

Development of Econometric Models for Cost & Time Over-runs: An Empirical Study of Major Road Construction Projects in Pakistan

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Abstract-The construction industry is flourishing worldwide and contributes about 10% to the GDP of the world i.e. up to the tune of 4.6 Trillion US dollars. It employs almost 7% of the total employed persons and, consumes around 40% of the total energy. The Pakistani construction sector has displayed impressive growth in recent past years. The efficient road network is a key part of construction business & plays a significant role in the economic uplift of country. The overruns in costs and delays in completion of projects are very common phenomena and it has also been observed that the projects involving construction of roads also face problems of delays and cost over runs especially in developing countries. The causes of cost overruns and delays in road projects being undertaken by the premier road construction organization of Pakistan National Highway Authority (NHA) have been considered in this study. It has been done specifically in the context of impact of cause(s) determined from project report of a total of one hundred and thirty one (131) projects. The ten causative factors which we recognize as Design, Planning and Scheduling Related problems, Financial Constraint Related reasons, Social Problem Related reasons, Technical Reasons, Administrative Reasons, Scope Increase, Specification Changes, Cost Escalation Related reasons, Non-Availability of Equipment or Material and Force Majeure play a commanding role in determination of the cost and time over runs. It has also been observed that among these identified causes, the factors of Administrative Reason, Design, Planning and Scheduling Related, Technical Reasons and Force Majeure are the most significant reasons in cost and time overruns. Whereas, the Cost Escalation related reasons has the least impact on cost increase and delays. The NHA possesses a financial worth of around Rs. 36 billion and with an annual turn over amounting to Rs. 22 billion is responsible to perform road construction project in entire Pakistan and abroad do faces such problems of increase in completion cost and delays in completion time as

compared to targeted project cost and duration. The study revealed that there was an increase in cost in 62% projects i.e. out of 131 road construction projects 82 Projects observed cost over runs (Table I, Fig. 1).

Keywords-Cost Overruns, Delays, Road Projects, Time Overruns, Economic Model.

I. INTRODUCTION

The noticeable point in construction projects is that they are often not well planned. The improper financial estimation and cash flows are very common reason hampering the timely and within schedule costs of projects and usually leads to failure of a project but also gives birth to other cost-time overrun related dilemmas. The reasonable Cost estimation and scheduling are among the core values of a project's success and these should be analyzed carefully & monitored throughout the course of a project life cycle for its successful completion within schedule cost and time for deliverance of its objectives. Not with standing their immense importance, the construction project managers frequently do not follow these core values resulting in cost and time overruns.

It is fairly common to observe projects having cost-time overruns and it is very common in nearly all construction industry of the globe due to one or more reasons. However, in developing countries the cost & time overruns in projects has become a rather grave matter and in some cases the cost-time overrun exceeds more than 100% of their original cost-time calculation. This is due to various causative factors that have been explained in similar studies. In practice, many public infrastructure works undergo delays and cost overruns.

The Reviewed two hundred and fifty eight (258) transport infrastructure projects [i] which were implemented world wide during the period from the years 1920's to the 2000's and found that

about 90% of them experienced considerable cost overruns. According to the World Bank database, which is composed of about 110 road development projects in the 2000s, Africa's road projects were delayed by 10 months on average [ii].

The infrastructure based works are highly customized and extremely dependent upon the correct selection of site and technical requirements. It is worth mentioning that not many contractors are able to carry out such infrastructure project. Resultantly, competition is generally limited as far as public infrastructure projects procurement is concerned. The literature commonly finds that only about three to six companies compete in competitive bidding for public infrastructure bidding [iii] [iv] [ii].

Due to these characteristics of infrastructure procurement, governments are likely to be facing hold-up problem in timely and within stipulated cost completion of projects. In general, there is potential for hold-up if either party involved in the contract is not satisfied and cease to fulfill the contractual obligations [v]. The literature discusses how to design a contract to avoid the hold-up problem [vi]. In infrastructure procurement, contracts are imperfect and rebidding or re-awarding is exorbitantly costly. Therefore, governments have no choice but to allow these cost overruns and delays.

