.124@I                         I
                                      I                         I
 V59 -  BUR9                    7.995*I                         I
                                 .566 I                         I
                               14.124@I                         I
```

```
                                  I                                I
V60 -BUR10                   8.191*I                                I
                              .580 I                                I
                            14.124@I                                I
                                  I                                I
V61 -BUR11                   8.245*I                                I
                              .584 I                                I
                            14.124@I                                I
                                  I                                I
V62 -BUR12                   8.118*I                                I
                              .575 I                                I
                            14.124@I                                I
                                  I                                I
V63 -BUR13                   7.838*I                                I
                              .555 I                                I
                            14.124@I                                I
                                  I                                I
V64 -BUR14                   8.260*I                                I
                              .585 I                                I
                            14.124@I                                I
                                  I                                I
V65 -BUR15                   7.660*I                                I
                              .542 I                                I
                            14.124@I                                I
                                  I                                I

 VARIANCES OF INDEPENDENT VARIABLES (CONTINUED)
 ----------------------------------------------

V66 -BUR16                   7.788*I                                I
                              .551 I                                I
                            14.124@I                                I
                                  I                                I
V67 -BUR17                   8.295*I                                I
                              .587 I                                I
                            14.124@I                                I
                                  I                                I
V68 -BUR18                   8.195*I                                I
                              .580 I                                I
                            14.124@I                                I
                                  I                                I
V69 -BUR19                   8.017*I                                I
                              .568 I                                I
                            14.124@I                                I
                                  I                                I

02-DEC-09      PAGE:  19  EQS     Licensee:
 TITLE:   Model built by EQS 6 for Windows

 MAXIMUM LIKELIHOOD SOLUTION (NORMAL DISTRIBUTION THEORY)

 VARIANCES OF INDEPENDENT VARIABLES
 ----------------------------------
 STATISTICS SIGNIFICANT AT THE 5% LEVEL ARE MARKED WITH @.
```

```
                   E                                  D
                  ---                                ---
E8   -  PRE8              8.418*I D7   -   F7                 .000*I
                           .596 I                            9.353 I
                         14.124@I                             .000 I
                                I                                  I
E21 -DIR13                8.585*I                                  I
                           .608 I                                  I
                         14.124@I                                  I
                                I                                  I
E32 -RES11                7.968*I                                  I
                           .564 I                                  I
                         14.124@I                                  I
                                I                                  I
E43 -WTE11                8.003*I                                  I
                           .567 I                                  I
                         14.124@I                                  I
                                I                                  I
E48 -   VAR5              8.821*I                                  I
                           .625 I                                  I
                         14.124@I                                  I
                                I                                  I
E70 -BUR20                7.778*I                                  I
                           .551 I                                  I
                         14.124@I                                  I
                                I                                  I
E71 -   WFR1              3.840*I                                  I
                          9.357 I                                  I
                           .410 I                                  I
                                I                                  I
E72 -   WFR2              8.170*I                                  I
                           .578 I                                  I
                         14.123@I                                  I
                                I                                  I
```

```
STANDARDIZED SOLUTION:                                      R-
SQUARED

PRE8   =V8   =    .076 F1    +  .997 E8
.006
 DIR13    =V21 =    .004 F2    + 1.000 E21
.000
 RES11    =V32 =    .163 F3    +  .987 E32
.027
 WTE11    =V43 =    .182 F4    +  .983 E43
.033
   VAR5   =V48 =    .135 F5    +  .991 E48
.018
 BUR20    =V70 =    .205 F6    +  .979 E70
.042
   WFR1   =V71 =    .701 F7    +  .713 E71
.491
```

