Impact of supply chain risks on the completion for time of rural road projects in Bangladesh

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C H R O N I C L E	A B S T R A C T
	The volume of rural road construction projects has increased over the last decade in Bangladesh though these projects are experiencing failure in terms of time for completion. Therefore, this study focuses on nine risk factors specifically in case of Bangladesh. The objectives are to examine and quantify the contribution of supply chain risk factors on completion time of rural road projects and to assess the prioritization of identified risks. An insignificant number of researches have been performed on the effect of supply chain risks on completion time of rural roads in Bangladesh. To the best of authors' knowledge, the three factors such as, upper contract price, prolong rainy season and time of monitoring have not yet been used as independent variables in any research. A linear model has been drawn and the proposed model shows that upper contract price, delay of the site handover, delay of site materials mobilization, change of scope and prolong rainy season cause time overrun, whereas, time of monitoring, delay in payment and delay in submission of contract schedule did not have significant effect on time. These findings will help the government of Bangladesh take the necessary actions to complete the projects on time.

1. Introduction

Infrastructural development plays a vital role in the economic growth of developing countries (Project Management Institute, 2012). Infrastructure includes structures, systems, and facilities serving a country/city/area (Arthur & Sheffrin, 2003). It also includes the services as well as facilities, which are necessary to continue the function of economy (Jeffrey, 2009). US National Research Council (1987) has defined public works infrastructure as the combination of technical physical structure of specific functional mode, such as roads, bridges, tunnels, water supply, electrical grids, etc. and operating procedures, management practices, and development policies. Due to lack of accessibility to rural roads, rural people remain poor (Lebo & Schelling, 2001). To achieve the expected growth rate, Bangladesh depends on the improvement of transportation infrastructure (Alam, 2015). The transportation system of Bangladesh consists of roads, railways, inland waterways, ports, maritime shipping, and air transport. Among the different modes of transportation, road transportation has become the dominant mode, carrying over 70% of passengers and 60% of freight traffic. Realizing

the importance of transport infrastructural development, the government of Bangladesh has been setting higher target on a regular basis compared with previous years in road construction projects (Alam, 2015). In Bangladesh, rural road covers more than 85% of the total road network of the country and it has increased agricultural production by as much as 32%, and reduced transportation cost by 36% (Federal Ministry for Economic Cooperation and Development, 2013).

The completion time also reaches further than what have been set out in the initial/approval stage (Mydin et al., 2013). It happens due to weakness in managing risk especially supply chain related (Wiguna & Scott, 2005) as supply chain is the attributable character of the implementation stage of the construction project (Jagtap & Kamble, 2015). The time overruns not only threaten the sector's potential to achieve the desired quality but also affect negatively on sustainability of existing infrastructure system (Adam et al., 2014). The Government of Bangladesh spends the development budget to implement ADP through implementation of development projects (Ahmed, 2010). The number of development projects included in ADP is increasing due to accelerate economic growth. During 2009-10 and 2013-14 the targeted number of projects were not completed and large number of completed projects were affected by time overrun (Table 1).

Table 1
Year wise comparison of time overrun of the projects included in ADP

Financial Year	Total number of projects included in ADP (%)	Number of projects were targeted for completion	Actual number of projects that completed (%)	Time overrun in case of completed projects (%)
2013-14	1366(2.86)	298	233 (78.19)	114 (49)
2012-13	1328 (-)	324	206 (63.58)	90 (43)
2011-12	1340 (3.72)	285	199 (69.82)	79 (40)
2010-11	1292 (9.21)	268	257 (95.90)	100 (39)
2009-10	1183	232	195 (84.05)	51 (26)

Source: Annual Progress Report of IMED (2015)

Annual progress report of IMED (2015) has identified the delay in procurement and land acquisition as the reasons for delay though the literature review shows the supply chain risk factors are the main causes of time and cost overrun of rural roads. An insignificant number of studies have been conducted on rural road construction project risk as well as impact of supply chain risk on the success of rural road construction project in public sector. For successful implementation of projects and to make the rural roads cost effective, large-scale project specific research is essential. This research has been conducted in view of this perspective.

