ANALYSIS OF COST AND TIME OVERRUN IN CONSTRUCTION PROJECT USING SMART-PLS

Patel Harjinder[1], Patel Saurabh[2], Mehta Nirav[3], Desai Mit[4]

[1] *Student of Construction Management, Civil Engineering, MIT ADT University, Maharashtra, India*
[2] *Student of Construction Management, Civil Engineering, MIT ADT University, Maharashtra, India*
[3] *Student of Construction Management, Civil Engineering, MIT ADT University, Maharashtra, India*
[4] *Student of Construction Management, Civil Engineering, MIT ADT University, Maharashtra, India*

ABSTRACT

Infrastructure projects regularly experience cost and schedule overruns. Unfortunately construction industry today is facing major risk in achieving completion of project within estimated time and cost. Total 37 factors affecting cost and time overrun were categorized in 5 major groups. After consideration of factors and ranking them with the help of questionnaire survey, the data has been analysed using Smart PLS software. In software analysis by Smart PLS, the coefficient of determination, R^2, is 0.496 for the Cost Overrun endogenous latent variable and similarly for time overrun, the coefficient of determination, R^2, is 0.60 for the Time Overrun endogenous latent variable. This study also suggest that assurance of Funds Resources, availability of good quality construction material, owners quick response and many others will help to control the identified risk factors. It is hoped that finding of this paper will help the stakeholders to act on critical causes and further to reduce cost and time overrun in construction project.

Keyword: - *overrun, Delay, Cost overrun, Time overrun, Smart PLS, Partial least square***.**

1. INTRODUCTION

In the construction industry, the aim of project control is to ensure the projects finish on time, within budget and achieving other project objectives. It is a complex task undertaken by project managers in practice, which involves constantly measuring progress; evaluating plans; and taking corrective actions when required. Success in any project is measured by time, cost, and quality, which show the performance of the construction parties involved. There is an inherent uncertainty in the schedule of the construction phase for different projects. Completion time is particularly important and it is one of the performance measures of construction projects. Schedule delay can be defined as the time overruns either beyond the completion date specified in a contract or beyond the date that the parties agree upon for delivery of a project. It is considered to be one of the most common occurring problems in construction projects.

In construction, delay could be defined as the time overrun either beyond completion date specified in a contract or beyond the date that the parties agreed upon for delivery of a project. It is a project slipping over its planned schedule and is considered as common problem in construction projects. Schedule delay can lead to many undesirable effects on the project and its participating parties such as lawsuits between utilities and contractors, increased costs, loss of revenue, and contract termination. To the utility, delay means loss of revenue while to the contractor, delay means higher costs because of a longer work period, additional material cost, and extra labour cost. Successful management of a project requires identification and evaluation of factors causing delay. Delays on

construction projects are a universal phenomenon. They are almost always accompanied by cost and time overruns. Construction project delays have an adverse effect on parties (developer, contractor, and consultant) to a contract in terms of a growth in adversarial relationships, distrust, litigation, arbitration, cash-flow problems, and a general feeling of apprehension towards each other. So, it is essential to define the actual causes of delay in order to minimize and avoid the delays in any construction project.

1.1 Objectives

- To identify the causes affecting cost and time overrun in construction projects.
- To analyse the causes and give appropriate mitigation measures.

2. RESEARCH METHODOLOGY

Firstly the literature review was carried out referring various national and international journals from which various factors causing cost and time overrun were identified. Total 37 factors (mentioned below in brackets) were identified which is categorized in 5 major groups viz.