```
  WFR2   =V72 =     .020*F7     + 1.000 E72
.000
   F1    =F1  =   -.015*V1      +  .997*V2      -  .012*V3      -  .059*V4
                -  .036*V5      +  .039*V6      +  .012*V7
   F2    =F2  =   -.129*V9      -  .008*V10     -  .076*V11     +  .044*V12
                +  .972*V13     -  .065*V14     +  .007*V15     +  .071*V16
                -  .135*V17     +  .016*V18     +  .050*V19     -  .030*V20
   F3    =F3  =   -.034*V22     +  .385*V23     -  .025*V24     +  .363*V25
                -  .356*V26     -  .145*V27     -  .081*V28     +  .162*V29
                +  .273*V30     +  .680*V31
   F4    =F4  =   -.046*V33     +  .180*V34     -  .179*V35     +  .052*V36
                -  .335*V37     +  .232*V38     -  .405*V39     +  .428*V40
                +  .314*V41     -  .565*V42
   F5    =F5  =    .675*V44     -  .038*V45     +  .663*V46     +  .309*V47
                -  .032*V49     +  .086*V50
   F6    =F6  =   -.140*V51     +  .099*V52     +  .445*V53     -  .318*V54
                -  .458*V55     +  .278*V56     -  .254*V57     +  .236*V58
                +  .151*V59     +  .136*V60     -  .010*V61     -  .104*V62
                +  .328*V63     +  .130*V64     +  .051*V65     -  .215*V66
                -  .055*V67     -  .129*V68     +  .137*V69
   F7    =F7  =    .901*F1      +  .419*F2      +  .089*F3      +  .058*F4
                +  .037*F5      +  .020*F6      +  .000 D7
1.000


 BENTLER-RAYKOV CORRECTED R-SQUARED COEFFICIENTS:
 SQUARED CORRELATIONS BETWEEN DEPENDENT VARIABLES AND PREDICTORS

   PRE8  =V8    0.006
 DIR13   =V21   0.000
 RES11   =V32   0.027
 WTE11   =V43   0.033
   VAR5  =V48   0.018
 BUR20   =V70   0.042
   WFR1  =V71   0.491
   WFR2  =V72   0.000
    F1   =F1    1.000
    F2   =F2    1.000
    F3   =F3    1.000
    F4   =F4    1.000
    F5   =F5    1.000
    F6   =F6    1.000
    F7   =F7    1.000



