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Evaluation of the Effect of Project Delay on Future Benefits in the Nepal Highway Infrastructure Construction Sector

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Abstract: Public infrastructure projects are implemented to achieve targeted economic development of nations. However, due to the delayed execution of projects, the investment cost of the project increases in proportion to time overrun. The increased investment cost for the defined scope of project may have an effect on the achievement of planned future benefits, but the effect of delay on the loss of estimated benefits is not well explored. The primary objective of this research is to assess the effect of delayed execution of road and bridge construction projects on the estimated future benefits. Furthermore, the relationship between delay and the percentage loss of future benefits is modeled using the linear regression analysis. The data consists of 395 road and 248 bridge construction contracts under the Department of Roads, Nepal. The statistical analysis of road and bridge construction contracts showed that there is a reduction in estimated benefits in future years due to the effect of delay. The relationship between the percentage loss of estimated benefit and delay period in months was found to be significant for both road and bridge contracts. The results show that delay not only affects the short-term cost overrun but also the achievement of estimated future benefits. This research thus contributes valuable insights into the understanding of the impact of project delays on both cost overruns and the loss of estimated future benefits. Furthermore, this research has practical implications for policymakers, private sector investors, and financing agencies involved in infrastructure development projects.

Keywords: Road and bridge construction, Estimated future benefit, Regression, Cost overrun, Project delay.

1. INTRODUCTION

Infrastructure development is a sector which involves many stakeholders. There is always a risk of underperformance affecting the planned achievements. The implementation of infrastructure projects is affected by factors such as institutions, resource management, and unforeseen events [1], which lead to delayed execution. There are many studies on identifying the delay factors and their effect on the cost overrun of infrastructure projects. Those studies are focused on specific countries and regions to evaluate the effect of delay in cost overrun. The findings of those research around the world concluded that delay not only affects the execution time but also affects the cost overrun [2] [3] [4] [5]. Ayyub in his book highlighted the potential risks such as financial, economic, political, contractual/legal, and technical factors in any stage of development [6]. Specially, for transport projects, Flyvbjerg et al. critically analysed the risk of cost overrun due to delayed execution of projects [7]. He emphasized the concern of policymakers in mitigating the risk of cost overrun.

On the other hand, the delay in infrastructure project implementation is based on the economic conditions of the countries. One study conducted in developing countries to identify the infrastructure project implementation causes highlighted the weather/climate conditions, poor communication, lack of coordination and conflicts between stakeholders, ineffective planning, material shortages, financial problems, payment delays, equipment/plant shortage, lack of experience/qualification/competence among project stakeholders, labour shortages, and poor site management as major factors [8]. Among the delay issues, most importantly financial resources are key for the timely implementation of projects. Research conducted in developing countries in the road infrastructure sector showed that countries having less than USD 2,000 Gross Domestic Product (GDP) per capita have issues related to financial allocation [1]. Hence, delays due to financial resource constraints further hampers future project investment due to the higher per unit cost of infrastructure. In this aspect, the achievement of planned future benefits with timely implementation of projects is crucial for developing economies.

Above mentioned research findings on the delay effect on cost overrun of infrastructure projects indicate that investment cost for particular infrastructure construction has increased. The increased investment for the specified infrastructure increases the overall cost of the project. During the delay period, the project's estimated benefits are also lost due to non-achievement of project outcomes. Furthermore, the increased project cost due to delay affects the originally planned/estimated future benefits that can be achieved. However, the loss of benefit is not properly evaluated and estimated in the infrastructure construction sector. Therefore, this research aims to estimate the loss of future benefits due to delayed execution for road and bridge construction projects and establish the relationship between delay period and percentage loss of estimated future benefit of infrastructure projects. It has practical significance for policymakers, private sector investors and financing agencies to take proper measures for mitigating the delay risks in future projects. Additionally, it has a direct measurement of the revised rate of benefit without knowing the future revenue and expenditure stream during the project design period.

2. METHODOLOGY

2.1. Data Collection

The data on road infrastructure construction contracts were collected from the Department of Roads, Nepal. The data consists of 395 road contracts and 248 bridge construction contracts. The data were collected from 44 different road project offices and 35 bridge construction project offices implemented between the years 2008 to 2022 under the Department of Roads, Nepal. The contract data consists of the original contract duration (months), revised contract duration (months), and original contract cost (Nepalese Rupee (NPR), million). Administrative and supervision cost for individual contracts and price inflation during the delay period was also collected from the related government institutions.