2. Related Work

Delay in scheduling in case of construction projects is very common occurrence (Anastasopoulos et al., 2012) though factors vary from country to country. For instance, in Jordan owner's interference, inadequate experiences of contractors, financing and payment of the work are the top five reasons for the delay (Odeh & Battaineh, 2002), whereas, in Thailand shortage of materials, delay in designing, late delivery of materials, inadequate site monitoring and slow work approval are the main reasons (Ogunlana et al., 1996). Dutta and Dutta (2015) found that poor quality of feasibility study, natural calamities, larger size of projects, involvement of hierarchy in different government organization, project location are the reasons of time overrun in Bangladesh. Halwatura and Ranasinghe (2013) found that variation order, poor estimation of cost, order common. Poor estimation of cost, unforeseen site conditions, political pressure during construction stage are the reasons of time overrun in Sri Lanka. Doloi et al. (2012) mentioned that the lack of sophistication leaded to inconsistent performance and continuously failed across all the key performance measures including time, cost and quality what was the key issue in the industry. Factor analysis and regression modelling were also used. All the factors were positively correlated with the impact of delay in the regression model. The fitted model is: Impact of delay = -.853 + .368 (slow decision from owner)

+ .177 (consultant's and architect's reluctant for change) + .165 (poor labour productivity) + .299 (poor site management and supervision) + .325 (rework due to error).

3. Research Design and Objectives

The research aim is to capture the relationship between several supply chain associated risk factors with completion time of rural road in public sector and how these factors are managed in Bangladesh by using actual data. The objectives are to examine and quantify the contribution of supply chain risk factors on completion time of rural road projects and to assess the prioritization of identified risks.

4. Survey Methodology

Two completed projects named "Important Rural Infrastructure Development Project on Priority Basis" and "Union Road and Other Infrastructure Development Project" of The Local Government Engineering Department (LGED) have been selected for this study. Only 120 completed packages out of 137 packages of road construction in Narayangonj (Araihazar, Rupgonj, Bandar, Sonargaon) and Dhaka (Dohar, Savar, Keranigonj and Dhamrai) districts have been considered in the study. Data have been collected from project manager and contractors through both face-to-face (35%) and telephone interview (65%) during 20 March – 6 April 2016. In the study time of completion is being considered as dependent variables (Fig. 1) and measured by calendar days. Data for each road have been collected from the project annual report.
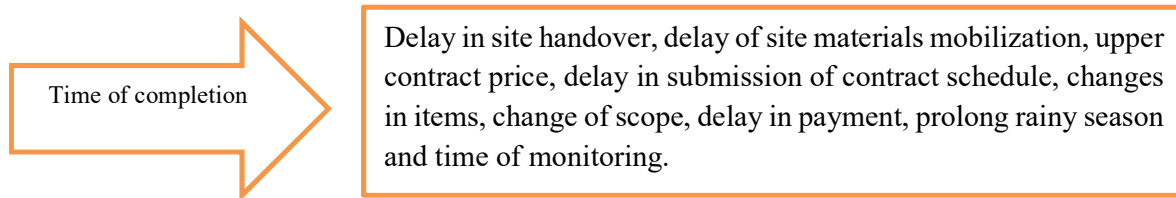
Time of completion →

Delay in site handover, delay of site materials mobilization, upper contract price, delay in submission of contract schedule, changes in items, change of scope, delay in payment, prolong rainy season and time of monitoring.

