**Supplemental Online Material for the research article titled:**

**Understanding the role of contractor capability in risk management: A comparative case study of two similar projects#**

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***Disclaimer:*** This report is prepared as a part of the research project ‘To develop a risk management framework’ for the funding agency (NBCC India Ltd.). The report is based on analysis of risk management in two ongoing projects located in Chennai and Coimbatore, India. The information presented in this report is based on the project documents, interactions with the site executes, archival records and direct observations made during site visit in April 2016. The purpose of this report is only to support academic research. The authors of this report restrict its use for any purpose other than academic research. Though, the authors have exercised extreme caution in presenting the collected information, the limitations on access to all the documents from various stakeholders may have affected the correctness of facts and figures. Further, name of the organizations involved in the two projects have been anonymised to avoid any impact on their brand image. PC1 to PC7 and QC are contractor organizations in Chennai Project (P) and Coimbatore project (Q) respectively. The authors and the affiliated institute have permission to use and publish data for the academic research. The Journal Paper# in this report refers to the article titled ‘Understanding the role of contractor capability in risk management: A comparative case study of two similar projects’.

**Case Study Reports**

**1. Chennai Project (P)**

**1.1 Description of Chennai project (P)**

A government hospital established in 1971 had been functional in the metropolitan of Chennai (India) with a land area of 20 acres. An Insurance Company (IC) is the owner of the hospital. In the same campus a new hospital project, hence forth referred as Chennai project (P), was proposed in the year 2010. The scope of the Chennai project included renovation of existing hospital and construction of a medical research institute to provide medical courses for undergraduate, graduate and paramedic students.

In February 2010 the owner IC had nominated a public construction company as Project Implementing Agency (PIA). As per terms of the IC-PIA contract, the project was awarded to PIA on ‘turnkey basis’ and empowered PIA to carry out bidding process to on-board contractors. The scope of the project was envisaged in the IC-PIA contract as a list of buildings and facilities to be developed. Stipulated project duration was 24 months with stipulated completion date being 19 February 2012. Consultancy fee of PIA was 5% of the cost of construction and contingencies. IC had signed a separate contract with an architect firm named M&A for a fee of 3% of the cost of construction. M&A was entrusted to develop the design and provide technical consultancy in preparation of the project estimates. Overlapping responsibilities of M&A and PIA had included site investigation, facilitating approval of detailed drawings along with bill of quantities (BOQ) and tender estimates. The project estimate at the time of awarding the contract from IC to PIA was INR 3704 million. There were multiple revisions in the project scope and the estimate due to inclusion of essential medial systems (such as medical gas pipe lines) which were not considered initially. A revised project estimate of INR 4706 million was approved in December 2010 based on which PIA carried out the bidding. The salient features of the Chennai project are summarised in Table 02 (of the journal paper). A schematic diagram depicting summary of the project, stakeholder relationships and important events is shown in Figure 01 (of the journal paper) and explained in this case report.

Originally, the scope of work in Chennai project was divided into two parts – main package for the construction of new buildings, and supplementary package for the renovation of existing hospital along with miscellaneous work. PIA had published Notice for Inviting Tender (NIT) for the main package on 13 May 2010 and later a revised NIT on 30 October 2010 to accommodate the revisions going on in the BOQ and the estimates. Through a traditional competitive bidding PIA had awarded the main package to PC1 at 134% of Base Estimate corresponding to Delhi Schedule of Rates (DSR) 2007. Date of agreement for PIA-PC1 contract was 21 December 2010 with stipulated project duration of 19 months. First piece of the work-front was made available by IC on 13 January 2011. Subsequently, PC1 started the execution of the project by subletting the entire scope of work to another agency named PC7 which was reporting to PC1. The information about PC7 was provided by the professionals during data collection for the case study research. There was no formal approval from IC or PIA to PC1 for subletting the work. On 28 April 2015 PIA terminated the contract with PC1 on the account of unsatisfactory progress by PC1. At the time of termination the PIA-PC1contract, PC1 had submitted 7th running account bill with cumulative value of work done being INR 402 million. In May 2015 PIA engaged PC6 to execute urgent work required for commencement of MBSS courses in the institute. The project value for PC6 was INR 85 million with project duration of one month. In the third quarter of 2015, balance work of PC1 was awarded to another contractor PC3 at the risk and cost of PC1. The cost index for PC3 was 141%. ‘At risk and cost of PC1’ means that any extra cost for execution of the project over and above the PIA-PC1 contract had to be borne by PC1. PC3 had mobilised its resources and project was under execution at the time of data collection (April 2016).

The supplementary package was awarded to PC2 on 23 April 2013. PIA had terminated the contract of PC2 on 21 June 2013. The reasons for the termination of this contract were cited as unsatisfactory progress of PC2 and its inability to mobilize resources even after two months of award of the contract. This supplementary package was subsequently divided into three sub-packages as shown in Figure 01 (\*of the journal paper). To carry out all the miscellaneous work a sub-package of INR 280 million was awarded to a contractor PC4. Stipulated start and finish dates of this sub-package were 27 August 2015 and 26 May 2016, respectively. All the required work-front was not available to PC4 till April 2016 and sub-package had slow progress. Second sub-package of INR 25 million included supply of non-medical and laboratory furniture urgently required to commence the MBBS course in July 2015. PIA had awarded this package to PC5 in May 2015. PC5 had completed the supply by the end of 2015 and its payment had not been processed till April 2016. The item rate approval of the supplied items was under process. Remaining INR 210 million constituted the third sub-package for which PIA had not floated any tender till April 2016.

The Chennai project also experienced unprecedented rain with flood in November-December 2015 which was declared a disaster by the government, i.e. *Force majeure risks (18)*. As a result of this disaster, the project was brought to stand still for over 60 days along with destructions of under construction sites, materials, site offices, documents and labour colony. PIA had submitted the 7th Extension of Time (EOT) application to IC requesting an extension of project till 31 May 2017. The application includes seeking a net project extension of 1928 days or 64.3 months with effect from 19 February 2012. This Figure 01 (\*of the journal paper) includes major events in the project mapped along the timeline. ‘Star’ symbols are original stipulated commencement and completion dates for different contracts and ‘Square’ symbol is time of data collection for case study research by the research team. ‘Solid dot’ symbols correspond to important events in the project. The axis for timeline is not to scale. More parts of the Figure 01 (\*in the journal paper) are explained later in this report. As on 31March 2016, the Chennai project which started with stipulated completion date of 19 February 2012, had achieved 37% completion.