- Owner (Change in scope of project, Delay in progress payment, Poor communication and co-ordination by owner with parties, Financial Difficulties of owner, Decision making (delay), Unrealistic Contract Duration)
- Contractor (Cash flow and financial difficulties, Rework due to errors during construction, Delay in site mobilisation, Lack of experience, Poor site management and supervision, Inadequate planning and scheduling, Conflicts between contractor and other parties)
- Consultant (Mistakes and errors in design, Delay in preparation and approval of drawing, Inflexibility of consultant, Delay in Inspection and approval of Completed works, Inadequate experience, Incomplete design at time of tenders, Complexity of project design, Inadequate and unclear details in drawing, Misunderstanding of owner's requirements by Design Engineer, Misunderstanding between Architect and Structural Engineer)
- Resource (Shortage of materials and equipment, Late delivery of material and equipment, Escalation in prices of material, Late Procurement, Labour Productivity, Shortage of site workers, Personal conflicts among workers, Equipment breakdown)
- External (Political and social issues, Delay in permission from local authority, Accidents on sites, Different weather and site conditions, Delay in providing services from utilities, Changes in government regulations and laws)

Considering such factors the questionnaire was designed and responses were collected from respondents which they ranked each factor based on following terms: A: Strongly Agree, B: Agree, C: Neither Agree nor Disagree, D: Disagree, E: Strongly Disagree. After the collecting responses the data was analysed by using a software called Smart PLS which gives us the output in terms of coefficient of determination. This value helps us to analyse the major factors causing cost as well as time overrun. Lastly, based on the factors causing overrun, certain mitigation measures are suggested to control it which will definitely help from failure of project.

3. SMART PLS

3.1 Introduction

Structural Equation Modeling (SEM) is a second-generation multivariate data analysis method that is often used in marketing research because it can test theoretically supported linear and additive causal models. With SEM, we can visually examine the relationships that exist among variables of interest in order to prioritize resources to better serve their customers. The fact that unobservable, hard-to-measure latent variables can be used in SEM makes it ideal for tackling business research problems.

There are two sub models in a structural equation model; the inner model specifies the relationships between the independent and dependent latent variables, whereas the outer model specifies the relationships between the latent variables and their observed indicators. In SEM, a variable is either exogenous or endogenous. An exogenous variable has path arrows pointing outwards and none leading to it. Meanwhile, an endogenous variable has at least one path leading to it and represents the effects of other variable.

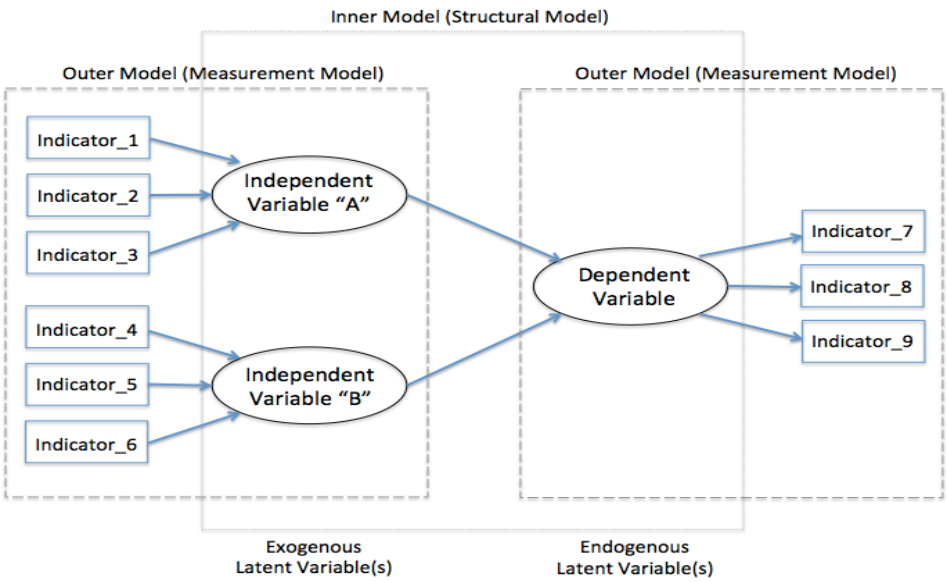

Fig -1: Inner v/s Outer model in SEM approach

3.2 PLS-SEM

PLS is a soft modeling approach to SEM with no assumptions about data distribution. Thus, PLS-SEM becomes a good alternative to CB-SEM when the following situations are encountered

- Sample size is small.
- Applications have little available theory.
- Predictive accuracy is paramount.
- Correct model specification cannot be ensured.