Fig. 1. Dependent and independent variables selected in the study

The prepared questionnaires have been completed by the contractors and project managers. This is an explanatory, 'Ex post facto' and quantitative type of research which includes descriptive statistics, Pearson's correlation and linear multiple regression analysis. Selected sample sizes of 120 responses out of 137 were analyzed. Linear Regression Model has been used to measure the relationship between dependent and independents variables, and descriptive statistics like standard deviation has been used for obtaining the mean (Fig. 2)
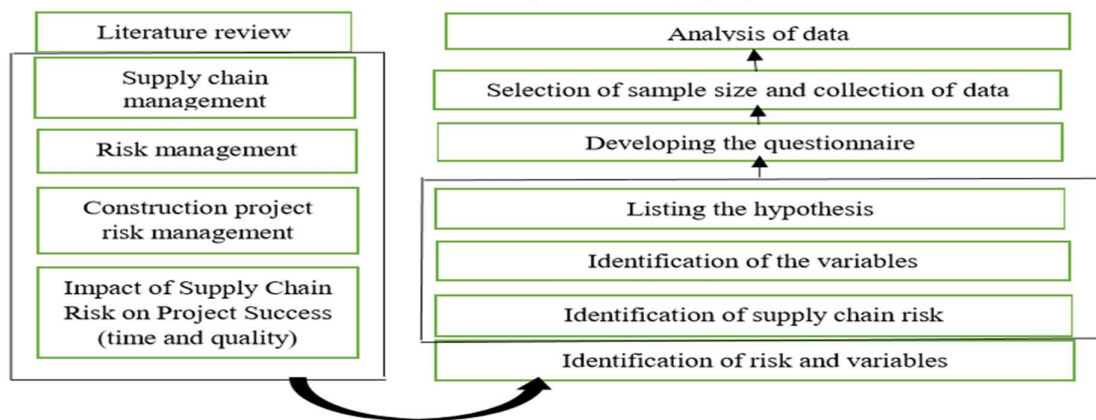
Literature review		Analysis of data
Supply chain management		Selection of sample size and collection of data
Risk management		Developing the questionnaire
Construction project risk management		Listing the hypothesis
Impact of Supply Chain Risk on Project Success (time and quality)		Identification of the variables
		Identification of supply chain risk
		Identification of risk and variables

Fig. 2. Map of research process/framework of this study

Among the respondents, the average age is 40 years and 14.5% of respondents completed 9-11 packages, 22.2% of respondents completed 15-17 packages and more than 5% respondents completed 18- more packages of construction in LGED. To ensure the accuracy/validity of data that has been collected through interview from the respondents has been verified from the official filed documents, which are being kept in the project office.

5. Result and Discussion

The Table 2 shows the descriptive statistics of dependent variable time for completion along with the independent variables.

Table 2
Descriptive statistics of dependent variable time for completion

Variables	Mean	Std. Deviation	Minimum	Maximum	Observation (N)
Time for completion	305.41	102.681	90	587	118
Delay in site handover	41.31	28.093	16	180	118
Delay in site mobilization	59.37	41.739	10	270	118
Upper contract price	158946.74	542055.656	47	3565229	118
Delay in scope change	34.03	23.928	12	120	118
Delay in contract schedule	27.01	16.698	7	120	118
Delay for prolong rainy season	28.70	15.130	15	65	118
Delay in item changed	13.01	6.966	7	35	118
Times of monitoring	2.03	0.470	1	3	118
Delay in payment	1.14	0.353	1	2	118