**1.2. Risk Identification in Chennai Project**

As mentioned in the methodology section of \*the research paper, the research team has taken conscious effort to provide, first, only a ‘description’ of the Chennai project mostly based on information stated in the project related documents. This approach has minimised inclusion of interpretations by the research team and hence has minimised possible biases to which a case study research remains susceptible. Even from the ‘description’ of the Chennai project, occurrence of some risks such as ‘schedule overrun’, ‘scope variation’, and ‘poor performances of contractors’ are evident. However, identification of several other risks that depend on multiple aspects of the project requires a deeper analysis of information stated in the project documents. For further analysis of the collected information and the identification of risks from the project there are two possible approaches – (i) consider the role of each stakeholder and identify risks rooted into each of them; and (i) to follow the evolution of the project along the temporal line and observe how various events have triggered different risks. Initially, first approach is adopted for risk identification because in traditional forms of contract responsibilities of individual stakeholders are rather well known, and corresponding risks can be directly identified. As the readers proceed through risk identification under each stakeholder, a number of risks would appear conspicuous but not reported under that stakeholder. It is a conscious decision to report such risk little later because they were found to be rooted in more than one stakeholder. The second approach of studying a case project along temporal line is used to identify and analyse interrelated risks in the Chennai project. Entire approach for analysis is repeated for the second case Coimbatore project as well. As important paragraph is assigned a Reference number P1.1., Q1.1, …, for cross referencing.

**Owner related risks**

**P1.1.** IC had appointed PIA in February 2010 and had provided a list of buildings/facilities to be constructed within 24 months. The IC-PIA contract had not provided detailed requirement and scope of each building/facilities. From February to December 2010 project estimate had increased by INR 1300 million due to addition of various medical service systems to the scope of the project. This had led to amendments in NIT published by PIA and had delayed the tendering process. Stakeholder correspondences in 2015-16 showed that finalization of some requirements of the project (such as non-medical furniture) was pending with IC and the institute administration. This scenario manifests that the owner had started the project under *risks due to unclear requirements (1).*

**P1.2.** Chennai project site was an operational hospital that inherited several constraints over construction activities. Records show that the actual date of commencement of project was 13 January 2011 when first piece of work-front had been made available by IC, i.e. almost 11 months from stipulated date of commencement. IC had not completed the handing over of the hindrance free site till April 2016, i.e. even after a delay of over 64 months compared to 24 months of the originally stipulated project duration. This problem was further intensified by the unsystematic manner of handing over the sites and delays in approval for demolition of existing facilities. Therefore, even though *land acquisition risk* did not occur in this project, *risk of delay in handing over of project site (4)* free from all hindranceshad impacted the project.

**Design and Technical consultant related risks**

**P2.1**. M&A was appointed by IC for site investigation, design development and technical consultancy, and preparation of tender estimates. Records show that major addition in project scope, changes in specifications of work and material, delay in availability of the good for construction drawings, supply of drawing in sequential manner, and errors/omissions in drawings were hurdles continuously affecting the project. Till April 2016, over 3300 number of drawings had been issued by M&A and still the drawing supply was not complete. Further, modifications in design and specifications even after execution of the work had led to several instances of rework. All these observations establish that the project was impacted by *design risks (2).*

**P2.2.** Design modifications and additions in the scope of work also resulted in a number of BOQ items surpassing the 10% ‘deviation limit’ envisaged in the contact. In brief, this clause states that changes in the quantity of BOQ items up to 10% of initial quantity will be paid at the contract prices. For quantities going beyond the 10% limit, contractors may be eligible for payment at current market rates. Many items initially not in BOQ were also added due to changes initiated by IC and change in detailed scope of work. The latest scope variation estimation submitted to IC on 13 April 2016 amounted to 39% of original estimate. These observations highlight occurrence of *scope variation risk (3)*.

**P2.3.** Scope variation had also resulted from insufficient site investigation. For instance, during excavation by a contractor a large well was discovered at the site which was not identified in the site investigation process. This had led to stalling of work, reinvestigation of the site and subsequent design changes. However, subsequent contribution to overall delays in P was low. These are the effects of *risk due to* *inaccurate site investigation (5).*

**Contractor related risks**

**P3.1.** The Chennai project had begun with two contractors for two packages but more contractors were engaged later as shown in the Figure 01 (\*of the Journal paper). IC had engaged PIA on turnkey basis and PIA in turn engaged PC1 and PC2 as prime contractors. After award of the contract PC2 had not mobilised its resources. PC1 had started execution of the work through another agency PC7. Non-mobilization of sufficient resources and subletting entire work to another agency was in violation of the terms of the contract. Similarly, inability of IC to provide hindrance free site and inability of M&A to provide good for construction drawings were breaches of contacts. These instances highlight the *risk of* *breach of contract by the stakeholders (12).*

**P3.2.** Unsatisfactory progress and breach of contracts by PC2 and PC1 had resulted in termination of respective contractors. Even the new contractors PC3, PC6 and PC4 (ISK) were not able to maintain revised schedules which were evident from the repeated EOT applications being submitted. Among these firms, PC3 was engaged to complete PC1’s balance work of INR 4000 million while PC3 had annual turnover of INR 8500 in the year 2014-15, i.e. PC3’s package itself was 47% of its annual turnover. In addition to risks identified earlier, the Chennai project was also affected by several hindrances such as contractor’s limited financial capability and lack of experience, shortage skilled workers, and breaches by contractors. Rooted to contractors, these instances is evidence of *risk from poor performance of contractors (14)* impacting the project.