It is important to note that PLS-SEM is not appropriate for all kinds of statistical analysis. Marketers also need to be aware of some weaknesses of PLS-SEM, including:

- High-valued structural path coefficients are needed if the sample size is small.
- Since arrows are always single headed, it cannot model undirected correlation.
- A potential lack of complete consistency in scores on latent variables may result in biased component estimation, loadings and path coefficients.
- It may create large mean square errors in the estimation of path coefficient loading.

In spite of these limitations, PLS is useful for structural equation modeling in applied research projects especially when there are limited participants and that the data distribution is skewed.

The following example of the construction industry is used to demonstrate how to use the Smart-PLS software application. This example of a latent variable that is multidimensional and difficult to observe directly. However, one can measure it indirectly with a set of measurable indicators that serve as proxy. In order to understand, a survey has been conducted to ask respondents about their views regarding the factors affecting overrun. In this fictitious survey, respondents are asked to rate their experience on a scale representing six latent variables, namely Owner,

Contractor, Consultant, Resources and External using a 5-point Liker scales [(1) strongly agree, (2) agree, (3) neither agree nor disagree, (4) disagree, (5) strongly disagree].

Also another latent variable namely Cost Overrun is used and the responses are taken based on 4-point scale which includes range of percentage overrun[(1)0-5%, (2)5-10%, (3)10-50, (4)50-100%].The indicators for the latent variables are the factors which are categorized in five groups.

3.3 Project creation in Smart PLS

The smart PLS software is downloaded from its official website www.smartpls.de. The analysis of our project is carried out in smart PLS v3. Now, launch the Smart PLS program and go to the "File" menu to create a new project. We will name this project as "cost overrun". We can press the "Ok" button to create the PLS file.

Once on creating the project on smart PLS then by right clicking on the "cost overrun" tab, clicks on the "import data file" and select "dataset_11.csv" file to import the data in smart pls.

"dataset_11.csv" file consist of data in following manner. The dataset of owner and contractor groups are shown below and dataset for consultant, resources and external are saved accordingly in "dataset_11.csv" file.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	own_1	own_2	own_3	own_4	own_5	own_6	cont_1	cont_2	cont_3	cont_4	cont_5	cont_6	cont_7
2	2	2	3	1	2	2	2	3	3	3	3	3	1
3	2	1	3	2	3	4	2	2	4	3	2	1	4
4	2	1	2	1	1	2	1	4	2	4	2	2	2
5	1	2	3	2	2	2	1	3	3	2	2	2	3
6	1	2	2	2	2	2	1	2	1	2	2	2	2
7	3	2	1	1	1	2	1	2	2	1	1	1	1
8	2	1	3	1	2	4	1	2	2	2	1	2	3
9	2	4	4	1	2	3	4	3	3	3	4	1	2
10	3	2	3	1	1	3	3	3	4	3	3	4	3
11	1	2	3	1	1	1	1	2	3	1	1	1	3
12	2	1	2	1	2	2	1	1	2	1	1	1	1
13	1	2	3	2	2	2	1	3	3	2	2	2	3
14	2	1	2	1	1	2	1	2	4	3	2	1	2
15	1	2	3	2	2	2	3	2	1	2	2	3	2

Fig -2: Data input format

3.3 Building Inner Model

The latent variables are created by clicking on the "latent variable" from the top bar. This latent variable is of red color as shown below. Once the circles are placed, right click on each latent variable to change the default name into the appropriate variable name in your model.

After this the remaining five latent variables are established. These latent variables are connected by using the "connect" tab from the top bar.