Source: Field survey, 2015

Table 3
Correlations in case of dependent variables time for completion

Variables	Time for completion	Delay in site handover	delay of site material mobilization	Upper contract price	Delay in payment	Delay in submitting work schedule	Delay in scope change	Prolong rainy season	Delay in item changed	Times of monitoring
Time for completion	1.000									
Delay in site handover	.525	1.000								
Delay of site material mobilization	.545	.426	1.000							
Upper contract price	.122	-.087	-.038	1.000						
Delay in payment	-.126	-.136	-.068	-.011	1.000					
Delay in submitting work schedule	.361	.211	.637	-.098	.024	1.000				
Delay in scope change	.339	.244	.237	-.104	.008	.214	1.000			
Prolong rainy season	.344	.166	.258	.109	-.094	.283	-.066	1.000		
Delay in item changed	.376	.182	.403	.099	-.174	.497	.404	-.014	1.000	
Times of monitoring	.002	.040	.117	-.069	-.030	.017	.138	.106	.170	1.000
Time for completion	.									
Delay in site handover	*.000	.								
Delay in site mobilization	*.000	*.000	.							
Upper contract price	$.095	.174	.343	.						
Delay in payment	$.086	$071	.234	.452	.					
Delay in submitting work schedule	*.000	°.011	*.000	.146	.396	.				
Delay in scope change	*.000	≠.004	≠.005	.132	.467	≠.010	.			
Prolong rainy season	*.000	°.036	≠.002	.120	.155	*.001	.238	.		
Delay in item changed	*.000	°.024	*.000	.142	°.029	*.000	*.000	.438	.	
Times of monitoring	.493	.334	.104	.229	.375	.427	$.068	.127	°.033	.
Time for completion	118	118	118	118	118	118	118	118	118	118
Delay in site handover	118	118	118	118	118	118	118	118	118	118
Delay in site mobilization	118	118	118	118	118	118	118	118	118	118
Upper contract cost	118	118	118	118	118	118	118	118	118	118
Delay in payment	118	118	118	118	118	118	118	118	118	118
Delay in submitting work schedule	118	118	118	118	118	118	118	118	118	118
Delay in scope change	118	118	118	118	118	118	118	118	118	118
Prolong rainy season	118	118	118	118	118	118	118	118	118	118
Delay in item changed	118	118	118	118	118	118	118	118	118	118
Times of monitoring	118	118	118	118	118	118	118	118	118	118

Significant at 0.001 level (<0.001), ≠ Significant at 0.01 level (≠<0.01), ° Significant at 0.05 level (°<0.05) and $ Significant at 0.1 level ($<0.1)

Multiple R is 0.722 which indicates large correlation between the predicted and observed values of outcome. So, it can be stated that the model predicts the observed data very well as R=1 represents defines that the model perfectly predicts the observed data. Value of R^2 is 0.522 which expresses that the independents variables are account for approximately 52.2% of the variation in time for completion. 'Durbin-Watson test' tests whether residuals are correlated (Field, 2005). The value of 'Durbin-Watson test' is 1.273, which is below 2, indicates that there is positive correlation between adjacent residuals. F ratio is 13.082, significant at p<0.001 which is more than 1, indicates that regression model overall predicts time for completion significantly well. The mean square for regression and residual is calculated by dividing sum of squares by the degree of freedom. Table 3 exhibits the correlation matrix, which have been derived from Pearson correlation analysis for time for completion. There is no value more than 0.8 in both the correlation matrix, which expresses that there is no multi-co-linearity among the variables. The range of value from 0.5 – 0.7, mentioned in red color means strong correlation, 0.3 – 0.49 identified by yellow color means moderate correlation and 0.1 – 0.29 mentioned by violet color indicates lower correlation. Significant at 0.001 level is expressed by * (*<0.001), significant at 0.01 level is expressed through # (# <0.01), significant at 0.05 level is expressed by ° (°<0.05) and significant at 0.1 level is expressed through $ ($<0.1). Table 3 shows that in majority cases correlation is lower between the variables.

Linear regression analysis for time for completion is described in Table 4 with the level of significance.

Table 4
Coefficients in case of dependent variable time for completion

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	175.798	43.149		4.074	*.000	90.269	261.327
	Delay in site handover	1.149	.279	.314	4.116	*.000	.596	1.702
	delay in site mobilization	.686	.242	.279	2.840	≠.005	.207	1.165
	Upper contract price	2.460	.000	.130	1.851	$.067	.000	.000
	Delay in payment	-6.574	20.228	-.023	-.325	.746	-46.670	33.522
	Delay in submitting work schedule	-.185	.569	-.030	-.325	.746	-1.312	.942
	Delay in scope change	.838	.325	.195	2.576	°.011	.193	1.483
	Prolong rainy season	1.621	.504	.239	3.219	≠.002	.623	2.620
	Delay in item changed	1.901	1.279	.129	1.486	.140	-.635	4.437
	Times of monitoring	-24.486	15.130	-.112	-1.618	.109	-54.477	5.505

a.   Dependent Variable: Time for completion
b.   *Significant at 0.001 level (*<0.001), ≠ Significant at 0.01 level (≠<0.01),
     ° Significant at 0.05 level (°<0.05) and $ Significant at 0.1 level ($<0.1)

5.1 Upper Contract Price (UCP) (b = 2.460, p = 0.067)

This value indicates that as contract price increases by one unit, time for completion increases by 2.460 units. Independent variable is measured in money but dependent variable is measured in days. This interpretation is true only if the effects of the other variables are held constant.