The provision of component of cost adjustments in contracts is very essential; [vii] observed that there was adjustment in costs at about \$2.70 per \$1.00 of adjustment in the US highway sector in 1995-2000. [viii] The Comparison of around 160 traditional road projects and another 60 public-private partnerships in Europe revealed that there was 24% risk premium of cost overruns in total road project costs. A concessionaire will include the expected cost overruns and the cost of delays in the initial contract because the concessionaire and not the government have to deal with the costs later on.

The Finance planning of regulatory bodies of public and private organizations should control the construction in road construction related projects. The measures to avert causative factors via planning before the finalization of projects and before execution are essentially required to be taken into account by clients, consultants and contractors in order to avoid any unforeseen changes/additions in design and scope during different phases in the life of projects. All efforts should be made to acquire land and resources before commencement of work and qualified staff should be deployed by all stake holders including client, consultant and contractor organization for close monitoring in terms of quality and management. In order to avoid all kind of frauds, corruptions, kickbacks and contract rigging by incorporating fair and transparent mechanism be evolved. It will help for fair competition to get promoted and consequently shall also minimize cost and time overruns in construction

projects in Pakistan.

The construction industry has brought new innovations in almost all fields of life i.e. living style, transportation system, irrigation facilities, water storage methods, sub-sea construction, underground constructions, desert and mountains masterpieces etc. The use of technical knowledge with innovative technology like modern planning/scheduling and design software may assist in better controlling of cost-time overrun factors to a considerable extent. Due to revolution in information technology, arrival of up to date designing, planning and monitoring software packages, advance monitoring techniques and precise/skilled control of construction projects has completely transformed the principles of the entire construction industry which was not possible in past years.

Due to revolution in information technology, arrival of up to date designing, planning and monitoring software packages, advance monitoring techniques and precise/skilled control of construction projects has completely transformed the principles of the entire construction industry which was not possible in past years. With the help of the developed tools one can control various projects parameters like monitoring and controlling, client requirement, specification alteration, cash flows, financial impediments, allocation of resources, effective utilization of available resources, material management, progress tracking, quality of the output work, project speed, optimization of resources and material etc. within a meager span of time enabling the successful completion of the endeavor being undertaken.

The construction industry today is considered as a prime sector for boasting development & the economy of a country. The quantum of construction work in a country is the barometer which depicts development category and state of economy. In any country of the world, the construction industry is the basic which shares a major portion in the development of that country. The infrastructure development status and its quality may be considered the determining factor for the development status of the country. The more the construction quality is found in its land, the more it is closer to development rank. The industry, however, holds heterogeneous characteristics instead of exhibiting the characteristics of a homogenous entity. Starting from a small home to high rise buildings for residential and commercial purpose, landscaping and development of colonies, schools, hospitals, airports, roads, bridges, parks etc. all are a part of this ever expanding construction industry. This industry has also given a boom to the other related business like real estate, renting and commercialization of high profile buildings.

As is the case in other developing countries, the construction projects in Pakistan also exhibit time and cost overruns due to various reasons like

mismanagement, political disorder, unexpected changes in government policies in respect of development schemes/projects, malpractices and corruption, financial drawback, unaccounted inflation rates, expensive equipment services, bidding irregularities and old procedure of procurement, lax site administration, provision of incomplete design/drawings at bidding time, miscalculation in the bill of quantities (B.O.Q.) and Financial estimations, Extension in scope of work, improper planning and scheduling, site handing over issues, restructuring laying of additional services at site, social and religious barriers/opposing of the plan, problems in having the expert labor and quality materials, late payments of the work and financial constraints due to government policies, security and law & order considerations in design and implementation phase, climatic intensity and lack of facilities at site, non-hiring of expert staff/manger/consultants, lack of government collaboration etc. However, in this study which we have conducted after careful analysis of 131 project reports a lot has been revealed. National Highway Project the most common and recurring 10 causative factor has been identified as responsible for cost and time over run these causative factors are Design, Planning and Scheduling Related (DPSR), Financial Constraint Related (FCR), Social Problem Related (SPR), Technical Reasons (TR), Administrative Reasons (AR), Scope Increase (SI), Specifications Change (SC), CER-Cost Escalation Related (CER), Non Availability of Equipment or Materials (NAEM), Force Majeure(FM).The regression techniques have been used to formulate a regression model for cost and time overrun.