2.2. Evaluation Approach

The main approach of quantifying the delay effect on achieving future benefits is the increased cost of the project due to delay. The effect of the delay on cost has been calculated considering the price inflation, cost of supervision and administration, and lost benefit during the delay period. While calculating cost overrun, the inflation of prices during the delayed period is estimated using the inflation index published by the Central Bank of Nepal [9]. Based on the existing provision in the government's regulation, 5% as supervision and administrative cost was added to price inflation for the delay period [10]. Furthermore, the lost opportunity cost due to delayed execution of contracts was considered at 12%, which is the minimum value of the estimated return on investment of the project [11]. In evaluating percentage benefit, it is assumed that each contract as a small unit of the project also has the same percentage of benefit. Then, the revised investment cost due to delay effect has been estimated using the following equation:

$$X_2 = X_1 + D_c \tag{1}$$

Where, X_1 = Original contract cost, X_2 = Revised cost of the project and D_c = Delay cost effect in monetary term

Then, the delay cost effect in monetary term is calculated as follows:

$$D_c = I_p + S_c + O_c \tag{2}$$

Where, I_p = Inflation during delay period, S_c = Supervision & administration cost and O_c = Loss of opportunity cost during delay period

While calculating the economic rate of return, the term Rate of Return (RoR) is used. It is the rate at which benefits are achieved following an initial investment, revenue, operation and maintenance cost throughout the project lifecycle [12]. Thus calculated RoR is an average value which is assumed to be achieved in the ideal condition of the project. Due to the delay, the investment cost increased which is calculated using equation (1). However, the revenue and operation and maintenance costs remain the same because there is no change in project scope. Then, the originally planned RoR of 12% has been used to calculate the actual benefit in the delayed condition of the project. The following relationship is used to calculate the revised value of the benefit in delayed project condition:

$$A = X_1 * \frac{R_1}{100} \tag{3}$$

Where, A = Value of RoR without delay condition of the project in any one year and R_1 = RoR in percentage on the original investment

$$A_1 = X_2 \left[\left(1 + \frac{R_2}{100} \right)^n - 1 \right] \tag{4}$$

Where, A_1 = A = Value of RoR with delay condition of the project in any one year, R_2 = RoR in percentage on revised investment in delayed project condition and n = number of years
The value of R_2 gives the revised rate of RoR which is used to calculate the loss of estimated future benefits during the delay period of infrastructure projects.

Alternatively, the Asian Development Bank (ADB), which is a dominant financing institution in developing nations in Asia, has introduced 9% RoR as a minimum to accept public infrastructure projects during the feasibility study stage [13]. Therefore, analysis results using 9% RoR are compared with analysis results using the 12% RoR applied in Nepal to study the effect of change of minimum RoR on the dependent variable i.e. percentage loss of estimated future benefits.

2.3. Data Analysis

2.1.1. Delay and Cost Overrun in Construction Contracts

The construction of infrastructure is a temporary endeavor which has a defined scope of work to be performed within the specified time period. Delay in construction contracts is the time required for completion of work beyond the specified time period in the contract agreement. The cause of delay may be the Employer related, Contractor related, third party related or reasons beyond the control of the parties [14]. The effects of delay in construction contracts are cost overrun, dispute, arbitration, litigation and complete abandonment of the project [2]. Furthermore, cost overrun in construction contracts is due to price inflation, delayed execution of construction works or change of scope of works. The effect of delay on investment cost is evaluated as cost overrun due to more time spent to achieve the same output. The overrun may be price inflation, administrative and supervision costs and lost benefits due to delayed availability of the facility [15]. Firstly, the time overrun was calculated considering the revised time for completion and the original time for completion. Then, the effect of time overrun in investment cost is calculated using equations (1) and (2).