H₁: *Upper contract price* is negatively related with the *time for completion*.

Therefore, null hypothesis is rejected. In case of higher contract price, the procuring entity has to adjust money from contingency fund. In such case, the contractor does not stop the work, as there is certainty of payment. They manage money and they are unable to buy, bring materials and have to pay the other cost timely. It slows the process indirectly. Enshassi et al. (2009) have also observed that a shortage of cash slows the progress when the contractors are unable to purchase the needed equipment/materials for work.

5.2 Delay in Payment (DIP) (b= - 6.574, p = 0.746)

This value indicates that time for completion is not statistically dependent on delay in payment. According to literature review, time for completion depends on delay of payment but the study design, used to generate the data, does not have sufficient power to detect that dependence. Independent variable is measured in BDT but dependent variable is measured in days.

H₂: *Delay in payment* is positively related with the *time for completion*.

Therefore, the null hypothesis is rejected. This indicates that the delay of payment does not affect directly on the work of the contractors. There is certainty of payment as LGED is a government organization. Due to this, the contractor continues the construction work as they know they will get payment. The contractors have to borrow money from banks or others to continue the work. Ogunlana et al. (1996) have found similar result in their study on construction projects in Thailand.

5.3 Time of Monitoring (TOM) (b = - 24.486, p = 0.109)

This value indicates that time for completion is not statistically dependent on time of monitoring. The study design, used to generate the data, does not have sufficient power to detect that dependence.

H₃: *Time of monitoring* is negatively related with the *time for completion*.

So, the null hypothesis is rejected. In the study, it is observed that monitoring does not have significant impact on early completion. It is seen that in the entire 120 packages site inspection book were present where the comments were written. The contractors sometimes are not interested to follow the comments. It depends on the relationship between the client and contractors.

5.4 Changes in Items (CIT) (b = 1.901, p = 0.140)

This value indicates that time for completion is not statistically dependent on changes in items. Time for completion is known to depend on changes in items but the study design, used to generate the data, does not have sufficient power to detect that dependence.

H₄: *Changes in items* is positively related with the *time for completion*.

Therefore, null hypothesis is rejected. If the cost of the items increases due to scarcity of any item or faulty design, the contractor changes the item in the middle of the work with the approval of the authority. It takes time for approval. Approximately in case of 42% packages the authority took at least 15 days to approve the item change. Thus, time for approval of item change does not have significant impact on completion of the construction work.

5.5 Delay in Site Handover (DSH) (b=1.149, p = .000)

This value indicates that as delay in site handover increases by one unit, time for completion increase by 1.149 units. Both variables are measured in days. This interpretation is true only if the effects of the other variables are held constant.

H₅: *Delay of the site handover* is positively related with the *time for completion*.

Therefore, null hypothesis is accepted. Delay in site handover has great impact on the completion time of the construction. According to Ahmed (2010) land acquisition problem is the major reason of delay in site handover in Bangladesh. In his study among 70 respondents, 58 respondents agreed that delay in site handover due to land acquisition problem affect completion time. In this study, the findings are similar to Ahmed's findings, about 58.6% delay occurred due to land acquisition.

5.6 Delay in Site Material Mobilization (SSMM) (b = 0.686, p = 0.005)

This value indicates that as delay in site mobilization increases by one unit, time for completion increase by 0.686 units. Both variables are measured in days. This interpretation is true only if the effects of the other variables are held constant.

H₆: *Delay of site material mobilization* is positively related with the *time for completion*.