**P3.3.** Based on inputs provided by the site executives and subsequently verified from press releases, it was found that an investigation by a law enforcement agency was initiated against the managing director of PC1 in the same period. Brief of the investigation included alleged backing from a political party for PC1, amassing of disproportionate properties and attachment of the managing director’s property by a statuary authority. As both IC and PIA were public organizations, possibility of a political interference cannot be ruled out. The ongoing investigation against PC1’s top management, which was engaged to execute majority of the work, provides clues for occurrence of *risks due to lack of support from management or poor leadership risks (7)*, *corruption risks* (23) and *political risks (22).* The research team did not find any project document to substantiate impact of these risks on the project within the limits of this case study. It is highly unlikely that stakeholders would discuss such sensitive issues (corruption) through written communication.

**PIA related risks**

As a ‘turnkey contractor’ PIA had responsibility to ensure performance from all the contactors it had engaged and hold them contractually accountable for any failures on their part. As a project management consultant PIA was also responsible for ensuring fulfilment of commitments from the designer and the owner. Therefore, strictly speaking, PIA had responsibility for carrying out risk management for most of the risks identified in the project even if they originated from other stakeholders. On the other hand, if all the stakeholders had performed well, responsibility of PIA had been minimal. Due to the role PIA had in the project, risks rooted in PIA are not obvious from ‘description’ of the case and surfaced only after further analysis of risks. Before moving to next section which presents further discussion of hindrances/risks along timeline to analyse the risks, a brief summary of sporadic hindrances which had occurred in the project is included here.

**P4.1.** There were constraints of noise, dust and space against installing concrete batching plant inside the operational hospital campus. The project being located in a metropolitan city, movement of transit mixers and heavy vehicles faced restrictions in movement. This represents the *risks due site constraints (6)*. However, due to very slow progress, its impact on project was insignificant and not documented. In 2011 the Indian government had increased the rate of royalty on aggregates making them costlier. This is an example of *legislation risk (19)* affecting cost of the project*.* Against government’s decision of increasing royalty, quarry owners organised strikes and halted operations of their quarry plants that resulted in the shortage of aggregates. In August 2011 there was strike also by truck owners disrupting the supply chain of the materials. During December 2011 there was shortage of bricks in the local market. These instances of disruption in logistics and material shortage indicate the occurrence of *material management risks (8)*. Complaints were filed in Chief Minister’s office by the neighbours of the project against the poor maintenance of sanitary facilities in labour colony built inside the hospital campus. The labour colony and its sanitary facilities were temporary in nature with service life of couple of years. Due to prolonged project duration these facilities had deteriorated and generated nuisance leading to resentment in the neighbourhood. This incident of hostile attitude of neighbourhood along with two instances of strikes by suppliers mentioned above highlights occurrences of *socio-political risks (22)* in the project. For commencing the medical course, Medical Council of India, a regulatory authority for certifying medical institutions, was supposed to inspect the hospital. It is common practice to stop construction activities during such inspection periods. Due to frequent rescheduling of inspection from 2012 to 2015, the project suffered repeated stoppage of work which highlights occurrence of *administrative and regulatory risks (21)*.

**1.3. Evaluation of risks in Chennai project (P)**

Previous section has identified risks considering roles and responsibilities of the stakeholders in the project. In this section, the research team has analysed the project along time line to explore the interdependency among risks and their collective consequences on the project. This is done by building ‘explanations’ of how the initial events in the project have led to its current status. These ‘explanations’ also include interpretations of the observed facts by the research team. By separating the ‘description’ from the ‘explanation’, the case study also draws a line between observed facts and the research team’ interpretations making the later available for scrutiny by readers. Yen (2014, p 133-170) has recommended such practice for a better validity/reliability in a case study research. It would allow readers to know where the possibility of biases lay and systematic rival explanations can also be developed.

Theoretical support for drawing inferences about risks in projects is largely based on three phenomena observed by studies on risk relationships (Jha and Devaya 2008, Iyer and Sagheer 2010) that are integral to project risks but not directly visible from project documents. First among these phenomena is – risks are interdependent and impact of some risks originating from one stakeholder may trigger other risks related to other stakeholders. Second, a true evaluation of a risk must consider not only the direct impact of that risk on the project but also its ability to trigger other risks as well as its vulnerability of being affected by other risks Third, the risks of *schedule overrun (15)* and *cost overrun* (16) which are prime concerns of stakeholders are observed as cumulative impacts of various other risks much later in a project. The analysis here looks at the project from the beginning considering all stakeholders together.

**P5.1.** IC had awarded the project to PIA in February 2010 with 24 months of project duration and a list of buildings and facilities as its project requirements. At the same time IC engaged M&A for the design development. A number of revisions in the scope of work, estimates and designs illustrates that IC and M&A had not managed *scope variation risks (3)* and *design risks (2)*. Even after initial delays, the possibility of schedule recovery in the project was affected because of *delays in handing over of site (4)* by IC. This risk had not been mitigated completely till April 2016. The project had experienced a scope variation of INR 1300 million and schedule overrun of almost 1 year prior to a contractor joined the project in January 2011. Therefore, responsibility of all impacts on the project up to January 2011 has to exclusively lie with the upstream stakeholders, namely IC, M&A and PIA.

**P5.2.** PIA had awarded the main package to PC1 in December 2010 and the supplementary package to PC2 in April 2013, after 14 months of the original stipulated completion date. Execution of both these packages was necessary for the completion of the project, yet awarding the secondary package so late does not justify intention of PIA and CI for timely completion of the Chennai project. Further, following termination of PC2’s contract in June 2013, no new contractor had joined the supplementary package for another two years. After May 2015, PC4 was involved for miscellaneous work and PC5 for supply of non-medical furniture. From February 2010 to May 2015, over five and half years, only the upstream stakeholders (IC, PIA and M&A) were present in the secondary package of the project. This information is presented in Figure 01 (\*in the journal paper) with more clarity, where execution of the secondary package starts after on-boarding of PC5 and PC4. The impact on the secondary package due to breach of contract by PC2 could justify only small part of total delays allocating responsibility for most of the delays with the upstream stakeholders. These observations about taking a year to clarify major project requirements including project scope, and then failing to on-board contractors establishes the failure of IC and PIA in taking initiatives to execute the project and manage project risks. This claim is further substantiated by a fact that a part of the supplementary package had not been tendered till April 2016. Lack of initiatives on the part of IC, PIA and M&A demonstrates occurrence of *risk due to poor leadership* in the project from the upstream stakeholders*.* An alternateexplanation for non-award of work could be lack of interest from the contractors*.* Considering that project location was in a metro city, it is extremely unlikely that no contractor was interested in this sub-package. As both the successful bidders PC1 and PC2 had left the project, the scenario also hints at occurrence of *bidding risk (9)* which had resulted in selection of non performing partners.Non-performance of PC2 is further evident by PC2 reporting losses in 2013-14 and 2014-15.