2.1.2. Economic Rate of Return

Infrastructure construction projects support the economic development of the region/nations [16]. The RoR is estimated considering the investment cost, revenue, operation and maintenance cost and other externalities [17]. The economic RoR in Nepalese road sector projects is considered 12% of initial investment as a minimum which is used by the World Bank for transport financing in developing countries [11]. On the other hand, ADB has introduced 9% minimum RoR to select the infrastructure project for investment. So, this research has considered a 12% and 9% RoR to find the percentage loss of estimated benefit due to delay. The RoR is the rate of discount at which the Net Present Value (NPV) of the project is reduced to zero. The Economic Rate of Return (ERR) is equivalent to RoR which is used for evaluating the cost and benefits of public investment projects [18]. The following formula is used to calculate the RoR:

$$\left[B_0 - C_0 + \left(\frac{B_1 - C_1}{(1+RoR)}\right) + \left(\frac{B_2 - C_2}{((1+RoR)^2)}\right) + \cdots + \left(\frac{B_t - C_t}{((1+RoR)^t)}\right) + \cdots + \left(\frac{B_n - C_n}{((1+RoR)^n)}\right)\right] = 0 \quad (5)$$

Where, B_t is the benefits in t years, B_0 is benefit in 0 years, C_0 is cost in 0 years, C_t is the cost in t years, RoR is the rate of return and n is the design life of project.

However, in this research, there was no information about the benefits and cost stream throughout the project period. There is only yearly RoR in percentage is available for each project based on initial investment cost. The revised RoR considering the delay effect on the cost component is calculated using the equation (4).

2.1.3. Delay Effect on Economic Rate of Return

Due to the delayed execution of projects, the revised RoR has been calculated using the equations (3) and (4). Using those equations, R_2 has been estimated which is the revised RoR in delayed conditions in terms of percentage. Then, the percentage loss of estimated RoR has been calculated using the following equation:

$$R_L = R_2 - R_1 \quad (6)$$

Where, R_L = Percentage loss of benefit due to delay

Finally, the relationship between the delay period (months) and the percentage estimated benefit loss was established using the regression equation. The analysis has been performed in road contracts and bridge contracts separately. Additionally, to understand the role of minimum RoR value, ADB's newly introduced 9% RoR value was also used to evaluate the relationship and accordingly conclusion has been drawn. The results of the analysis including linear regression output are presented in the results and discussion section of this paper.

3. RESULTS AND DISCUSSION

3.1. Results of Road Construction

At first, the descriptive statistics of time overrun was calculated which have a maximum 47.44, a minimum 4.54, and an average 28.10 months of delay. Similarly, maximum, minimum and average cost overrun in percentage were 64.81, 6.21 and 37.56 respectively (Table 1). Those figures in cost overrun are due to the effect of delay which is the basis for the estimation of revised RoR on investment. This is because the RoR is dependent on investment costs. Due to the delay, the government has to invest more for the same output. Based on that information, a revised RoR rate was calculated incorporating delayed cost to the initial investment. The difference was calculated with the original estimated benefit of 12% which is the percentage loss of benefit due to the effect of delay (Table 2). There was the maximum, minimum and average revised RoR of 11.30%, 7.28% and 8.81% respectively. Similarly, the percentage loss of benefit has maximum, minimum and average values 4.72%, 0.70% and 3.19% respectively. Using the time overrun in months and the estimated loss of benefit due to the delay in percentage values, linear regression analysis was performed. The analysis results are presented in Table 3. The plot between the delay period in months and the percentage loss of estimated future benefit showed the linear relationship between those two variables (Figure 1). The results showed that there was a significant relationship at 95% significance level between delay and percentage loss of estimated future benefits. The R^2 value of 0.9779 signifies that the variability in percentage loss of estimated benefits is sufficiently explained by the delay in road projects. It means that delay not only affects the cost overrun of the project but also affects the achievement of estimated future benefits in road construction projects. This percentage loss of benefit means projects get lower benefits in comparison with the originally estimated benefit during the whole project design period. In road construction projects of Nepal, the design period for evaluating the rate of return considered is 20 years [19] in which the projects achieve a reduced rate of return.