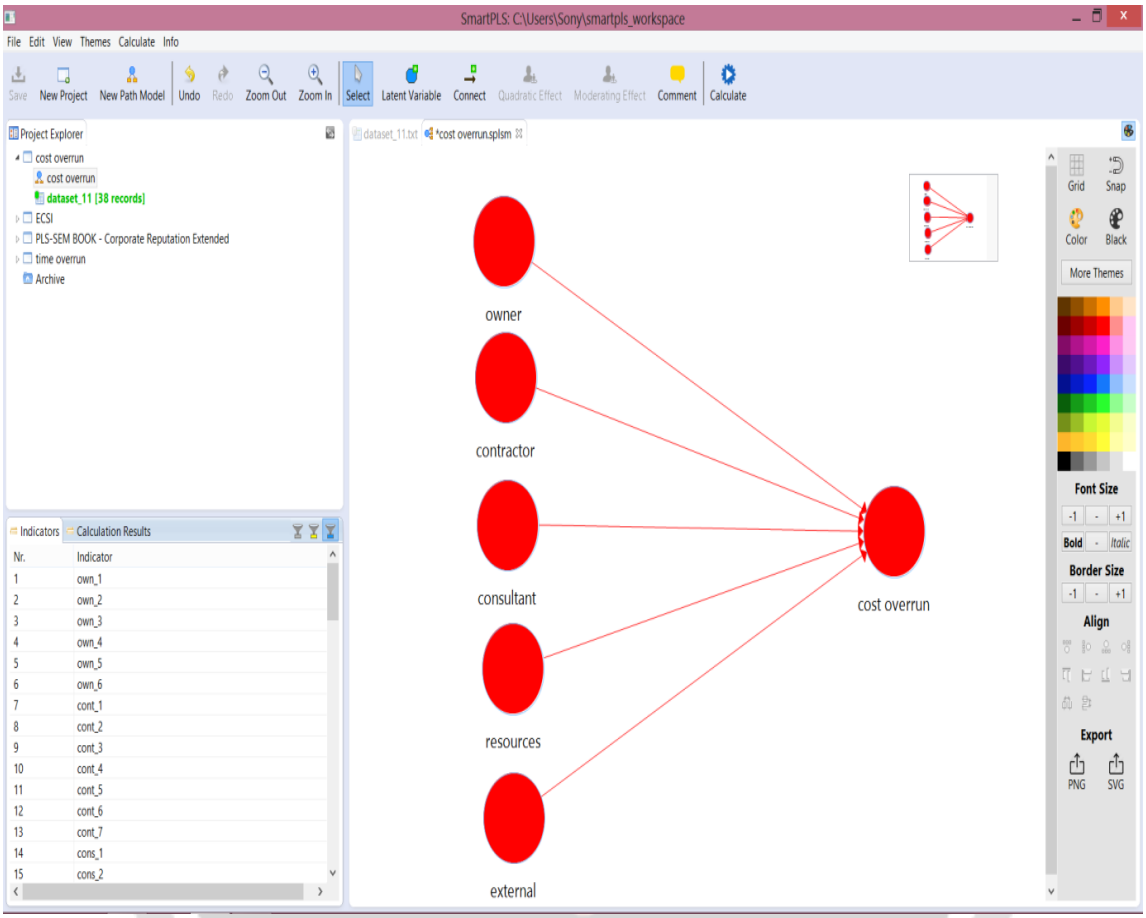

Fig -3: Inner Model

3.4 Building Outer Model

The next step is to build the outer model. To do this, link the indicators to the latent variable by dragging them one-by-one from the "Indicators" tab to the corresponding red circle. Each indicator is represented by a yellow rectangle and the color of the latent variable will be changed from red to blue when the linkage is established. The indicators can be easily relocated on the screen by using the "Align Top/Bottom/Left/Right" function, if you right click on the blue-color latent variable. The resulting model should look like as follows:

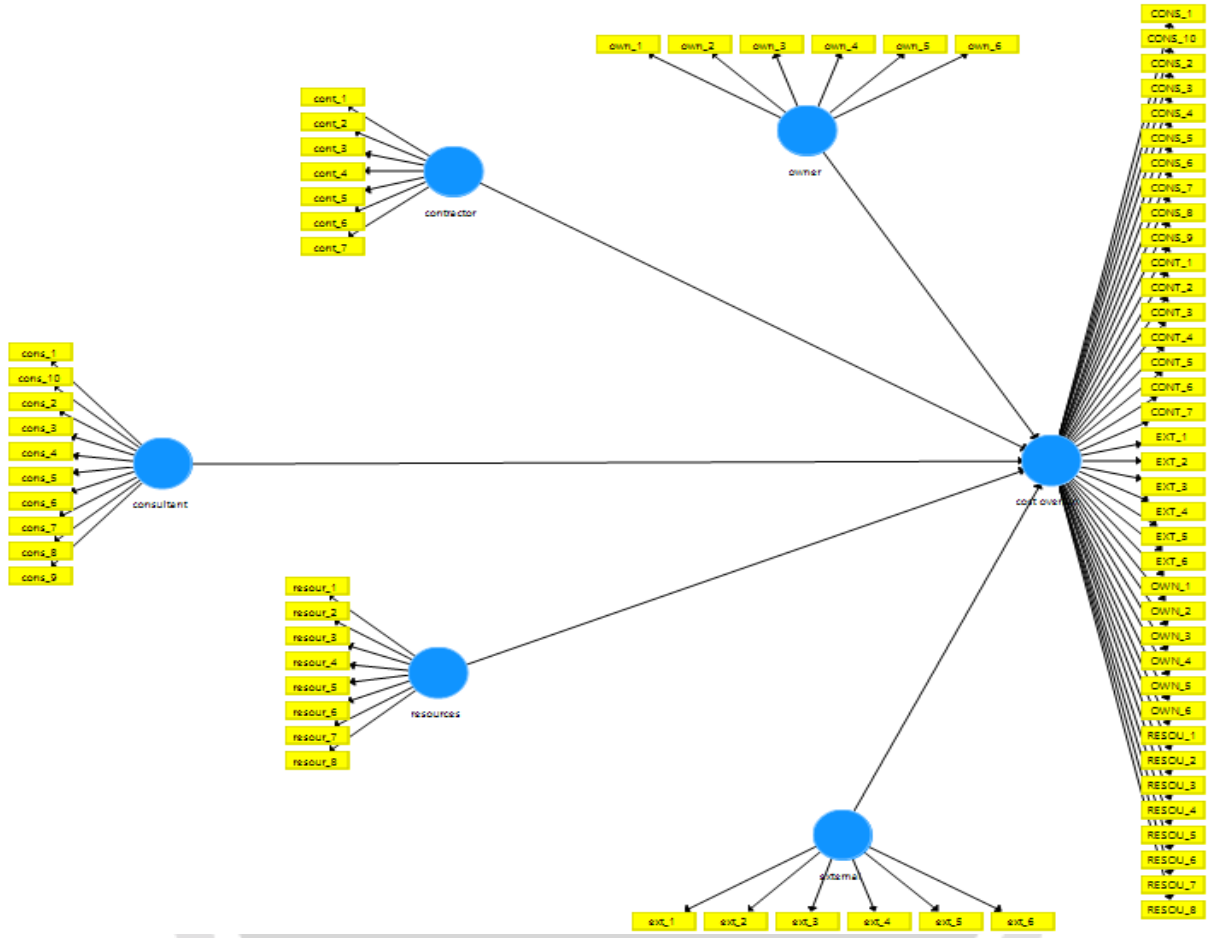

Fig -4: Outer Model

3.5 Running the Path modelling Estimation

Once the indicators and latent variables are linked together successfully in Smart PLS (i.e., no more red-color circles and arrows), the path modeling procedure can be carried out by going to the "Calculate" menu and selecting "PLS Algorithm". A pop-up window will be displayed to show the default settings. Since there is no missing value for our data set, we proceed directly to configure the "PLS Algorithm – Settings" with the following parameters:

- Weighting Scheme: Path Weighting Scheme.
- Maximum Iterations: 300.
- Stop Criterion: 1.0E-5

By running such algorithm we get the following figure as an output.