-----------------------------------------------------------------------
--------
                          E N D    O F    M E T H O D
 -----------------------------------------------------------------------
---------
1
  today is 2009/12/02
  Execution begins at 18:10:37
  Execution ends   at 18:10:40
  Elapsed time =       3.00 seconds
```

APPENDIX C

Source of each question in the checklist (survey questionnaire)

Measured Variables	Source
PRE1. Prior work is complete with desired quality.	Liu and Ballard (2008)
PRE2. The pre-requisite work has been verified to meet current work needs (dimensions, locations, etc)	Liu and Ballard (2008)
PRE3. All regulatory inspections needed were conducted and successfully passed.	Author
PRE4. The prerequisite work is officially handed over from prior trade.	Liu and Ballard (2008)
PRE5. The weather forecast is favorable for performing work.	Liu and Ballard (2008)
PRE6. Access to the work area (permits, etc) has been obtained and cleared with respective party.	Author
PRE7. All coordination issues with following trade have been addressed by the project team.	Dai. et. al. (2009)
PRE8. Overall, the prerequisite work is complete.	Author
DIR1. The D&E documents for current work are acceptable.	Dai et.al. (2009)
DIR2. The D&E documents for current work are available.	Dai et. al. (2009)
DIR3. All RFI's for current work are addressed satisfactorily.	Dai et. al. (2009)
DIR4. The owner is agreeable to any design/scope changes, if any.	Author
DIR5. The standard of work performance is available.	Author
DIR6. The standard of work performance is clearly	Author

expressed.

DIR7. The submittals are approved.	Author
DIR8. The submittals are available.	Author
DIR9. Final design instructions have been confirmed by architect/engineer to avoid change.	Author
DIR10. All lien waivers are in order.	Author
DIR11. All permits are available.	Dai et. al. (2009)
DIR12. All lien waivers are submitted.	Author
DIR13. Overall, all the directives are in order.	Author
RES1. The material is/will be delivered on time.	Dai et. al. (2009)
RES2. The material specifications match contract/submittal specs.	Liu and Ballard (2008)
RES3. Space is available for material lay-downs.	Author
RES4. Path available for material transport.	Author
RES5. The labor is informed of all work assignments.	Dai et. al. (2009)
RES6. The labor needed is available.	Author
RES7. The tools to be used are in good working condition.	Dai et. al. (2009)
RES8. Right tools are available in enough quantity for crews to work with.	Author
RES9. The equipment to be used is in good working condition.	Dai et. al. (2009)
RES10. Right equipment is available in the desired quantity.	Author
RES11. Overall, all the required resources are available.	Author
WTE1. The amount of work is sized appropriately to	Horman and Thomas

avoid overproduction.	(2005)
WTE2. Transportation of raw/processed materials requires single handling (as opposed to more than once).	Ballard and Howell (1998)
WTE3. Transportation of raw/processed materials is over short distances.	Dai. Et. al. (2009)
WTE4. No amount of rework/correction is required for completed work.	Love et. al. (1999)
WTE5. No over-processing (unnecessary finishing) is performed for completed work.	Love et. al. (1999)
WTE6. Inventory is delivered just-in-time to the production unit.	Thomas and Sanvido (2000)
WTE7. The production unit makes no unnecessary movements to complete the work.	Author
WTE8. The production unit is always working to complete the work.	Author
WTE9. The production crew is consulted on the best way to perform the work.	Dai et. al. (2009)
WTE10. The production crew is consulted on the safest way to perform the work.	Author
WTE11. Overall, sufficient steps have been taken to prevent generation of waste.	Author
VAR1. There was no absenteeism in the workforce.	Dai. et. al. (2009)
VAR2. The production crews operate with reserve capacity.	Horman and Thomas (2005)
VAR3. The learning curve effect is realizable for the crews.	Author
VAR4. Recovery plans from occupational accidents are standard practice.	Rojas and Aramvareekul (2003)

VAR5. The production rates of the crew are consistent over time (match Takt).	Author
VAR6. The production plan has workable backlog in case of interruptions to current assignment(s).	Horman and Thomas (2005)
VAR7. The production plan has time buffers to prevent interruptions to project completion.	Author
BUR1. The work environment is free of potential environmental hazards (air-borne pathogens, dust, chemical agents, ultra-violet light, and ionizing radiation).	Author
BUR2. The work environment is comfortable to function in (temperature and humidity, lighting, sun exposure, noise levels).	Liu and Ballard (2008)