Table 1. Descriptive statistics of time and cost overrun in road infrastructure construction contracts

Description	Sample size	Maximum	Minimum	Mean	Standard Deviation	Coeff. of Variation
Time overrun, months	395	47.44	4.54	28.10	9.83	34.99
Cost overrun, %	395	64.81	6.21	37.56	13.06	34.78

A similar analysis using the RoR of 9% which is applied by ADB in developing countries, has been performed which also showed the significant relationship between delay and percentage loss of estimated benefit with R^2 value 0.9779. In comparing the results of RoR 12% and 9%, the strength of relationship did not change. It means that delay in the project is the major concern which affects in the achievement of planned benefit whatever the planned estimated benefit.

Table 2. Revised percentage estimated Return on investment after delay effect and percentage loss of estimated benefit in road contracts using 12% RoR

Description	Sample size	Maximum	Minimum	Mean	Standard Deviation	Coeff. of Variation
Revised estimated return on investment (%)	395	11.30	7.28	8.81	0.85	9.67
Loss of estimated benefit due to delay, %	395	4.72	0.70	3.19	0.85	26.65

Table 3. Regression between Delay and % loss of estimated benefit due to delay in road contracts

Variable/Intercept	Coefficients	Standard Error	t Statistics	P-value
Regression between Delay and % loss of estimated benefit due to delay in road contracts using 12% RoR				
Intercept	0.7904249	0.0193220	40.91	$2e^{-16}$***
Delay in Months	0.0855959	0.0006493	131.83	$2e^{-16}$***
R^2 = 0.9779				
Regression between Delay and % loss of estimated benefit due to delay in road contracts using 9% RoR				
Intercept	0.592819	0.014491	40.91	$2e^{-16}$***
Delay in Months	0.064197	0.000487	131.83	$2e^{-16}$***
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1, R^2 = 0.9779				

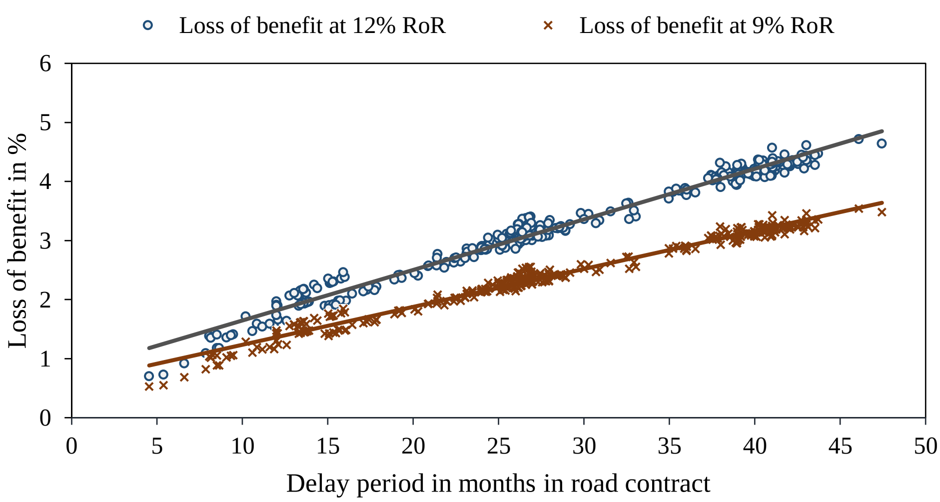

Figure 1. Relationship between delay and % loss of benefits in road contracts using 9% and 12% RoR

3.2. Results of Bridge Construction

Similar to road construction contracts, bridge construction had a maximum time overrun of 29.92, a minimum 13.02 and an average 23.56 months. The cost overrun values in percentage were maximum 44.88, minimum 16.11 and average 30.79 (Table 4). The revised RoR values in percentage after the delay effect were maximum 10.34%, minimum 8.28% and average 9.20%. So, the percentage loss of benefit from the originally planned benefit had maximum, minimum and average values 3.72%, 1.66% and 2.80% respectively (Table 5). The regression analysis between the delay period in months and the

Table 4. Descriptive statistics of time and cost overrun in bridge infrastructure construction contracts

Description	Sample size	Maximum	Minimum	Mean	Standard Deviation	Coeff. of Variation
Time overrun, months	248	29.92	13.02	23.56	4.24	18.00
Cost overrun, %	248	44.88	16.11	30.79	6.22	20.21