The causative factor pertaining to Design, Planning and Scheduling Related (DPSR) may be referred as any variation encountered due to change in design or creation idea of a plan for the completion of a construction project such as change in architectural blueprints, engineering design drawings that may lead to cost and time overruns. Similarly any departure from plan and schedule to implement a design also hamper the implementation of project within targeted milestones. The Financial Constraints Related (FCR) reasons are usually comprised of issues pertaining to imbalance cash flows faced during the different stages of a project lifecycle which affect the amount of anticipated cost and planned timelines of the project. The factors of Social Problem Related (SPR) issues arise due to social vision and behavior of people associated with the project either in the design/feasibility stage or during the execution of the project. Such issues have an imperative impact on the time and cost of the project. The Technical Reasons (TR) usually concerns with the technical glitches being faced in the life cycle of project involving the technical parameters of design that need to be changed as per factual position and site requirement. Such issues are

known to affect time-plan work and cost estimation of the project and usually extend it. The Administrative Reasons (AR) relate to the issues which cause cost & time overruns due to staff behavior, local and international laws, national policies and tendencies, working environment, work ethics & attitude of the people deployed for governing the project as the issues have vital effects on the planned timelines and targets. The Scope Increase (SI) relates to the issues that happen due to utilization of any item or items worked out during execution on factual requirement in contrary to the planning/estimation phase requirement of these item(s) worked out in construction feasibility or estimate. This factor may change the cost-time framework of the project significantly. Specification change (SC) pertains to the matters of changes in designed specification due to site requirement or requirement to change the specs as a result of obsolete material/equipment or aesthetic aspects of the project as per desire of client. These changes cause to suffer the work schedule and cost of the project. The Cost Escalation Related (CER) factor deals with cost increase due to inflation, and escalation of cost & their claims etc. Any delay to address such phenomena may alter the cost anticipated and schedule programmed for the completion of the project. The Non Availability of Equipment or Materials (NAEM) handles the variation in cost-time spectrum of the project due to miscalculation of availability of resources, incapability to arrange the required equipment or materials, difference in planned and actual work conditions etc. The Force Majeure (FM) factors concerns cost-time schedule variation where arise due to any natural disaster such as earthquake, flood etc. social or political turmoil/disorder that may cease the project activities and disengages the project resources from it. In such situation the binding parties are set free from their obligation and raise the cost-time overruns of a project.

II. METHODOLOGY

The construction of a highway project involves several technicalities one of which is that the risk factor may be determined in a linear manner dependent on certain variables. In order to develop an economic model for cost & time overrun, the study has been carried out in 02 stages. In the first stage the causative agents for cost and time overruns have been sorted out. The first phase involves the identification of various factors causing cost overrun and delay. This was done through the study of National Highway Authority report on each project. These factors have been identified based on common reasons affecting cost & time overruns. In the second phase, critical factors have been grouped in 10 faculties which were initially identified in the first phase. This was done by studying project reports of each project in the first phase and each factor was based on the effect and causing the

delay of the project.

The factors pointed out in the second phase have been molded into a Linear Step-to-Step Multiple Regression model in which the dependent variable is calculated through these variable i.e. cost and time overruns.(Table I, Fig. 1).

