- PV of net financial contribution from government. The government pays the required annual revenues (or annuities) to the concessionaire and may also pay subsidies during the construction period and recovers corporate taxes and VAT during the operation period. The indicator shows the present value and the financial balance for the government throughout the concession period. When the PV of net financial contribution from government is zero, the project is fiscally neutral for the government. However, in the case of Availability Payment PPP Projects, PV should in general be negative, which is shown in red in the graph sheets. The tax amounts (corporate tax and VAT) are positive (for this purpose), but they would in general be much smaller than the annual revenue paid to the concessionaire by the government.

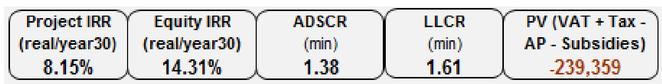

Figure 6: Project indicators / ratios.

Thirteen key project characteristics (Figure 7) can be modified in any of the three graphs. Following any change in parameters, all the worksheets are automatically updated. The ranges of variables included in the model reflect realistic conditions in most projects. When required, such ranges can be changed by model specialists.

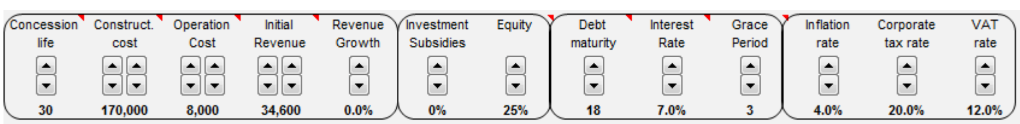

Figure 7: Key project characteristics.

Comments are triggered by the model to inform of unrealistic or impossible data entries. For example, if the concession life is set at a value less than the debt maturity, a message is displayed to alert the user and the model automatically corrects the debt maturity to ensure consistency. Comments are also provided if results deemed unfeasible are obtained (e.g., ADSCR less than 1.1).

NUMERICAL EXAMPLE

Assuming that previous studies have shown that a proposed PPP project to build a motorway is economically justified, and socially and environmentally sound, the following numerical example will show how the financial model can be used to estimate the minimum Annual Availability Payment that a potential concessionaire will require from the government to undertake the project. Table 1 provides summary of data for the proposed PPP project.

Table 1. Example of basic assumptions used to estimate the minimum availability payment for a PPP project to attract private investors.

A. Project Parameters
Concession term: 30 years
Construction cost: $170 million
Three-year construction period, with progress rates of:
Year 1: 30%; Year 2: 40%; Year 3: 30%
Operating expenses: $8 million per year (at opening year)
Capital structure: Equity, 25%; Subsidies, 0%; Loans, 75%
Discount rate (real terms): 6%
Inflation=4% per year
Tax rates: (a) VAT: 15%; (b) Corporate tax: 20%
Amortization period: 27 years
B. Loan Terms
Nominal Interest rate=7% per year
Loan grace period: 3 years;
Loan repayment period=15 years

Let us also assume that the following targets (or constraints) will have to be met for the project to be able to attract private investors:

Project Financial Internal Rate of Return:	FIRR $\geq$ 8%
Equity Internal Rate of Return (or Return on Equity):	ROE $\geq$ 14%
Annual Debt Service Cover Ratio:	ADSCR $\geq$ 1.2

The model can now be used to estimate the minimum Annual Availability Payment that a potential concessionaire will require from the government to undertake the project. As a first step, the user should enter the data provided using both the Data and the Cash Flow Graph worksheets. Assuming there are no revenues to the concessionaire other than the Availability Payment, the "Initial Revenue" in the Cash Flow Graph will be the Annual Availability Payment required by the concessionaire.

The user can now go to the Cash Flow Graph and obtain the minimum Annual Availability Payment ($ million) by trial and error, by varying the Initial Revenue so that the financial indicators calculated by the model are just above the minimum required threshold given above for the three indicators considered critical for the project: FIRR, ROE, and ADSCR. By doing this, the user should find that an Initial Revenue of $31.7 million is the minimum amount that would satisfy the three indicators.

In conclusion, an Annual Availability Payment of $31.7 million (in the first year of operation; payments in subsequent years would be adjusted according to inflation) should be able to attract private investors. The corresponding three financial indicators are FIRR = 8.02%, ROE = 14%, and ADSCR = 1.36.