Table 5. Revised percentage estimated Return on investment after delay effect and percentage loss of estimated benefit in bridge contracts using 12% RoR

Description	Sample size	Maximum	Minimum	Mean	Standard Deviation	Coeff. of Variation
Revised estimated return on investment (%)	248	10.34	8.28	9.20	0.46	4.98
Loss of estimated benefit due to delay, %	248	3.72	1.66	2.80	0.46	16.34

Table 6. Regression between Delay and % loss of estimated benefit due to delay in bridge contracts

Variable/Intercept	Coefficients	Standard Error	t Statistics	P-value
Regression between Delay and % loss of estimated benefit due to delay in bridge contracts using 12% RoR				
Intercept	0.304741	0.031209	9.764	< 2e-16***
Delay in Months	0.106020	0.001304	81.333	< $2e^{-16}$***
$R^2 = 0.9641$				
Regression between Delay and % loss of estimated benefit due to delay in bridge contracts using 9% RoR				
Intercept	0.2285559	0.0234070	9.764	< 2e-16***
Delay in Months	0.0795153	0.0009777	81.333	< $2e^{-16}$***
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1, $R^2 = 0.9641$				

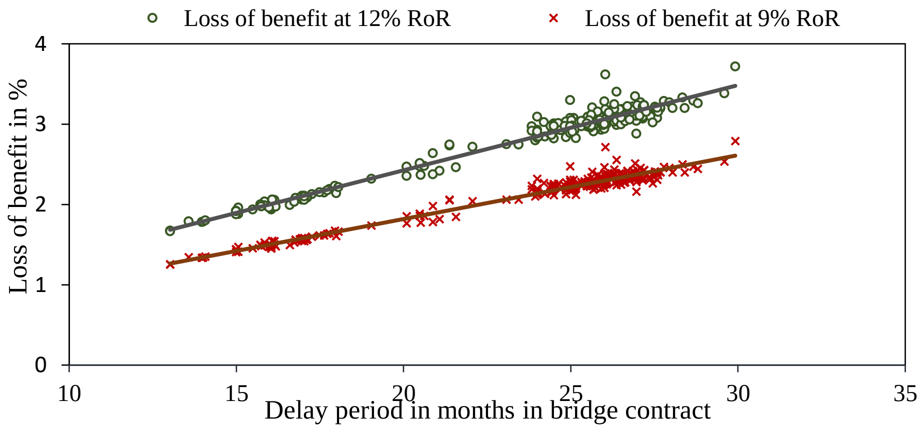

Figure 2. Relationship between delay and % loss of benefits in bridge contracts using 9% and 12% RoR

percentage loss of estimated future benefit showed a significant linear relationship with a p-value less than 0.05. The regression results with R^2 value of 0.9641 in both 12% RoR and 9% RoR cases signifies that the relationship had a strong strength of explanation of variability in percentage loss of benefit due to delayed execution of bridge projects (Table 6 and Figure 2).

During the planning period of bridge projects, the benefit calculation is estimated using all cost components during the design period. In bridge construction projects in Nepal, the design period of the bridge considered is 50 years [20]. Therefore, due to the delayed project delivery, the reduced rate of benefit will apply until the end of the design period of the project. The results showed that due to delayed execution of road and bridge construction projects, estimated future benefits will not materialise throughout the project design period. Road and bridge construction contracts have differences in time overrun and cost overrun. However, both infrastructures have a very similar trend of percentage loss of future benefits due to the effect of delay. Regardless of infrastructure type, the yearly estimated benefit achievement and delay in projects have a similar relationship. It means that the delay effect is widespread in the economy affecting the whole design life of the infrastructure. The originally planned RoR of 12% and 9% results were compared to understand the role of RoR in establishing a relationship between delay and percentage loss of benefits. The results confirmed that irrespective of the original RoR, each project was affected by delay which consequently reduced the targeted RoR throughout the life of infrastructure.