BUR3. The work environment is not congested.	Dai et. al. (2009)
BUR4. Overtime is not needed on our jobs.	Author
BUR5. The work is adequately paced to avoid physical fatigue.	Thomas and Raynar (1997)
BUR6. The workers are equipped with PPEs, as necessary.	Author
BUR7. The workers are not allowed to engage work involving heavy muscular loads.	Author
BUR8. The workers have access to material-lifting equipment.	Dai et. al. (2009)
BUR9. A Job Safety Analysis is performed.	Dai et. al. (2009)
BUR10. Workers are trained on proper lifting techniques.	Liu and Ballard (2008)
BUR11. Rest cycles are built into the work method.	Thomas and Raynar (1997)
BUR12. Workers receive sufficient information regarding the process flow and output.	Dai et. al. (2009)
BUR13. The rate of information does not exceed the	Thomas and Raynar (1997)

mental capacity of the worker to process.

BUR14. Identical or very similar signals don't occur for a long time.	Author
BUR15. Adequate time is allowed for decisions and resulting actions in the normal circumstances.	Author
BUR16. Adequate time is allowed for decisions and resulting actions in emergencies.	Author
BUR17. Hand tools used are the correct ones for the task.	Author
BUR18.Hand tools used are adequately maintained.	Author
BUR19. All safety signs and visuals are correctly located.	Dai et. al. (2009)
BUR20. Overall, the workers do not feel any kind of burden.	Author

REFERENCES

Arditi D. (1985). "Construction Productivity Improvement." *Journal of Construction Division,* Vol. 111(1), pp. 1-14.

Arditi, D., Tokdemir, O.B. and Suh K. (2002). "Challenges in Line-of-Balance Scheduling." *Journal of Construction Engineering and Management,* ASCE, NY, Vol. 128 (6), pp. 545-556.

Bae B.R. (2005). "*LISREL structural equation model: Understanding & Application.*" Chunglam Publishing Company, Korea.

Ballard G. (1997). "Lookahead Planning: The Missing Link in Production Control." *Proceedings of the 5th Annual Conference of the International Group of Lean Construction,* IGLC-5, Gold Coast, Australia.

Ballard, G. (1999). "Improving Work Flow Reliability." *Proceedings of the 7th Annual Conference of the International Group of Lean Construction,* IGLC-7, Berkeley, CA, USA.

Ballard, G. (2000). "The Last Planner System of Production Control." *Ph.D. Thesis, School of Civil Engineering, University of Birmingham,* Edbagston, UK.

Ballard, G. and Howell, G. (1998). "Shielding Production: An Essential Step in Production Control." *Journal of Construction Engineering and Management,* ASCE, Vol. 124 (1), pp. 11-17.

Ballard, G., and Tommelein, I., and Koskela, L., and Howell, G. (2002). "Lean Construction Tools and Techniques." Section 15 in Rick Best and Gerard de Valence (editors, 2002). *Design and Construction: Building in Value.* Butterworth-Heinemann, Elsevier Science Ltd, pp. 227-255.

Barclay D., Higgins C., and Thomson R. (1995). "The Partial Least Squares Approach (PLS) to Causal Modeling, Personal Computer Adoption and use as an Illustration." *Technology Studies,* Vol. 2(2), pp. 285-309.

Bentler P.M., and Chou C. (1987). "Practical Issues in Structural Modeling". *Sociological Methods & Research,* Sage Publications, Vol. 16 (1), pp. 78-117.

Bollen K., and Lennox R. (1991). "Conventional Wisdom on Measurement: A Structural Equation Perspective." *Psychological Bulletin*, Vol. 110(2), pp. 305-314.

Bollen K.L. (1989). "*Structural Equations with Latent Variables.*" John Wiley, New York, USA.

Borcherding J., and Oglesby C. (1974). "Construction Productivity and Job Satisfaction." *Journal of Construction Division,* Vol. 100(3), pp. 413-431.

Byrne B.M. (2006). "*Structural Equation Modeling with EQS – Basic concepts, Applications, and Programming* (2nd edition)." Lawrence Erlbaum Associates, Mahwah, New Jersey, USA.

Chua D.K.H., Kog Y.C., Loh P.K., and Jaselkis E.J. (1997). "Model for Construction Budget Performance – Neural Network Approach". *Journal of Construction Engineering and Management,* Vol. 123(3), pp. 214-222.

Coltman T., Devinney T.M., Midgley D.F., and Venaik S. (2008). "Formative versus reflective measurement models: Two applications of formative measurement". *Journal of Business Research,* ScienceDirect, Vol. 61, pp. 1250-1262.

Dai J., Goodrum P.M., and Maloney W.F. (2009b). "Construction Craft Workers' Perceptions of the Factors Affecting Their Productivity." *Journal of Construction Engineering and Management,* Vol. 135 (3), pp. 217-226.

Dai J., Goodrum P.M., Maloney W.F., and Srinivasan C. (2009a). "Latent Structures of the Factors Affecting Construction Labor Productivity." *Journal of Construction Engineering and Management,* Vol. 135(5), pp. 397-406.