**P5.3.** In the main package, PC1 had started execution through PC7 in January 2011 after the first piece of project site was handed over to the contractor. From December 2010 till April 2015, when PC1’s contract was terminated, PC1 had submitted only 7 running account bills amounting to about 12% of its contract value (9% of overall project value). As per this contract PIA was empowered to impose liquidity damages or to terminate contract in case of unsatisfactory progress. The termination was done only after allowing four and half years of delay without any liquidity damages, clearly indicating impact of *risk due poor contract management* by PIA. Decision of PIA and IC to not to invoke the clause for liquidity damages also supports the observations that the upstream stakeholders themselves had contributed to project delays. If it was not so, then such decisions does not reflect practice of a prudent client. The news of investigation against the managing director of PC1 had also preceded the termination of the PC1’s contract, asserting the previous observation about occurrence of *political risk (22)* in the project.

**P5.4.** The latest project estimate updated in April 2016 at DSR 2007 was INR 4632 million and at market rate the estimate was INR 5000 million, creating an impact of INR 368 million on the cost of the project. A delay of six years in the project had made the consequences of *inflation* *risk* substantial. IC had released only 75% of the bill amount and withheld 25% for reasons such as escalation, non-approval of item rate/scope variation, etc. Release of partial payments had led to an outstanding of INR 380 million against IC by April 2016. Partial payments and delayed payments highlight the *risks of delay in payment processing (11)*. This had adversely affected the cash flow of the contractors and had created *financial risks (13)* for them which in turn further aggravated the *risk due to poor performance of contractors (14)*. As per IC-PIA contract, PIA was empowered to claim compensation from IC if payments are delayed. However, this clause had not been invoked substantiating the previous observation of *risk due to poor contract management* (10) by PIA.

**P5.5.** During the tenure of PC1 from January 2011 to June 2015, 9% of project progress (12% of PC1’s package) was achieved by PC1 in four and half years. In 9 month period from June 2015 through March 2016, the project has achieved another 28% of progress, making the total progress of 37%. PIA had submitted 7th EOT on 21 December 2015 seeking an extension up to 31 May 2017. The net project delay calculated from the original date of completion was 64.3 months, i.e. 270% of *schedule overrun (15)*. A quote from the EOT application included here shows that even with 270% schedule overrun, PIA was not in position to commit any firm date for the completion of the project.

“… *Due to various hindrances listed above [in the annexure of 7th EOT application] … our [PIA’s] planned progress was affected severely and the construction works were getting delayed and we are not in a position to ascertain the exact completion time even at this stage ...*”

Various hindrances listed in the annexure of the EOT application correspond to various risks identified here. An expressed inability of PIA to commit any firm completion date for the project provides evidence for persistent unmitigated risks in the project and lack of commitment from the stakeholders to manage them. This sums up the consequences of various risks on the project as 270% of *schedule overrun (15),* and it may further increase. Project progress along with the schedule overrun expressed in months has been shown on the left side in Figure 01 (\*of the journal paper).

**P5.6.** The original estimate of the project in February 2010 was INR 3600 million (DSR 2007). Scope variation statement submitted to IC in April 2016 showed that the revised estimate of the project was INR 4630 million (DSR 2007). Substantial increase in the scope of work had led to increase in the project estimate. With six years of delays, inflation and price escalation had also led to increase in the cost of the project. Further, partial increase in the estimate was also due to increase in the cost index for award of work from PC1 (134%) to PC3 (141%) after the termination of PC1’s contract. The estimate of project at market rate in the scope variation statement is INR 5000 million, and shows a *cost overrun* of over 8% with respect to the revised estimate. However, this *cost overrun* had not included implications of inefficient use and idling of resource, rework and wastage, increase in prices of cost components not included in the escalation clause, and site overheads for contractors and PIA. The actual *cost overrun (16)* for contractors would be higher after consideration of all these factors. Given the project is only 37% complete, the *cost overruns (16)* for PIA and its contractors are bound to be in excess of 8%. Through scenario analysis of delays in a real estate project, researchers (Iyer and Kumar, 2016) have shown that in case of inordinate project delays site overheads can be substantial leading to losses.

**P5.7.** Stakeholder correspondences was also analysed to explore quality of stakeholder relationship. Two pieces of contents from actual correspondences are quoted below that reflects the quality of stakeholder relationships.

*…The said analysis [of furniture variation] is submitted without any covering letter & also not signed and stamped by your [M&A’s] authorised representative. This clearly shows very casual & un-professional approach from your side, as sending any document without any covering letter & authentication does not solve any purpose ...* (IC to M&A, dated 09 December 2015).

*… The documents … do not have proper authentication by PIA … It appears that PIA is in the habit of sending the documents without application of mind and for sake of sending anyhow to fulfil the formality… it leads to sheer wastage of time and energy… the issue has been pending due to lackadaisical approach by PIA officials… PIA has failed to play a proactive role… you [PIA] are requested to explain the reasons … and send a certification as to why 1% penalty as per [the] Contract Agreement [between IC and PIA] should not be imposed on PIA…* (IC to PIA, dated 21 January 2016).