TABLE I
DEPICTING COST OVER-RUNS IN 82 NOS. (62%)
PROJECTS OUT OF 131 NHA ROAD CONSTRUCTION
PROJECTS UNDER STUDY

Sr. No.	Description	Nos. of Projects	%age of Projects
1	Projects Completed Over and above scheduled or budgeted cost	82	62.6
2	Projects Completed within scheduled or budgeted cost	39	29.8
3	Projects Completed below the scheduled or budgeted cost	10	7.6

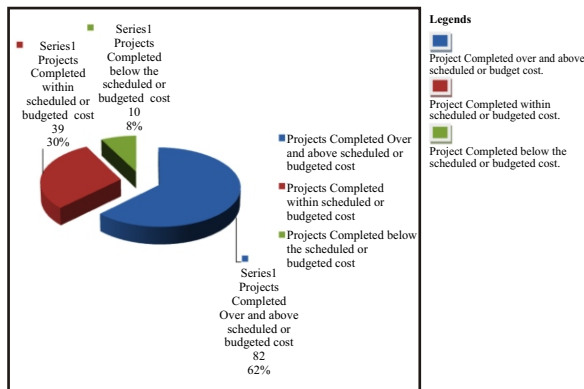


Fig. 1. Depicting Cost Over-runs in 82 nos. (62%) projects out of 131 NHA Road Construction Projects under study

Incorporation of Linear Multiple Regression with the independent factors viz. Design, Planning and Scheduling Related (DPSR), Financial Constraint Related (FCR), Social Problem Related (SPR), Technical Reasons (TR), Administrative Reasons (AR), Scope Increase (SI), Specifications Change (SC), CER-Cost Escalation Related reasons (CER), Non Availability of Equipment or Materials (NAEM), Force Majeure (FM) and putting dummy variable (explanatory or indicative variable) as regression value one and has been inserted for projects which suffer cost/time overruns and a few project which does not observe cost/time overruns. The underlying role of the summary of the regression with coefficients for the regression model is shown in the following Table II.

TABLE II
DESCRIPTIVE STATISTICS PROJECT COMPLETION
PERIOD OVER-RUNS % AGE WISE (PCPORPW)

Mean PCPORPW	130.7118
Standard Error	10.52287
Median	100
Mode	0
Standard Deviation	120.4397
Sample Variance	14505.72
Kurtosis	5.200724
Skewness	1.80347
Range	700
Minimum PCPORPW	0
Maximum PCPORPW	700
Sum PCPORPW	17123.24
Count of Projects	131
Largest (1) PCPORPW	700
Smallest (1) PCPORPW	0

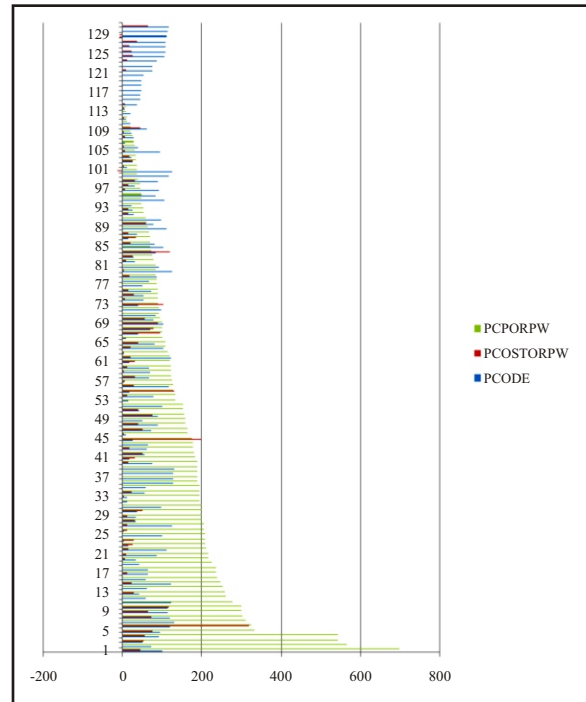


Fig. 2. Cost and Time Over-Runs in 131 NHA Projects

Where
PCPORPW= Project Completion Period Verrun Percentage wise
PCOSTORPW = Project Cost Overrun
PCODE= Project Code

III. DATA COLLECTION AND ANALYSIS

All it represents whether the cost/time overrun occurs or otherwise, the data related to highway projects have been assembled and analyzed in this work. The details related to highway projects have been gained from only National Highway Authority source has been accumulated and analyzed in this work an. However, the result of this work could also be applied to other infrastructure projects in Pakistan. Therefore, in its present context, the findings should only be applied to highway infrastructure projects in Pakistan. It may be noted that some of the research project data is related to socio/geographical condition and contracting climates that may have varied from time to time during the analysis period.