Therefore, the null hypothesis is accepted. It means if materials are not brought at the construction site timely, it delays the completion period. Enshassi et al. (2009) have found that about 89.77% of total projects are delayed due to delay of site materials, whereas, Alaghbari et al. (2007) have indicated that this happens due to the mismanagement of the contractors. In this study, the findings are similar to Alaghbari et al.'s (2007) result. About 60% delay of site materials mobilization happens due to contractor's mismanagement.

5.7 Delay in Submitting Work Schedule (DSWS) (b = - 0.185, p =0.746)

This value indicates that time for completion is not statistically dependent on delay in submitting work schedule. Time for completion is known to depend on delay in submitting work schedule but the study design, used to generate the data, does not have sufficient power to detect that dependence.

H₇: *Delay in submitting work schedule* is positively related with the *time for completion.*

Therefore, the null hypothesis is rejected. The contractors submit their work schedule to the authority after signing the contract and they start construction work after getting the possession of the site. According to contract, site should be handover to the contractor within seven days of signing contract. Therefore, these two works are accomplished, simultaneously. The delay in site handover has more significant effect than delay of submitting work schedule on time for completion.

5.8 Change in the Scope of Work (CSW) (b = 0.838, p = 0.011)

This value indicates that as the scope of work increases by one unit, time for completion increases by 0.838 units. Both independent variable and dependent variables are measured in days. This interpretation holds only if the effects of the other variables are remained constant.

H₈: *Change in the scope of work* is positively related with the *time for completion*.

So, null hypothesis is accepted. The scope of work changes in the middle of the work due to faulty design, local demand etc. If the number of scope changes increase, the time for completion of the construction package also increases. Chen and Kumaraswamy (1998)'s findings in Hong Kong are similar to the findings of this study.

5.9 Prolong Rainy Season (PRS) (b = 1.621, p = 0.002)

This value indicates that if the rainy season increases by one unit, time for completion increase by 1.621 units. Both independent variable and dependent variables are measured in days. This interpretation is true only if the effects of the other variables are held constant.

H₉: *Prolong rainy season* is positively related with the *time for completion*.

Therefore, the null hypothesis is accepted. Construction work is not carried out due to heavy rainfall during summer. If the rainy season starts early or it ends late, work can be delayed. Similar result is found by Al-Mamoni's (2000) where completions of projects have been strongly affected by bad weather.

5.10 Linear Regression Model for Dependent Variable Time for Completion

Y = 175.798 + 2.460 (UCP) - 6.574 (DIP) - 24.486 (TOM) + 1.901 (CIT) + 1.149 (DSH) + 0.686 (SSMM) - 0.185 (DSWS) + 0.838 (CSW) + 1.621 (PRS) + …………... + 8.17 (Eᵢ)

6. Scatter plot Matrix

According to Field (2005), scatter plot matrix shows the relationships between multiple pairs of variables. It helps to determine if there is linear correlation between multiple variables. According to Fig. 3, the scatter matrices indicate linear relationship between the dependent variable times for

completion with related independent variables. Matrices show the strong or weak positive or negative correlation among the variables.
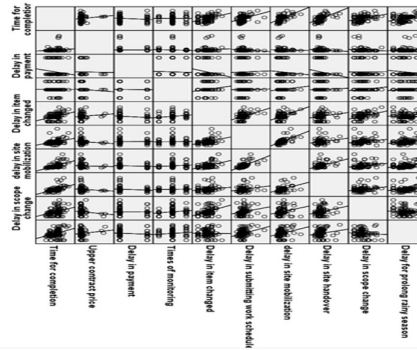

Fig. 3. Scatter matrices show linear relationships among dependent variable time for completion and the independent variables

7. Identification and ranking of Risks

In case of ranking risk, chance, impact and detection difficulty have been measured by the respondents. Likert Scale (1 to 5) has been used to indicate the severity. Measuring scale of chance, impact and detection difficulty: Negligible: 1, Minor: 2, Moderate: 3, Serious: 4, and Critical: 5. The averages of chances, impact and detection difficulty mentioned by the 120 respondents have been placed in Table 5 to measure the rank of the identified risks.