These examples raise three concerns. First, IC has shown intentions of claiming compensation for poor performances of PIA, reflecting potential of *risk of liquidity damages* for PIA*.* Any such claim from PIA would in turn be passed on the downstream contractors by PIA. Second, the accusatory language shows that stakeholders no longer had trust in the capabilities and commitment of the partners. Third, the observations raised by IC establish that PIA and M&A had not maintained basic professional conduct in the communication and documentation. Alongside this, in the 7th EOT application, delays in decision making by IC concerning finalization of project requirements, approval of scope variation, handing over project site and delays in processing of payment had been listed as main reasons for project delays. M&A and PIA had not used any accusatory tone in writing to their employer, an observation in line with the practice of trade. This scenario provides evidences for *risk due to poor stakeholder relationship (17)* and *poor communication.*

All the 23 of total risks identified in the Chennai project (P) are listed in Table 3 (\*of the journal paper). This table also provides additional information for comparative analysis of risks in the two projects and which is discussed in Section 5 and 6 (of Journal paper). Following sections explores impact of a risk on other risks to understand dynamics of risks in the Chennai project.

**1.4. Hierarchy of risks in Chennai Project**

Analysis of hindrances in the project for identification of risks also provided clues about how a particular risk had impacted other risks in the project. Evidences from the case analysis that represent direct impact relationship of a risk on other risks were mapped using Cross Impact Matrix (CIM). CIM is a method of capturing data where each element of the matrix represents ‘impact of a row element on the corresponding column element’. The elements corresponding to the recognised direct impacts relationships among risk in the Chennai project and summary evidences are listed in in Table I (of this report). These relationships are then mapped for all risks identified in the project to develop a hierarchy of risks and shown using influence line diagram in Figure 2 (\*of the journal paper). In this figure, an arrow between two risks represents flow of direct impact along the direction of the arrow. Intuitively, more risk relationships could possible but presentation in the figure and subsequent analysis is limited to the direct impacts recognised from the case. For brevity of the paper, further discussion of the figure is included while presenting comparative analysis of two cases.

**2. Coimbatore Project**

**2.1 Description of IC Coimbatore project (Q)**

Coimbatore is the second largest city in the State of Tamil Nadu after Chennai. The owner IC had proposed to develop a new medical institution for conducting medical courses for undergraduate, graduate and nursing, along with upgradation of the existing hospital facilities to international standards. The existing hospital had a campus area of 36 acres and was run by the state government. IC had planned to invest INR 5160 million (DSR 2007) for development of this project. Henceforth, this hospital project is referred as Coimbatore Project (Q). IC had engaged M&A to develop design and to prepare tender estimates for. Fee of M&A was 3% cost of construction. Further, IC had nominated PIA (Project Implementation Agency) as a ‘turnkey contractor’ for a fee of 5% of cost of construction. In the Coimbatore project the terms of agreements in contracts, roles and responsibilities of IC, M&A, and PIA were same as those in the Chennai Project described previously.

The Coimbatore project had consisted of three packages: a main package of INR 2710 million with stipulated project of duration 24 months, a retrofitting package of INR 76 with stipulated project duration of 12 months, and a supplementary package of INR 890 million with stipulated project duration of 5 months. Through a traditional competitive bidding, PIA had awarded all these packages to QC in September 2009, August 2010 and April 2012, respectively. In this project, the terms of agreement between PIA-QC were similar to those between PIA-PC1 in the Chennai project. PIA had also engaged a third party quality auditing agency for quality monitoring in the project. Important details of the three packages are included in the Table 2 (\*of the journal paper). The project documents did not provide separate progress records for each package. Within first two years the project had achieved about 50% of the progress which included majority of structural work. From 2012 onwards the rate of project execution had slowed. As on 31 December 2015, QC had applied 15th EOT application in the main package, 16th EOT application in the retrofitting package and 11th EOT in the supplementary package. By March 2016, 19 out of 23 buildings had been completed and handed over to IC and total progress was 92%. Overall delay in the Coimbatore project with respect to stipulated completion date was 64 months against the owner’s original project duration of 24 months. Some parts of the project were incomplete due to non-availability of the work front, non-finalization of finishing items, and pending approvals for scope variation. A six month contract of INR 2 million was awarded to a contractor organization named Abirami for operations and maintenance of the hospital premise. The hospital was formally inaugurated in February 2016 by the Prime Minister of India. A summary of important information related to the Coimbatore project is presented in Figure 03 (of the journal paper) and explained here.

**2.2 Risk Identification in Coimbatore project (Q)**

The methodology for risk identification in the Coimbatore project is same as in the Chennai project case analysis. Even from the ‘description’ of the Coimbatore project some risks such as ‘schedule overrun’ and ‘delay in handing over of the project site’ are evident. The upstream stakeholders for the project were the owner IC, designer and technical consultant M&A, and project implementing agency PIA. QC was the only prime contractor engaged by PIA for execution of all the three packages. Contractor Abiramani had very small package of INR 2 million for operation/maintenance of hospital and it had no role in the project development. Hence this agency has been left out in further analysis. In the following subsections risks rooted in each stakeholder are identified by considering role and responsibility of each stakeholder separately. A similar approach was used in the analysis of Chennai project case.

**Owner related risks**

**Q1.1.** The Coimbatore project was being developed in the campus of an existing hospital and additional land acquisition was not required. The hospital was in operation so parts of the buildings were occupied by nursing patients and medical departments. This situation had necessitated development of alternative facilities to accommodate the patients and the departments prior to handing over the work front to the contractor. Making such arrangement had resulted in unplanned handing over of work fronts to the contractor. Lack of sufficient work front in timely manner had affected the progress of the project. The construction activities also faced some constraints of working hours and controlled noise or dust generation, depicting *risks due to site constraints (6)*. However, due to slow progress, this risk had insignificant impact on the project. Some parts of the hospital proposed to undergo renovation had not been handed over to contractor till April 2016. This scenario highlights occurrence of risk due to *delays in handing over of project site (4)*.

**Q1.2.** The retrofitting package of INR 76 million is only 2% of the main package and its value has been neglected from further analysis. The main package had achieved progress of over 50% during September 2009 to December 2011. After start of the project, IC and M&A had made several changes in the original BOQ. Such changes had led to scope variation and required approvals by IC for execution. Abnormal time taken by IC and M&A in finalization of these changes along with approval of scope variation had caused execution delays. The latest approval for scope variation was accorded in June 2013 whereas all three packages of the project had continued beyond April 2016. At this time project had achieved 92% progress. As on 31st March 2016 works of value INR 680 million which were critical for hospital operation (such as sewage collection well, underground reservoir for municipal water supply, and 1800 square meter of vinyl flooring) had been pending for approval by IC. This scenario highlights occurrence of *risk due to scope variation (3)* and delay in decision making by the owner or *poor leadership (7)* from the owner.