The Study of the analysis of cost and time overruns factors holds an important value for the betterment of the present system and can be used as a helpful tool to diagnose trouble spots in construction activities and to pinpoint areas in highway construction projects where the greatest improvement can be obtained by taking care of such dependent variables (Fig. 2).

General Form of Multiple Regression Model Equation

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \epsilon$$

Where, Y is the value of the Dependent variable i.e. predicted Project Cost Overrun Percentage wise (PCORPW) and $X_1 - X_{10}$ are independent variables that is the variance in explaining Y;

y	=	β_0	+	$\beta_1 X_1$	+	$\beta_2 X_2$
Predicted PCORPW	=	6.898	+	0.186*DPSR	+	0.199*F CR

+	$\beta_3 X_3$	+	$\beta_4 X_4$	+	$\beta_5 X_5$
+	0.100*SPR	+	0.165*TR	+	0.248*A R

+	$\beta_6 X_6$	+	$\beta_7 X_7$	+	$\beta_8 X_8$	+
+	0.136*SI/C	+	0.105*SC	+	0.012 *CER	+

$\beta_9 X_9$	+	$\beta_{10} X_{10}$	+	ϵ
0.079*NAEM	+	0.188*FM		

$\beta_1 - \beta_{10}$ are the Slopes (Beta coefficient) for $X_1 - X_{10}$

the independent variables those are explaining the Variance in Y i.e. Predicted Time overrun Percentage wise (PTORPW).

Whereas, β_0 (Beta) is the Constant or intercept, β_1 is the Slope (Beta coefficient) for $X_1 =$ DPSR- Design, Planning and Scheduling related Problems, β_2 is the Slope (Beta coefficient) for $X_2 =$ FCR- Financial Constraints related Problems, β_3 is the Slope (Beta coefficient) for $X_3 =$ SPR- Social Problems related Factors, β_4 is the Slope (Beta coefficient) for $X_4 =$ TR- Technical Factors, β_5 is the Slope (Beta coefficient) for $X_5 =$ AR- Administrative Factors, β_6 is the Slope (Beta coefficient) for $X_6 =$ SI_D- Scope increase or change factors, β_7 is the Slope (Beta coefficient) for $X_7 =$ SC- Specifications change factors, β_8 is the Slope (Beta coefficient) for $X_8 =$ CER- Cost Escalation related factors, β_9 is the Slope (Beta coefficient) for $X_9 =$ NAEM - Non availability of materials or equipment related factors and β_{10} is the Slope (Beta coefficient) for $X_{10} =$ FM - Force majeure related factors.

Similarly

Y is the Dependent variable, i.e Predicted value of Project Time over Runs percentage wise (PTORPW)

Y	=	β_0	+	$\beta_1 X_1$	+	$\beta_2 X_2$
Predicted PCORPW	=	0.414	+	0.205*DPSR	+	0.190*FCR

+	$\beta_3 X_3$	+	$\beta_4 X_4$	+	$\beta_5 X_5$
+	0.167*SPR	+	0.172*TR	+	0.219*AR

+	$\beta_6 X_6$	+	$\beta_7 X_7$	+	$\beta_8 X_8$
+	0.235*SI/C	+	0.214*SC	+	0.049*CER

+	$\beta_9 X_9$	+	$\beta_{10} X_{10}$	+	ϵ
+	0.122*NAEM	+	0.101*FM		

IV. RESULT

The analysis of actual data of 131 road construction projects shows delay and cost overruns are significant and in 82 projects and there is a road construction project for the state holders responsible for construction of road related projects. The delay and cost overruns play a vital role in the determination of the success rate of such projects. It is imperative to identify and address the construction features making the project run over and above the planned cost and competition responsible for such overrun in cost and time are also required to and make accountable.