The financial model, as currently developed, does not directly address the uncertainty in model parameters, such as construction cost and traffic and revenue forecasts. Nevertheless, the model can be used to carry out sensitivity analyses. The user can change the value of an input parameter (e.g., construction cost) and obtain the resulting impact, for example, on the project financial internal rate of return.

Examples similar to the above can be run for any other type of infrastructure, such as a railway, port, airport, or water treatment facility. It seems reasonable to expect that the methodology and tool described in the paper will be widely used for financial assessment of AP PPP projects in different infrastructure subsectors. Such a simplified model is particularly useful when only preliminary project data is available.

SUMMARY AND CONCLUSIONS

Availability payment PPPs have been increasingly used for financing of infrastructure in developing and developed countries.

The paper presented the development of a user-friendly model to assess the financial feasibility of availability payment PPP projects. The tool is based on the graphical financial model of the Toolkit for Public Private Partnership in Roads and Highways, which was developed by the World Bank, supported by the PPIAF.

The applicability of the tool has been demonstrated through a numerical example of a potential road PPP project. The model can also be applied to any other type of infrastructure.

The model can be used to carry out sensitivity analyses. The user can change the value of an input parameter (e.g., construction cost) and obtain the resulting impact, for example, on the project financial internal rate of return. Such a simplified model is particularly useful when only preliminary project data is available.

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Estimation of Highway Project Duration at the Planning Stage and Analysis of Risk Factors Leading To Time Overrun

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ABSTRACT

Estimation of time duration of highway projects at the planning stage serves as a vital input for construction planning, scheduling and contract administration. However time overrun, resulting from various factors is the most cardinal issue which eventually leads to cost overrun and hence induces turbulence in the initial cost and time estimates. In this paper, highway project duration is estimated on the basis of variables such as planned cost and project type which are known at the planning phase. Data comprises of project types such as pavement construction, improvement, rehabilitation and bridge construction projects of National Highway Authority, Pakistan. A mathematical relationship between highway project duration, planned cost and project type is demonstrated in this paper by using various model specifications. Furthermore using multivariate regression analysis correlation of the time overrun with potential risk factors is investigated encompassing attributes such as project type, cost and geographical location. This paper identifies a number of significant risk variables and their severity that contributes to the extensive delays and consequently exceeds the planned time estimates. The models developed can assist the project administrators in determining improved estimates of project duration and enhancing the expected delay estimation in completion time of planned projects.

INTRODUCTION

Realistic and precise planning helps to derive maximum benefits out of investments. The key goal of every project is to achieve work completion on time and within the specified budget. Transformation of paper drawings into concrete form while ensuring quality and safety is indeed a daunting task. As time is the essence of every project, development of reliable duration estimates can help agencies to deliver optimum project schedules and thus avoid issues pertaining to time overruns.

Success rate of most of the highway projects in Pakistan is relatively unsatisfactory; the commonality among the projects is time overrun and cost overrun. These two reasons can be attributed by various risk factors arising at every stage of the project development. It's known worldwide that economic sustainability depends largely upon the expansion of the existing facilities along with their modernization to meet the growing needs. For the rapid socio-economic uplift government of Pakistan desires to execute maximum public development projects in short span of time. 75% to 80% of Pakistan's total commercial traffic is carried by National Highway Network and Motorway system. NHA's official website reports that two-third of the total road network is in relatively poor condition. This scenario indicates a number of upcoming rehabilitation, construction and improvement projects in the pipeline.

Early and reliable cost estimates are essential inputs for decision making in the initial stages of construction projects (Czarnigowska et al. 2013). Project duration is essentially needed for proper project planning and contract administration. Prior knowledge of the project expected duration can be useful in bid evaluation and life cycle cost analysis (Irfan et al. 2010). Considerable reliance on engineering judgment is made while a project is planned (Hendrickson et al. 1987) though early studies have proposed that only the completion of the project marks its true duration though the final duration is adversely affected by some aberrations (Arditi et al. 1985; Kraiem 1987; Majid and McCaffer 1998). These aberrations could include extreme weather conditions, financial delays, skilled labor scarcity, political situations, force majeure and other project related changes taking place at various phases of the project's life cycle.