**Q1.3.** Changes in the quantity and specification of work, related delays in approval of scope variation estimates, and finalization of rates for new items had caused delays in processing of contractor payment as well as withholding of partial payments. These payment related issues had created an outstanding of INR 770 million against IC which included INR 340 million unpaid escalation amount, INR 200 million unapproved scope variation, and INR 230 million on account of other reasons. This scenario manifests risk due to *delays in payment processing* by the owner. During data collection PIA executives clarified that to compensate the contractor against huge outstanding, PIA had invested its own fund of INR 800 million in the project and released payment to the contactor QC. However, this support was provided by PIA to QC, after QC had nearly completed the project. This shows *financial risk (13)* for PIA as well.

**Designer and technical consultant related risks**

**Q2.1.** IC had appointed M&A as designer and technical consultant for the Coimbatore project. Unavailability of drawings and non-finalization of specifications had been documented as major constraints affecting the progress. Site executives were dissatisfied with unplanned sequence of drawing supply by designers. For instance, drawings for false ceiling were provided when the drawings of electrical fittings and HVAC (heating, ventilation, and air-conditioning) systems were not released. Erection of false ceilings is done after installations of electrical and HVAC systems. Site hindrance register had listed some design related constraints as delay in finalization of non-medical furniture and drawings for their location; shop drawings for signage, artefacts, glass roofing, X-ray rooms, and outpatient department; finishing drawings for kitchen and examination hall. Delays of some drawings were also caused by delayed approvals from government and statuary authorities. Therefore non availability of appropriate drawings had caused interruptions to the work and resource idling. Moreover, M&A had not completed the supply of drawings till April 2016. This scenario highlights the impact on project due to delay in design finalization and unplanned supply of drawings. It is an evidence for occurrence of *design risks* *(2)* in the project which was not managed properly.

**Q2.2.** M&A had responsibility of technical consultant as well. It had to facilitate finalization of project scope and its approval by IC. The last scope variation in the Coimbatore project was approved by IC in November 2013 while the project had continued beyond April 2016 when the pending scope variation had accumulated to INR 200 million. Further, the basic estimates of the project were prepared based on DSR 2007 in the year 2009. After 2009 CWPD had published DSR 2012, DSR 2014 and DSR 2016. There were implications of revised DSR on scope variation estimates and the project costs. This situation asserts occurrence of *risk due to* *scope variation (3)* identified previously under the owner’s risks. Stakeholder correspondences revealed that M&A was not prudent in facilitating approval of scope variation. This observation was further substantiated by feedback from executives of PIA and QC. They commented that M&A had been engaged in both the Chennai project and the Coimbatore project but the designer lacked suitable expertise in hospital projects, professionalism and resources to develop design in timely manner. Similar feedback about M&A was also given by the executives in the Chennai project. This analysis brings out occurrence of *risk due to poor performance of the designer* and consultant, similar to *risk due to poor performance of the contractor*s (14). These risks from designers and owners can be referred as *breach of contractor by stakeholders (12).*

**Contractor related risks**

**Q3.1.** PIA had awarded all three packages constituting the Coimbatore project to QC gradually in September 2009, August 2010 and April 2012. Till December 2011, overall progress for the project, primarily in the main package, was over 50%. For all three packages project progress till April 2016 was 92%. Progress records for each package were not available during data collection but repeated EOT applications for each package indicate that all the three packages were delayed beyond April 2016. Apparently project delays were not due to lack of resource mobilization or poor performance from the contractor as project had stared within a month of awarding the work and had achieved 50% initial progress. The satisfactory performance of the contractor was substantiated by stakeholder correspondences accessed by the research team, as these documents had not raised issue to sight poor capability or performance of the contractor causing delays in the project. Some sporadic issues observed from correspondences were about quality and workmanship in the finishing work. In the interactions with the research team, PIA executives expressed their satisfaction with the performance of QC in terms of resource mobilization (labour, plant and machinery), deployment of engineers at site and quality. A representative of the third party quality monitoring agency had expressed his satisfaction with the quality of work done by QC. Most significant fact to establish satisfactory performance of the contractor was that PIA had awarded both the subsequent packages of the Coimbatore project to QC. A prudent client will shall not award future contracts to a contractor having unsatisfactory performance in current project. This analysis provides evidences for ‘non-occurrence’ of *risk due to poor performance of contractor (14)* in the Coimbatore project. Put simply, the risks that arise from contractors were effectively managed by QC.

**PIA related risks**

**Q4.1.** Similar to its role in the Chennai project, PIA was a project management consultant in the Coimbatore project. Thus risks related to PIA in the Coimbatore project were risks originating from other stakeholders which were not effectively managed by them. Hence risks related to PIA are reflected in analysis analyses of risks in the Coimbatore project along temporal line and interdependence among these risks. Prior to presenting further analysis, ‘description’ of some isolated hindrances which had occurred in this project is included here.

Approvals from the forest department and municipal bodies were required for cutting of trees at the construction site. This represents *Environmental risks (24).* This risk was managed effectively and its implication on the project was insignificant. The Coimbatore project and the Chennai Project were located in the same State of Tamil Nadu and have almost concurrent project timeline from 2010 to 2016. Therefore the *legislation risk (19)* related to increase in the royalty of aggregates, and *material management risks (8)* due to shortage of aggregates and disruption of logistics also occurred in the Coimbatore project. The hospital project had required approval from 11 government and statuary authorities including Medical Council of India, municipal bodies, fire department and hospital authorities. For instance, some materials had required inspection by both the fire department and the Medical Council. Due to lack of coordination among these agencies with the hospital authorities, there were delays in the approval of the materials which in turn delayed the project. Additionally, interruptions of the construction activities due to rescheduling of inspection by the Medical Council, as noted in the Chennai project, had occurred in the Coimbatore project as well. These incidences of project delays due to delays in approvals and inspection by authorities represent occurrences of *administrative and regulatory risks (21)* in the Coimbatore project.