The dependent construction features of delay and cost overrun now been used in the regression development research for cost over runs and time over runs separately and the independent values have been captured in term of percentage cost and time over run. In order to develop economic model liner regression has been carried out by using Microsoft Excel software

and for carrying out comparison between the predicted and the actual values of percentage cost and time over run.

The predicted values worked out by the help of regression models and hence it is concluded that the proposed cost overrun and time overrun models are accurate with a probability of 95%. This accuracy level of prediction obtained in the form of project cost and duration in the form of equations are the same as actually worked out in the monitoring reports and through the use of models.

V. CONCLUSIONS

The time and cost run over are very critical features for determination of success of project. The economic models developed may play a major role in the prediction of likelihood of cost over runs and delays in road construction projects. The developed economic model shall support decision makers to keep an eye while undertaking such endeavors and it shall also be beneficial for contractors and other stake holder for making corrective measures to avert cost and time over runs in construction project on various stages in the life of a project.

As a result of this work following conclusions are made.

1. The first accomplishment was the identification of construction factors responsible for cost run-over and delays in construction projects. The purpose has been achieved by detailed literature review and study of monitoring reports of 131 mega road construction projects.
2. The second achievement of this research was to evaluate the impact of identified causative factors on the schedule delay and cost over runs on road related construction projects. Among the ten identified causative factors, the factors of Administrative Reason (AR), Design, Planning and Scheduling Related (DPSR), Technical Reasons (TR) and Force Majeure (FM) were the most significant factor causing cost and time overruns. The Cost Escalation Related (CER) reasons have been found to have the least amount of impact on cost increase and delays.
3. In the third achievement, causes were ranked according to the ability to impact and it was observed that factors of Administrative Reason (AR), Design, Planning and Scheduling Related (DPSR), Technical Reasons (TR) and Force Majeure (FM) were the most significant factors in cost and time overruns. It was also noted that Cost Escalation Related (CER) had the least impact on cost increase and delays and had maximum contribution to cost over-run.
4. In the fourth achievement cost and time over-runs models have been made by using regression techniques. This was done by inputting causative

factors as dependent variables and to develop independent variables i.e. cost and time over-run, model equations respectively.

5. In the fifth achievement, the results obtained through use of these equations have been compared with the real values for verification and perfection of the models.

The models developed by use of MS Excel software as a result of this research, can be utilized by the decision makers for minimizing cost and time over-runs in the road construction projects effectively.

VI. NOVELTY

There are very few organizations present in Pakistan which have developed organized data of road construction related projects. This data can actually be used or analyzed. Despite deploying our best efforts, the credible data showing details required to analyze cost and time over-runs factors could not be fetched from all the public organizations including MOP other than NHA. Therefore, the case studies selected were from the organization NHA only. However, the findings of the research are equally beneficial for other R & D organizations of Pakistan.


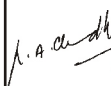

VII. FUTURE RESEARCH GUIDELINES

The proper knowledge of management and its practical implementation in an organization and its fruitful effects can be determined and associated with R&D performance by observing the factors underlined in this work. The R&D performance of the first phase can be measured through knowledge management and then by its results. A data of this work can be stored for historical picture and prove to be a foundation stone for future advancement in this research. All grand organization in Pakistan must benefit from the knowledge and implementation of management techniques.

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3	Shahab Khushnood Department of Mechanical Engg. University of Engg. & Tech. Taxila, Pakistan	Model Development and Identification of causative factors required to construct model	
4	Syed Athar Masood Department of Mech. Engg. International Islamic University, Islamabad, Pakistan	Literature review & Referencing and quality insurer	