Construction project duration is a very important factor for the client, consultant and the contractor, yet delay is a typical phenomenon which is bound to occur as construction projects are seldom on schedule, often delays are among the most critical construction disputes (Kraiem 1987). Ahmed et al (2003) regards delay as universal phenomenon which is usually accompanied by cost overrun.

Kaliba et al. (2009) identified that the duration of road construction projects in Zambia is influenced by economic problem, contract modification, material procurement, delayed payment, change in specification and drawings, construction mistakes and poor supervision and coordination on site. Similar studies have been conducted worldwide however no such problem occurs at the planning phase and the root causes for delay are unknown when a project is planned. Nevertheless knowing the probability of occurrence of a certain problem in a specific region can help the project planners in various aspects. They can act pro-actively and prepare a contingency plan keeping the historical risk factors under consideration. Hence adverse effects of potential risks can be minimized.

Planning being one of the major chunks of work sets the milestones for design and execution phases of the projects. The cardinal objective of every project is to achieve work completion on time and within the specified budget while ensuring no compromise on quality and safety. Several studies have been carried out regarding the estimation of project duration and evaluation of risk factors in highway projects. This study aims to add to the body of knowledge by estimating the project duration and identifying the potential risk factors which affect the highway projects and ultimately result into time overrun. The developed models can also act as empirical tools for the contractors who may find it useful for making appropriate project plans for equipment mobilization, material utilization and resource optimization.

LITERATURE REVIEW

Several studies on the nature of relationship between project duration and project cost annotate shifts in their underlying philosophy. Early studies assume a linear relationship between project duration and project cost (Fulkerson 1961) but subsequent studies showed flexibility by using variety of nonlinear mathematical functions that include discrete formulations (Skutella 1998; Zheng et al. 2004) convex (Foldes and Soumis 1993), concave (Falk and Horowitz 1972), hybrid of convex and concave (Moder et al., 1995) or quadratic (Deckro et al. 1995). Hierarchical rule based activity duration models were estimated by Hendrickson et al (1987). Chan (2001) carried out a study in Malaysia to estimate average project duration using a time-cost formula expressed as Duration= K x $Cost^B$, where K represents the characteristic of duration performance and B is the indicative constant of sensitivity of time performance to cost level. The possibility of having piecewise discontinuous activity time cost function has also been explained in recent past studies (Moussourakis and Haksever 2004; Yang 2005). Weibull functional form has been used for the analysis to describe the relationship between project cost and duration (Nassar et al. 2005), and contract type and project duration (Anastasopoulos 2007). Several other studies have not only sought out a relationship between cost and duration but have also proceeded using linear and integer programming techniques to investigate the trade-offs between project duration and cost (Chassiakos and Sakellaropoulous 2005). Optimization algorithm was used to develop a time-cost profile considering various mathematical forms (Yang 2007). Analyzing the data by linear regression mathematical models subsequently determined that linear forms could be used under certain conditions, like while accounting for the unique character of the empirical project data, and the restriction of Least- Square Estimation (LSE) techniques to incorporate certain project assumptions (Hosmer and Lemeshow 1999). When ordinary least square (OLS) techniques are used certain variables that are not represented by traditional explanatory variables could cause irreducible random noise (Hendrickson et al. 1987). Concept of earned value project management has also been applied by the researchers to predict the project duration (Vandevoorde and Vanhoucke 2006; Lipke et al. 2009).

This present study, structured on the findings of past research, seeks to estimate project duration by first describing the time duration data using more traditional functional forms and modeling techniques. The paper goes further to provide new insight into the potential risk factors affecting time overrun. All construction projects by their nature are economically risky undertakings. Risk is termed as an uncertain condition or event which if occurs, causes significant positive or negative effects (Project Management Institute, 2008b). Uncertain situations are characterized by the risk where actual outcome of an event or activity is deviated from the planned value (Raftery 1994) . Kwak and Stoddard (2004) termed identification of risks as the most crucial activity. Risk response measures need to be adapted to prevent the identified risk from materializing (Ropponen and Lyytinen

1997). Project duration and cost is dynamically affected by many variables at the execution stage (del Caño and de la Cruz 2002). Pakkala (2002) emphasized that better practices should be provided to ensure quicker project completion time and cost effective solutions to the owner, since he is most vulnerable to the design and construction risks.