**2.3 Evaluation of Risks in Coimbatore Project**

Risks in the Coimbatore project are identified considering roles and responsibilities of individual stakeholders from the ‘description’ of the case in the preceding section. In this section the project is analysed along the temporal line to explore risks which were rooted in more than one stakeholder or had appeared as intermediate risks. This analysis includes project data, information provided by the site executives and interpretations by the research team to provide ‘explanation’ for occurrence of risks as a chain of events. This approach is similar to one adopted in the temporal analysis of the Chennai project.

**Q5.1.** IC had nominated PIA as project implementation agency on 1 September 2009. IC had also engaged M&A as designer and technical consultant. PIA had awarded the main package to QC and execution had started in September 2009. Project had achieved overall progress of 50% during September 2009 to December 2011. Paragraph B3.1. has established that risks generally originating from a contractor had been managed effectively by QC. Apparently, risks rooted in the owner and the designer, viz. *delay in handing over of project site (4),* risk due to *unclear requirements (1), scope variation (3),* and *design risks (2)* had partly impacted the project from the start and continued to worsen. This inference is drawn on two sources of information. First, site handing over, supply of drawings, finalization of specifications and approval of scope variation was not completed till April 2016. Second, the EOT applications submitted by PIA to IC had assigned majority of project delays to hindrances corresponding to these risks (1,2,3 and 4). While the contractor engaged by PIA had performed well to mitigate contractor related risks, as a project management consultant PIA had not ensured fulfilment of commitments from IC and M&A. Altogether, lack of initiatives from the upstream stakeholders, namely PIA, IC and M&A, to mitigate risks rooted to themselves had manifested *risk arising from poor leadership (7)* and *Risk due to lack of support from top management* in the project.

**Q5.2.** Alongside, for all the three packages awarded in September 2009, August 2010 and April 2012, PIA had submitted 15th, 16th and 11th EOT applications in December 2015 seeking an extension up to 31 December 2016. Delays in each of the three packages calculated for respective stipulated completion dates were estimated as 265%, 500% and 1040%. Due to higher contract value of the main package a *schedule overrun* *(15)* of 265% in this package can be considered as representative impact on the project. The hospital was formally inaugurated for operations in February 2016 but it was only 92% complete till April 2016 hence further schedule overrun was imminent. For the contractor which had managed risks rooted to it effectively, a *schedule overrun* (15) of 265% had few additional implications. QC executives remarked that *schedule overruns* (15) of this magnitude was damaging the brand value of QC as the best contractor organization in the market. Brand image of PIA was also susceptible for similar damages. This scenario manifests *risk to the brand image/market risks* *(25)* for organizations. Contrary to the opinions of PIA executives who were satisfied with the performance of QC, the executives from QC expressed their dissatisfaction with the performance of PIA, M&A and IC, i.e. the upstream stakeholders. QC executives further added that their organization was considering no partnership with IC and PIA in future. This situation brings out a different perspective in *stakeholder relationship risk* *(17)* where a contractor is unwilling to continue relationship with the clients.

**Q5.3.** Above mentioned risks had also forced QC to incur extra cost due to idle and underutilised resources, site overheads, and repeated mobilization-demobilization of resources due to intermittent availability of work front. Concurrently, *scope variation* (3) and *delays in payment processing* (11) had impacted fund management of the contractor. As on 31 March 2016, an escalation payment of INR 303 million was pending against work done up to October 2014 and another INR 414 million was pending against running account bills. Due to prolonged delays of project, the impact of *price and inflation risk* *(20)* had also become substantial. About INR 290 million was pending due to non-approval of rates of items that were not in original BOQ. In total an outstanding of INR 1007 million in three packages worth INR 3676 million approximates to 27% of contract sums being held by IC. This had stressed the cash flow of QC and had triggered *financial risk.* Subsequently,increasing cost of financing had also added to the *cost overrun (16)* in the project. PIA executives revealed that to mitigate the implications of on hold payment on the project, PIA had invested its own fund of INR 800 million to pay QC. Due to this decision cash flow of PIA had been stressed and had brought *financial risks* for PIA. The risk of *cost overrun (16)* also occurred for PIA due to increased overheads expenses over prolonged project duration. *Cost overrun (16)* in the Coimbatore project was not quantified due to limitations of data collection. Yet, considering the similarities with the Chennai project and same amount of schedule overrun in both the projects, the *cost overrun (16)* for ICis likely to be close to 8% as calculated in the Chennai project. Additionally, as per the IC-PIA contract, PIA was empowered to claim compensation from IC for delays in the release of payment. However, PIA had not invoked this clauses giving rise to risk due to *poor contract management (10) by PIA.*

All the 19 risks identified in the Coimbatore project are listed in Table 3 (\*of the journal paper). This table includes a union of 25 risks identified from both the case projects and some additional information which are discussed while presenting Comparative analysis and Discussion (\*in the journal paper). Following section develops dynamics of risks by analysing cause-effect relationship among 19 risks.

**2.4 Dynamics/Hierarchy of risks in Coimbatore project**

List of direct impacts of a risk on other risks recognised from the analysis of Coimbatore project is presented in Table I (of this report). Methodology used to recognised direct impact relationships among risks and subsequent development of risk hierarchy was same as discussed for the Chennai project. Figure 4 (\*of the journal paper) presents this hierarchy for risks identified in the Coimbatore project. The ‘broken lines’ in Figure 4 (\*of the journal paper) are used to highlights risks whose occurrence in the Coimbatore project were different than their occurrence in the Chennai project.