4. CONCLUSION

In conclusion, delay and percentage loss of future benefits have a significant relationship. Irrespective of infrastructure type, the effect of delay on loss of future benefits have similar relationships. The methodology for quantification of the delay effect on achieving the planned benefit of the project devised in this research can support infrastructure project post performance evaluation. The quantified evaluation results further support future planning using data-driven approaches. It also supports evaluation without knowing every cost and income in every year. So, it has simplified the methodology of assessing the achieved benefit in a delayed project situation. Furthermore, the results of this research make aware project planners at an early stage of the project for the revision and adoption of new policies to minimize the delay risk which ultimately helps achieve the project's planned benefits. The loss of future benefits may raise questions about the economic viability of infrastructure financing. It indicates that low benefit may distract the foreign financing institutions and private investors from infrastructure investment. Therefore, it suggests that decision-makers need to take remedial measures for the reduction of implementation delays at the early stages of the project so that the planned benefit can be materialized. Finally, this research methodology can be utilized to measure the overall effect of infrastructure project delay on the national economy in financial terms by the developing nations.

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REFERENCES

[1] G. Mejía, O. Sánchez, K. Castañeda and E. Pellicer, "Delay causes in road infrastructure projects in developing countries," *Revista de la Construcción,* vol. 19, no. 2, pp. 220-234, 2020.

[2] A. A. Aibinu and G. O. Jagboro, "The effects of construction delays on project delivery in Nigerian construction industry," *International journal of project management,* pp. 593-599, 2002.

[3] T. Gebrehiwet and H. Luo, "Analysis of delay impact on construction project based on RII and correlation coefficient: Empirical study," *Procedia engineering,* vol. 196, pp. 366-374, 2017.

[4] D. Aydin and E. Mihlayanlar, "Causes and Effects of Construction Project Delays: A Local Case Study in Edirne City Centre," in *Proceedings of the 5th International Project and Construction Management Conference*, Nicosia, Cyprus, 2018.

[5] M. S. Islam and B. Trigunarsyah, "Construction delays in developing countries: a review," *Journal of Construction Engineering and Project Management,* vol. 7, no. 1, pp. 1-12, 2017.

[6] B. M. Ayyub, Risk analysis in engineering and economics, New York: Chapman and Hall/CRC, 2003.

[7] B. Flyvbjerg, H. Skamris, M. K. and S. L. Buhl, "What causes cost overrun in transport infrastructure projects?," *Transport Reviews,* vol. 24, no. 1, pp. 3-18, 2004.

[8] S. Durdyev and M. R. Hosseini, "Causes of delays on construction projects: a comprehensive list," *International Journal of Managing Projects in Business,* vol. 13, no. 1, pp. 20-46, 2020.

[9] NRB, "Nepal Rastra Bank, Current Macro-Economic and Financial Situation," 2023. [Online]. Available: https://www.nrb.org.np/category/current-macroeconomic-situation/?department=red. [Accessed 10 August 2023].

[10] "Public Procurement Act and Regulation," Government of Nepal, Kathmandu, Nepal, 2007.

[11] The World Bank, Handbook on Economic Analysis of Investment Operations, Washington, DC, USA: The World Bank, 1998.

[12] WB, "The World Bank, Notes on the Economic Evaluation of Transport Projects," The World Bank, Transport Economics, Policy and Poverty Themic group, Washington DC, 2005.

[13] ADB, "Guidelines for the Economic Analysis of Projects," Asian Development Bank, Manila, Phillippines, 2017.

[14] L. Klee, International Construction Contract Law, Prague, Czech Republic: John Wiley & Sons Ltd., 2018.

[15] A. Sepahi, S. Bakhshani and N. Dehani, "Presentation of the Economical Evaluation Model of Delay Cost in Civil Projects: An Iran Railway Case Study," *International Business Management,* pp. 1058-1063, 2016.

[16] P. Sahoo, R. K. Dash and G. Nataraj, "Infrastructure development and economic growth in China," *Institute of Developing Economies Discussion Paper,* pp. 1-33, 2010.

[17] EIB, The Economic Appraisal of Investment Projects at the EIB, Luxembourg: European Investment Bank, 2023.

[18] P. Belli, Economic analysis of investment operations: analytical tools and practical applications, Washington DC: The World Bank Publications, 2001.

[19] DoR, "Nepal Road Standard 2070," Department of Roads, Kathmandu, Nepal, 2013.

[20] DoR, "Nepal Bridge Standard 2067," Department of Roads, Bridge Branch, Kathmandu, Nepal, 2010.