Ibbs and Allen (1995) quantified the project changes impacts on engineering and construction project performance and concluded change as an event, which results in modification of original scope, execution time and cost of work. The problem remains the same that the future is not always predictable. Factor analysis technique was used to identify variable affecting construction time and cost overrun in Indonesia by grouping time and cost overrun variable into factors and then their relationship was determined, the study identified main causes of time delay as inadequate planning, design change and poor labor productivity (Kaming et al. 1997). According to Kaming et al. (1997) the results were specific to Indonesia but they reflected construction management problem in the developing countries. Chan and Kumaraswamy (1997) determined the significant factors causing time delays in Hong Kong and evaluated their relative importance. Their research stated poor supervision, poor site management, poor decision making, unexpected ground conditions and client initiated variations as the major causes of delay. Lo et al. (2006) found the distribution of construction delays in Hon Kong. Studies carried out in Ghana indicated time and cost overruns are related to poor contractor management, material procurement, material and cost escalation, poor technical performance and payment difficulties from agencies (Frimpong et al. 2003).

A number of studies have blazed the trail from the modeling techniques perspective, for examining the issue of cost overrun and time delays. The problem of time overrun in construction project was studied (Knight and Fayek 2002; Shaheen et al. 2007). Time and cost deviations were also investigated by Zheng and Ng (2005). This paper seeks to predict duration for various project types and identify the major risk factors for time overrun dominant in the highway projects of Pakistan. Development of reliable duration and delay estimates can help agencies to deliver optimum project schedules and thus avoid issues pertaining to time overruns that result in cost escalation.

DATA DETAILS AND ANALYSIS

To address the research objective, highway project data was collected from National Highway Authority Pakistan. This paper first describes project duration in terms of explanatory variable using traditional linear form. Separate linear models are also formed for different project types. Cognizance of past studies is taken into account to further investigate the project duration. Weibull analysis considered as a robust technique is used to yield survival curves and hazard functions. Survival analysis is used to model the time taken for an event to take place; it often involves the development of hazard function (Elandt-Johnson and Johnson, 1999). Time taken to project completion is sought to be modeled in this paper. Using historic data correlation between highway project delays and different types of projects is also calculated. Total of 120 projects, over financial years 2001-2012 were selected for estimation of highway project duration and for the analysis of potential risk factors. Projects costs were rebased to 2012 project prices. The data was related to four different project types: pavement construction, pavement rehabilitation, pavement improvement and bridge construction. Data was confirming to the regression assumptions. The residuals were random and independent. Outlying data (exceeding three standard deviations of the mean) of project duration and project delays was expunged using statistical software (SPSS). This section describes the detail on the data selection, its measurement and how we desire to elucidate it in framework of modeling results.

Planned Duration. This explanatory variable is measured as the length in calendar days allocated on the project at the preconstruction phase.

Actual Duration. It is the length in calendar days of the project estimated as a difference between the last day of work and stipulated start date of the project.

Delay Duration. It is taken as the difference between the planned duration and actual duration of the project.

Type of Projects. Four types of projects (pavement construction, pavement improvement, pavement rehabilitation and bridge construction) were selected for project duration estimation.

Project Cost. This explanatory variable depicts the size of the project and is measured in terms of total cost. Jahren and Ashe (1990) indicated size of the project a very significant predictor for time delay. Large projects are usually assumed to have greater duration. Involvement of huge number of contractors and subcontractors in large projects often leads to lapses in communication between them, thus makes them prone to longer delays.

Risk Factors. A number of time overrun factors were identified; a common time overrun variable was recorded for common time overrun factors across the projects. These variables, their frequencies and symbols are represented in Table 1. 16 risk variables were identified and were considered in multivariate delay analysis.