Table 5
Ranking of risk, response plan, control measures (Source: Field survey, 2015)

Risk Item	Chance	Impact	Detection Difficulty	Rank	
1	2	3	4	5=2*3	6=2*3*4
1.Delay in site handover	3.66	4.20	3.78	15.37	60.86
2.Delay of drawing	3.44	3.27	3.65	11.25	42.00
3.Submission of work schedule	2.30	2.45	2.45	5.64	13.45
4.Delay of site materials mobilization	3.32	3.43	3.73	11.39	42.13
5.Slow approval	3.68	3.23	3.90	11.89	49.25
6.Change of scope	3.81	3.27	3.87	12.46	50.53
7.Lower contract price	3.68	3.4	3.84	12.52	49.94
8. Upper contract price	3.23	2.78	3.45	8.98	30.99
9.Delay of payment	3.07	3.18	2.98	9.76	32.04
10.Shortage of manpower and equipment	3.71	3.42	3.86	12.69	51.03
11.Prolong rainy season	3.72	3.73	3.93	13.91	55.01
12. Lack of monitoring	3.40	3.36	3.85	11.42	45.83
13.Lack of action taken after monitoring	3.65	4.08	3.76	14.89	55.67

The risk matrix prioritizes risks for further quantitative assessment or response planning (PMI, 2013). Fig. 4 shows the risk matrix where probability and impact are shown in X-axis and Y-axis. Risk can be lower, moderate and higher category, which have been expressed by green, yellow and red color. The severity up to 5 means less risky, area from 6 to12 indicates moderately risky and area 13 to 25 is highly risky zone.
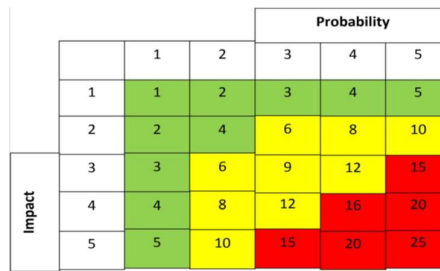

Fig. 4. Risk matrix

According to respondents, delay in site handover has severe effect (15.37) on time for completion. Similarly, in India, majority projects of national highway delayed due to land acquisition (Rajeswari, 2014). Both Kartam (2001) and El-Sayegh (2008) found that land acquisition is moderately risky. The respondents of this study have mentioned scope change (12.46), shortage of manpower and equipment (12.69) are highly risky but delay in payment (9.76) is moderately risky for delay. El-Sayegh (2008) has shown that in UAE, severity of these two risks are scope change (11.38), delay of payment (11.18) are moderately but shortage of manpower and equipment is highly risky (12.37). Kartam & Kartam (2001) has found that scope of work is moderately but delayed payment is highly risky (Appendix B). This study has found that lower contract price is riskier (12.52) than upper contract price (8.98). Mahamid (2013) has found in Palestine that high competition of bid is highly risky. This study has found that delay of drawing (11.25), delay in site material mobilization (11.39), slow approval (11.89) and time of monitoring (11.42) are moderately risky. Mahamid (2013) has also found the similar result though El-Sayegh (2008) has found that site material mobilization (12.8), slow approval (12.32) are highly risky but delay of drawing (10.12) is moderately risky.

8. Conclusion

This study has analysed the effect of supply chain risks on rural road construction project mainly from time perspective and how these risks were being prioritized using the available evidence from the People's Republic of Bangladesh. Selected sample size is 120 which has been calculated when the population size is 137 which is representative and reflective in terms of population size. Quantitative analysis based on multiple regression methods indicate that most of the Hypotheses were supported (i.e., delay in site handover, delay in site material mobilization, changes in scope of work prolong rainy season) indicate that they have significant impact on time for completion. The limitations of the study are 120 packages of two rural road projects have been considered in the study and only project managers and contractors are considered as respondents. It would be better if designers, consultants and local project authority were included as respondents in the study.

Acknowledgements

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