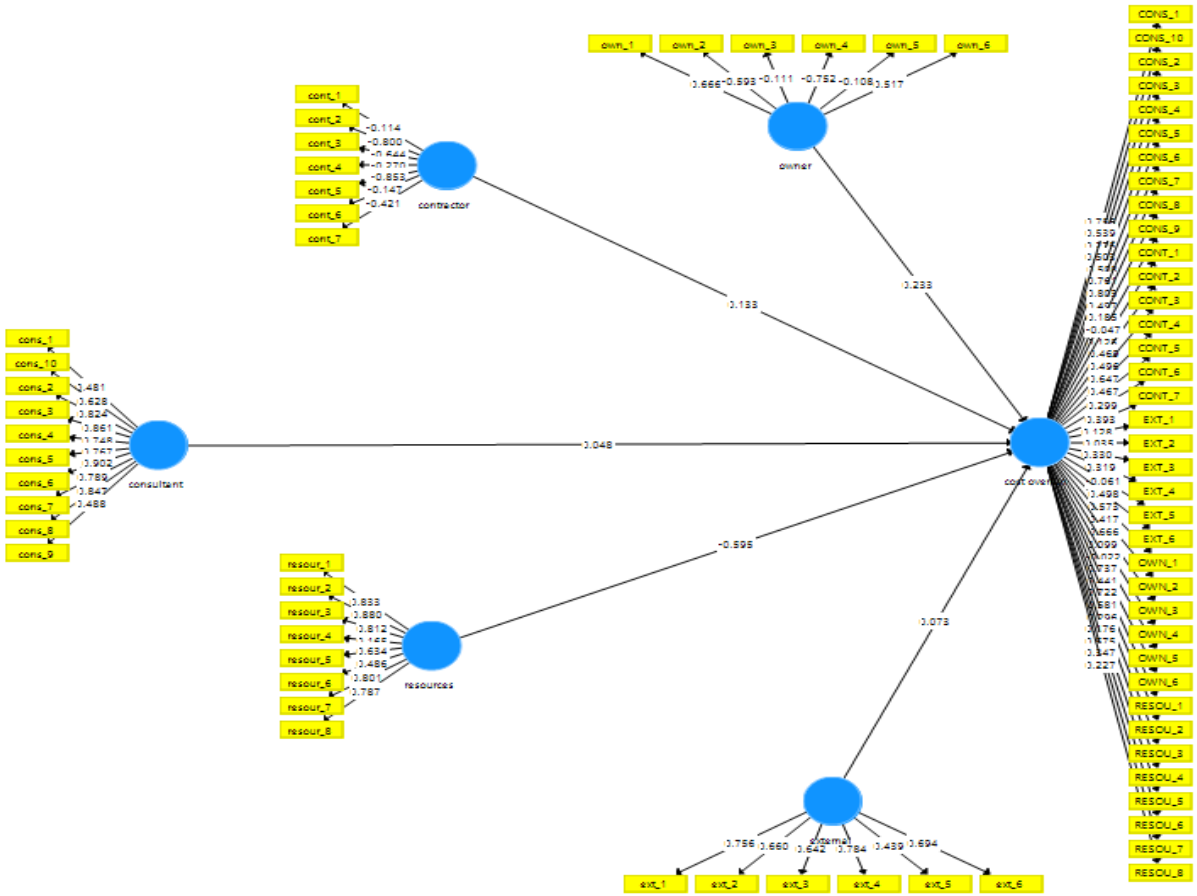

Fig -5: Output of Algorithm

3.6 Assessing the PLS-SEM output

The coefficient of determination, R^2, is 0.496 for the Cost Overrun endogenous latent variable. This means that the five latent variables (Owner, Contractor, Consultant, Resources, and External) moderately explain 49.6% of the variance in Cost Overrun.