Davis F.D., Bagozzi R.P., and Warshaw P.R. (1989). "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models." *Management Science,* Vol. 35(8), pp. 982-1003.

Diamantopoulos A. (2006). "The error term in formative measurement models: interpretation and modeling implications". *Journal of Modeling in Measurement,* Emerald Group Publishing Limited, Vol. 1(1), pp. 7-17.

Diamantopoulos A., and Winkholfer H.M. (2001). "Index Construction with Formative Indicators: An Alternative to Scale Development." *Journal of Marketing Research,* Vol. 38(2), pp. 269-277.

Diamantopoulos A., Riefler P., and Roth K.P. (2008). "Advancing Formative Measurement Models". *Journal of Business Research,* ScienceDirect, Vol. 61, pp. 1203-1218.

DiekmannJ., and Heinz J. (2001). "Determinants of Jobsite Productivity." *Construction Industry Institute Research Report No. 143-11,* University of Texas, Austin.

Dvir D., Raz T., and Shenhar A.J. (2002). "An Empirical Analysis of the Relationship between Project Planning and Project Success." *International Journal of Project Management,* Vol. 21(2), pp. 89-95.

Edwards J.R. (2001). "Multidimensional constructs in organizational behavior research: an integrative analytical framework." *Organizational Research Methods,* Sage Publications, Vol. 4(2), pp. 144-192.

Edwards J.R., and Bagozzi R.P. (2000). "On the Nature and Direction of Relationships between Constructs and Measures." *Psychological Methods*, Vol. 5(2), pp. 155-174.

Faniran O.O., Oluwoye J.O., and Lenard D. (1994). "Effective Construction Planning". *Construction Management and Economics,* Vol. 12, pp. 485-499.

Faniran O.O., Oluwoye J.O., and Lenard D. (1998). "Interactions between Construction Project Planning and Influence Factors." *Journal of Construction Engineering and Management,* Vol. 124(4), pp. 245-256.

Foulds, L.R., and Quaddus, M., and West, M. (2007). "Structural Equation Modeling of Large-scale Information System Application Development Productivity: The Hong Kong Experience." *6th IEEE International Conference on Computer and Information Science (ICIS).*

Hair J.F., Black W.C., Babin B.J., Anderson R.E., and Tatham R.L. (2005). "*Multivariate Data Analysis (6th Edition)*". Pearson Prentice Hall, Mahwah New Jersey, USA.

Hancock, G. R., and Freeman, M. J. (2001). "Power and sample size for the root mean square error of approximation test of not close fit in structural equation modeling." *Educational and Psychological Measurement*, Vol. 61(5), pp. 741-758.

Herbsman Z., and Ellis R. (1990). "Research of Factors influencing Construction Productivity." *Construction Management and Economics,* Vol. 8(1), pp. 49-61.

Horman M.J., and Thomas H.R. (2005). "Role of Inventory Buffers in Construction Labor Performance." *Journal of Construction Engineering and Management*, Vol. 131(7), pp. 834-843.

Islam M.D.M., and Faniran O. O. (2005). "Structural Equation Model of Project Planning Effectiveness". *Construction Management and Economics,* Vol. 23, pp. 215-223.

Jarvis C.B., Mackenzie S.B., and Podsakoff P.M.(2003). "A Critical Review of Construct Indicators and Measurement Model Misspecification in Marketing and Consumer Research." *Journal of Consumer Research,* Vol. 30, pp. 199-218.

Kankainen, J. and Seppanen, O. (2003). "A Line-of-Balance Based Schedule Planning and Control System." *Proceedings of the 11th Annual Conference of the International Group of Lean Construction,* IGLC-11, Blacksburg, Virginia, USA.

Kim D.Y., Han S.H., Kim H., and Park H. (2009). "Structuring the prediction model of project performance for international construction projects: A comparative analysis". *Expert Systems with Applications,* ScienceDirect, Vol. 36, pp. 1961-1971.

Kim, Y.W. and Ballard, G. (2000). "Is the Earned-Value Method an Enemy of Work Flow?" *Proceedings of the 8th Annual Conference of the International Group of Lean Construction,* IGLC-8, Brighton, UK.

Kim, Y.W. and Jang, J.W. (2006). "Applying Organizational Hierarchical Constraint Analysis to Production Planning." *Proceedings of the 14th Annual Conference of the International Group of Lean Construction,* IGLC-14, Santiago, Chile.

Kline, R. B. (2005). "*Principles and practice of structural equation modeling* (2nd edition)." Guilford Press, New York, USA.

Liberda M., Ruwanpura J., and Jergeas G. (2003). "Construction Productivity Improvement: A Study of Human, Management and External Issues." Construction Research Congress 2003, ASCE, Reston, VA.

Liker J.K. (2004). "*The Toyota Way – 14 Management Principles from the World's Greatest Manufacturer*". McGraw-Hill, USA.

Liu M., and Ballard G. (2008). "Improving labor productivity through production control." *Proceedings of the 16th Annual Conference of the International Group of Lean Construction,* IGLC-16, Manchester, UK.