Geographical Location. Extent of geographic area is identified as an important factor for competitive bidding in building projects (Drew and Skitmore 1992). Construction cost and time duration are usually observed specific to the geographic areas. The data collected was from four different provinces of Pakistan: Sindh, Punjab, Balochistan and Khyber Pukhtunkhwa. Provincial data was split in the group of two depending upon the strong relationship between the risk factors and other attributes like project cost that could lead to greater time duration and time delays. Sindh and Punjab were placed in group 1 while Balochistan and Khyber Pukhtunkhwa were stationed in group 2. Two binary variables were created for each of these groups. If the information pertained to the location in the group the variable takes the value of 1 otherwise 0 is inserted.

Table 1. Project Time Overrun Risk Factors

Causes of Delays	Code	Total Indices
Late funds release	R1	95
Relocation of underground utilities	R2	3
Extreme weather condition (rainfall/ snow)	R3	4
Floods in the area	R4	1
Land acquisition	R5	19
Design change	R6	2
Scope change	R7	3
Adverse law and order situation	R8	17
Weak financial position of contractors	R9	2
Traffic management problem due to high traffic	R10	1
Contractors' lack of competence	R11	5
Non-availability of bitumen in the country	R12	2
Non-availability of skilled labor	R13	2
Scarcity of water	R14	1
Cash flow problems	R15	22
Dismantling (structures, trees)	R16	3

RESEARCH METHODOLOGY

Identification of project duration and analysis of risk factors that influence the planned time estimates was the paramount objective of this paper. Data from the provinces showing similar trends was grouped together. One of the hypothesis thus in this paper is everything remains same, difference in geographical groupings may result in different project duration. For example the projects in group 1 are subjected to similar situations different than the projects in group 2. The variables that were used in the prediction of duration models are given in Table 2.

Table 2. Explanation of Variables

Variable	Description
Project Duration	Highway project duration in days
X_1= Project indexed cost	Final Cost in millions of PKR, rebased to 2012 price
X_2= Geographical Location	X_2=1 indicates that variable pertains to Sindh or Punjab X_2=0 indicates that variable pertains to Balochistan or Khyber Pakhtunkhwa

Considering the convenience for use linear normal models were formed. The general form of the duration model is presented in Equation 1:

$$\text{Project Duration} = X_1 \times \text{Cost} + X_2 \times \text{Geographical Location} + 433.6 \quad (1)$$

The regression results produced an R value of 0.56 indicating reasonably good correlation. It can be seen that marginal increase in project duration with unit increase in project cost seems to be linear, and gets high if the projects are placed in geographical locations in group 1. Table 3 represents the model estimation results for the duration model for all project types.

Table 3. Model Parameter Estimates

Variable	Coefficients (t-statistics in parentheses)
Project Duration Model	
Intercept	433.60 (3.343)
Project indexed cost	0.37 (8.369)
Geographical Location	156.17 (1.30)
Number of observations	92
R^2	0.56
Adjusted R^2	0.55

Separate models were also developed for different project types to study the impact of explanatory variables over the project duration. Table 4 represents the descriptive statics of selected variable by project type. Table 5 presents the coefficients of variables in individual project models and their corresponding t-statistics.

Table 4. Descriptive Statics of the Data by Project Type

Statistics	Construction	Improvement	Rehabilitation	Bridge
(a) Project Duration				
Mean	1585.46	1285.53	1047.85	1094.14
Std. dev	838.98	558.75	299.16	539.95
Minimum	545	333	395	250
Maximum	4474	26996.31	1500	2500
Observation Count	45	21	20	34
(b) Project Indexed cost (in millions PKR)				
Mean	1667.65	1299.98	1159.80	1031.76
Std. dev	1357.27	986.46	310.85	640.15
Minimum	300	287.29	664.5	148
Maximum	5617.73	27299.77	1616.57	3221.68
Observation Count	45	21	20	34

Probabilistic Modeling. Probabilities that change over time are generally suited for hazard function analysis. Probability plots generated by survivor function in log logistic analysis provide the likelihood of the project duration being equal or greater than some specified duration.

Log-linear functional form was used in this paper for survival and hazard models. The parameters are $\lambda > 0$ and $P > 0$. Though Weibull exhibits a flexible means of calculating duration dependence but it has a limitation of keeping the hazard to be