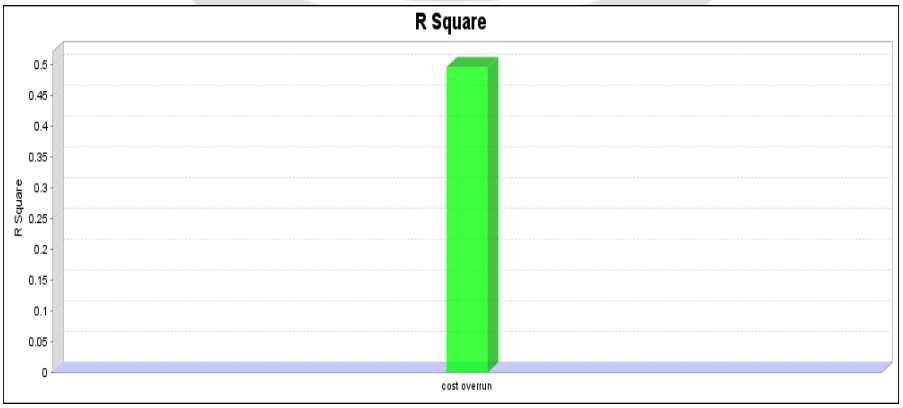

Fig -6: Coefficient of Determination for Cost Overrun

The inner model suggests that Owner has the strongest effect on Cost overrun (0.233), followed by Contractor (0.133), External (0.073), Consultant (0.048), Resources (-0.595). The hypothesized path relationship between Owner, Contractor and Cost overrun is statistically significant. However, the hypothesized path relationship between External, Consultant, Resources and Cost overrun is not statistically significant. This is because of its standardized path coefficient (0.073), (0.048), (-0.595) is lower than 0.1. Thus we can conclude that: Owner and Contractor are both moderately strong predictors of Cost overrun, but External, Consultant, Resources does not predict Cost overrun directly.