Love P.E.D., Mandal P., and Li H. (1999)."Determining the causal structure of rework influences in construction." *Construction Management and Economics,* Vol. 17(4), pp. 505-517.

MacCallum R.C., and Browne M.W. (1993). "The Use of Causal Indicators in Covariance Structure Models: Some Practical Issues." *Psychological Bulletin*, Vol. 114(3), pp. 533-541.

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). "Power analysis and determination of sample size for covariance structure modeling." *Psychological Methods,* Vol. 1(2), pp. 130-149.

MacCallum, R.C., and Austin, J.T. (2000). "Applications of Structural Equation Modeling in Psychological Research." *Annu. Rev. Psychol.,* Vol. 51, Pg 201-226. Downloaded from www.arjournals.annualreviews.org on 04/06/08.

MacKenzie S.B., Podaskoff P.M., and Jarvis C.B. (2005). "The Problem of Measurement Model Misspecification in Behavioral and Organizational Research and Some Recommended Solutions." *Journal of Applied Psychology*, Vol. 90 (4), pp. 710-730.

Maloney W.F. (1981). "Motivation in Construction: A Review." *Journal of Construction Division,* Vol. 101(4), pp. 641-647.

Mitropoulos, P.T. (2005). "Planned Work Ready: A Proactive Metric for Project Control." *Proceedings of the 13th Annual Conference of the International Group of Lean Construction,* IGLC-13, Sydney, Australia.

Molenaar K., Washington S., and Diekmann, J. (2000). "Structural Equation Model of Construction Contract Dispute Potential." *Journal of Construction Engineering and Management,* Vol. 126(4), pp. 268-277.

Oglesby C., Parker H., and Howell G. (1989). "*Productivity Improvement in Construction.*" McGraw-Hill, NY.

Purvis R.L., Sambamurthy V., and Zmud R.W. (2001). "The Assimilation of Knowledge Platforms in Organizations: An Empirical Investigation." *Organization Science,* Vol. 12(2), pp. 117-135.

Rojas M., and Aramvareekul P. (2003). "Labor Productivity Drivers and Opportunities in the Construction Industry." *Journal of Construction Engineering and Management,* Vol. 129(2), pp. 78-82.

Roberts N., and Thatcher J.B. (2009). "Conceptualizing and Testing Formative Constructs: Tutorial and Annotated Example". *The DATA BASE for Advances in Information Systems*, Vol. 40 (3), pp. 9-39.

Raykov, T., and Marcoulides, G. A. (2006). "*A first course in structural equation modeling* (2nd edition)." Lawrence Erlbaum Associates, Mahwah, NJ, USA.

Ruiz D.M., Gremler D.D., Washburn J.H., and Carrion G.C. (2008). "Service value revisited: Specifying a higher-order, formative measure". *Journal of Business Research,* ScienceDirect, Vol. 61, pp. 1278-1291.

Salem O., and Solomon J., and Genaidy A., and Luegring M. (2005). "Site Implementation and Assessment of Lean Construction Techniques." *Lean Construction Journal,* Vol. 2(2), pg 1-20, USA.

Schumacker, R. E., & Lomax, R. G. (2004). "*A Beginner's Guide to Structural Equation Modeling.*" Mahwah: Lawrence Erlbaum Associates, USA.

Shehnar A. J., and Laufer A. (1995). "Integrating Product and Project Management – A New Synergistic Approach." *Engineering Management Journal,* Vol. 7(3), pp. 11-15.

Singh, Y. (2007). "A Framework for Production Management of Renovation Projects." *Master's Thesis, SPDC, Michigan State University,* East Lansing, USA.

Thomas H.R., Horman M.J., Minchin Jr. R.E., and Chen D. (2003). "Improving Labor Flow Reliability for Better Productivity as Lean Construction Principle". *Journal of Construction Engineering and Management,* Vol. 129(3), pp. 251-261.

Thomas H. R., and Raynar K. A. (1997). "Scheduled Overtime and Labor Productivity: A Quantitative Analysis." *Journal of Construction Engineering and Management,* Vol. 123(2), pp. 181-188.

Thomas H. R., and Sakarcan A. (1994). "Forecasting Labor Productivity using Factor Model." *Journal of Construction Engineering and Management,* Vol. 120(1), pp. 228-239.

Thomas H. R., and Sanvido V. (2000). "Role of Fabricator in Labor Productivity." *Journal of Construction Engineering and Management,* Vol. 126(5), pp. 358-365.

Ullman J.B. (2006). "Structural Equation Modeling: Reviewing the Basics and Moving Forward." *Journal of Personality Assessment,* Vol. 87(1), pp. 35-50.

United Nations Committee on Housing, Building, and Planning (United Nations). (1965). *Effect of Repetition on Building Operations and Processes on Site,* United Nations, NY.

Walt, L. (2006). "Earned Schedule Leads to Improved Forecasting." *Proceedings of the PROMAC Conference,* Sydney, Australia.

Wilcox J.B., Howell R.D., and Breivik E. (2008). "Questions about formative measurement." *Journal of Business Research,* ScienceDirect, Vol. 61, pp. 1219-1228.