Table I Evidences for direct impact of one risk over other risks as observed in projects

| **Ri-Rj****Coimb-atore (Q)** | **Ri-Rj****Chennai****(Q)** | **Evidences for direct impact of iit risk on 'jth' risk (due to similarity in project, many of these evidences are also similar unless noted otherwise.** |
| --- | --- | --- |
| 1,2 | 1,2 | All changes in the projects had to be incorporated through design updation and specification |
| 1,3 | 1,3 | Changes in requirement had led to changes in quantity and specification of works resulting in variation of scope defined in BOQ |
| 2,14 | 2,14 | Unavailability of drawings affected execution by contractor, hence limited its performance |
| 2,15 | 2,15 | Unavailability of drawings delayed execution of the project affecting schedule |
| 3,11 | 3,11 | Scope variation in BOQ items and delayed approval led to holding of payment in running bills |
| 3,14 | 3,14 | Change in scope and delays in approval of variations had affected proper planning and execution of work by contractors |
| 3,15 | 3,15 | Change in scope and delays in approval had halted the work leading to schedule delays |
| 3,16 | 3,16 | Changes in scope and addition of new items in BOQ have led to increased cost of execution  |
| 4,14 | 4,14 | Due to absence and unsystematic availability of work front contractors were not able to plan and utilize its resources efficiently, thus achieving poor performances |
| 4,15 | 4,15 | Delays in the handing over of the site led to led to delayed project start and schedule overrun |
| 5,2 | 5,2 | Finding a large well led to changes in foundation drawings  |
| 5,3 | 5,3 | Findings of large well had led to changes in the scope of excavation and concrete quantity |
| 6,15 | 6,15 | Site related constraints on work hours, movement of vehicles had led to restricted work hours and increased schedule |
| 7,10 | 7,10 | Lack of decisiveness from top management of PIA and IC had caused non implementation of contract clauses related to termination of contracts. Further seeking claim for compensation from client were not invoked by PIA. |
| No relation | 7,14 | Poor leadership reflected as lack of resource mobilization, etc. in PC1 and VSC had resulted in lack of effective planning, execution, site management and poor performance |
| 8,14 | 8,14 | Shortage of aggregate materials/bricks, and disruption of logistics had led to shortage of construction materials which had affected site execution by contractors |
| No relation | 9,14 | Termination of VSC without resource mobilization and poor performance of PC1 are evidence of selection of incapable partners during bidding process |
| 10,14 | 10,14 | PIA did not invoke appropriated clauses during corresponding situations and allowed poor performances by contractors. *Non fulfilment of contractual obligations by IC such as clarifying requirement and supply of design by M&A had affected site execution by contractor and hence its performances, leading to poor performances* |
| 10,17 | 10,17 | The stakeholders did not performed their contractual obligations resulting in lack of trust and accusations among stakeholders |
| 11,13 | 11,13 | Delay in payment processing had affected the cash flow of the contractors and created Financial risks for them |
| 12,10 | 12,10 | Non fulfilment of contractual obligation by stakeholders had constituted the breach of contract, and led to poor management of contract by stakeholders and PIA |
| 12,17 | 12,17 | Breach of contract led to termination of contractors creating poor relationships between PIA and contractors |
| No relation | 13,14 | Scarcity of finances with the contractor had affected resource mobilization and affected their performances |
| 13,16 | 13,16 | Shortage of fund had made the contractors invest their own funds thus resulting in costlier financing and losing on interest |
| 14,15 | 14,15 | Poor performance of the contractor had resulted in slow progress and schedule overrun. Performance of the contractor was limited but not due to lack of capability with the contractor but instead due to other risks originating from other stakeholders which resulted in schedule overrun |
| 14,16 | 14,16 | Poor performance of the contractor had led to inefficient use of resources, increased overheads during extended period, and higher inflation rates creating increased cost of the project. *Performance of the contractor was limited but due not to lack of capability with the contractor but instead due to other risks originating from other stakeholders, which resulted in cost overruns* |
| 15,16 | 15,16 | Delay in projects had caused incurring more fixed costs such as overheads, P&M rental etc. leading to increase in the cost of the project |
| NA | 18,14 | Chennai flood had destroyed under construction sites, materials, site offices, labour colony and forced labour demobilization leading to poor performances of the contractors |
| NA | 18,15 | Flood had brought the project to standstill for 60 days causing schedule overrun |
| NA | 18,16 | Flood had caused destruction of materials, damages to under construction structures, demobilization and mobilization of resources forcing all stakeholders to incur extra costs  |
| 19,16 | 19,16 | Changes in government laws for increase in royalty of aggregates had caused increase in prices of aggregates leading to cost overrun |
| 20,16 | 20,16 | Due to long delays the increase in the inflation was significant hence leading to increase in the prices of resources resulting in cost overruns |
| 21,15 | 21,15 | Repeated rescheduling and delays in inspections by regulatory authority (Medical Council of India) had caused work interruptions leading to schedule overrun  |
| 22,17 | 22,17 | Poor maintenance of sanitary facilities had caused filing of complaints by neighbourhood of the project and intervention by Chief minister's office. This had created a deteriorating relationship between project team and neighbours of the project |
| 24,15 | NA | Approval required for cutting of trees from forest department had led to small amount of delays in the project |

**Reference not include in the Research Paper**

Iyer, K. C. and Kumar, R., 2016. Impact of delay and escalation on cash flow and profitability in a real estate project. *In: Chong O*.,et al. eds. *International Conference on Sustainable Design, Engineering and Construction*, 18-20 May 2016, Tempe, AZ., USA, Procedia Engineering, 145(na), 388-395.

**List of Abbreviations**

BOQ: Bill of Quantities

CIM: Cross Impact Matrix

DSR 2007: Delhi Schedule of Rates published by the government of India in 2007

EOT: Extension of Time

GCC: General Conditions of Contract for all contractors in the case projects

IC: Insurance Company (owner of the case projects)

ILD: Influence Line Diagram

INR: Indian National Rupee

M&A: Architectural firm engaged as the designer and technical consultant

NIT: Notice Inviting Tender

P: Chennai project, Case project located in Chennai

PC1, PC2, PC3, PC4, PC5, PC6 and PC7: Contractor organisations engaged in Chennai project.

PIA: Project Implementing Agency, turnkey contractor

PPP: Public-Private-Partnership

Q: Coimbatore project, Case project located in Coimbatore

QC: Contractor organisation engaged in Coimbatore project

USD: US Dollar

* **End of the Case Study Reports** -