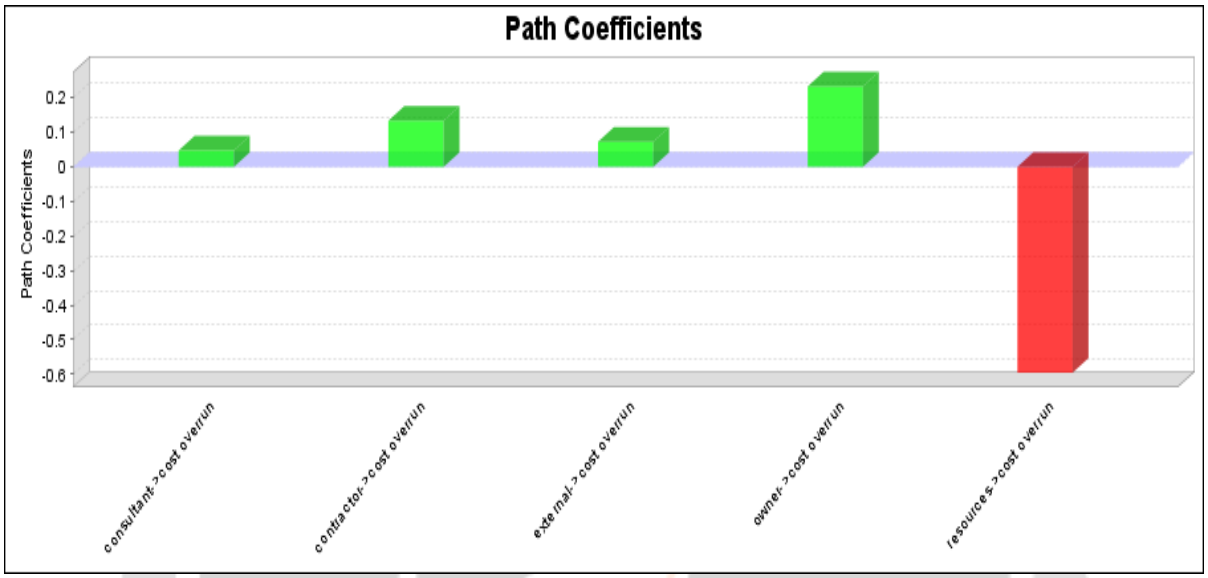

Fig -7: Path Coefficients for Cost Overrun

Similarly this analysis is repeated by changing Cost Overrun latent variable by Time Overrun. The results were, the coefficient of determination, R^2, is 0.60 for the Time Overrun endogenous latent variable. This means that the five latent variables (Owner, Contractor, Consultant, Resources, and External) moderately explain 60% of the variance in Time Overrun. The inner model suggests that Contractor has the strongest effect on Time overrun (0.476), followed by Consultant (0.006), Resources (-0.010), Owner (-0.289), External (-0.248). The hypothesized path relationship between Contractor and Time overrun is statistically significant. However, the hypothesized path relationship between External, Consultant, Resources, Owner and Time overrun is not statistically significant. This is because of its standardized path coefficient is lower than 0.1. Thus we can conclude that: Contractor is moderately strong predictor of Time overrun, but External, Consultant, Resources, Owner does not predict Cost overrun directly.

4. CONCLUSIONS AND RECOMMENDATIONS

Analyzing with the help of software conclude that Owner and Contractor are both moderately strong predictors of Cost overrun, but External, Consultant, Resources does not predict Cost overrun directly. Similarly Contractor is moderately strong predictor of Time overrun, but External, Consultant, Resources, Owner does not predict Cost overrun directly. The Following measures are recommended to control cost and time overrun:

- Better Formulation and Appraisal of project.
- Sound Implementation planning.
- Advance actions.
- Assurance of Fund resources.
- Better Contract management, penalties and incentives.
- Availability of good quality construction material.
- Implementation quality control and accuracy system.
- Owner's quick response.

- Owner should give special attention to following factors:

Owner should pay attention to all the factors that affect the construction quality due to decision taken by him and owner has to give quick response for the construction and a replay quickly for all the queries asked to him. Special attention has been given to the payment of the workers slippers and all the site staff to avoid delay and further consequences. Owners should contribute to what kind of design he wants thus helping him to achieve required output. Wins for all the contractors should be paid on the time to result in good relations with the contractors which in turn help in the good work by contractors. Owner's decision is generally considered the final decision should be quick and from which should not change time and again. You should be attention that the social economic and political environment should be good for the project and no dispute should arise as far as possible. Owner should maintain the quality check at every stage of the project.

- Architects and Consultant should give special attention to following factors:

Architecture plan and design the project as per the requirement and the quality recommended by him, but at the same time the design should be practical visible for the construction. Consultants to provide accurate and save design architecture and consultants should provide all the detailed drawing including all the sections, elevations etc. So that it can be easily understood on the site and the work can be carried out accurately according to it and thus maintaining the quality. The designs should not be repetitive and not a very complex. Review of the owners is very important and due to attention should be given to it. The level of competition should be high which brings the best out of the architectural consultants. The drawing should be adhering to the codes. The architecture and the consultants should check at every stage whether the construction is being carried out according to the drawings or not to check the quality and accuracy and if it is not according to it than necessary measures should be suggested to correct it.

- Project Manager and Engineer's should give special attention to following factors:

The role of project manager and engineers is very important because the woodworking of the project depends on the way to manage the work on the site. The project manager and the engineer have to make good quality materials available on site, on time and at the right place and at least cost. They have to make site layout well organized and everything on the side should be well accessible. The accuracy of doing work should be maintained. They have to maintain good quality control in every work. They should look after proper utilization of resources, and minimize the wastages. The duty of project manager and engineers is to make cooperation between Saab and General contractor. A contractor with the clear conditions about the project a minute of it all the contractors. The execution of the work should be according to the drawing and details provided to them to maintain the accuracy and quality of the work. Project manager and engineers should implement the accuracy and quality control system on site at every stage.

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