ANALYSING COMPLEXITIES AND UNCERTAINTIES IN INDIAN MEGAPROJECTS

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ABSTRACT

In India, the demand of infrastructure has been burgeoning rapidly owing to economic development and rapid pace of urbanization. Increasingly, the infrastructure planning and implementation strategy indicates the policy makers are leaning towards fulfilling this demand with megaprojects, having large scope and size, in terms of cost and resource requirements. The performance of these megaprojects has been dismissal with substantial time and cost overruns. The uncertainties and complexities associated with megaprojects is recognized as a major hurdle in effective implementation of megaprojects. There has been diversity of mechanisms adopted for managing complexities in Indian megaprojects. This paper analyses the case studies of Indian megaprojects to determine the types of mechanisms followed managing complexities as well as their effectiveness. Based on this analysis, the areas of improvement in existing mechanisms have been suggested, which would be help to the policy makers and ensure smoother implementation of megaprojects.

Keywords: *Complexity; India; Megaprojects; Uncertainty.*

1. INTRODUCTION

Infrastructure development continues to be one of the central themes of policy making in any country. Over the years, the aspirations of politicians, administrators and citizens alike have increased in terms of scope as well as scale of infrastructure projects. This has resulted in the emergence of projects involving large scale investments and resources. The global megaproject spending was pegged at US$ 6 to US$ 9 trillion annually, or 8% of the total global gross domestic product in 2014 (Flyvbjerg, 2014). There are different connotations for these types of projects such as large engineering projects, megaprojects and major projects. Leaving aside the differences in the terminologies, it may be said that the cost of a project is an important parameter that can categorise it as a megaproject or not. According to the US Department of Transportation, megaproject is a project with at least USD 1 billion budget while European (EU) and International Project Management Association stipulate a cost threshold of 100 million Euros (Flyvbjerg *et al.*, 2003).

The process of conversion of megaproject aspirations into reality is fraught with many challenges. Flyvbjerg (2014) has been researching and tracking the performance of megaprojects across the world; his analyses show that nine of ten megaprojects have cost overruns of up to 50 percent and consequential time overruns. Apart from the typical performance parameters - time and cost, megaprojects have piecemeal track record in the areas of sustainability, stakeholder participation, transparency, environmental compliance and accountability. The complexities and uncertainties associated with megaprojects is considered an important reason for the various challenges faced in the implementation of megaprojects. Therefore, the management of complexity and uncertainty is critical for realization of the benefits of megaprojects.

The Indian scenario on megaprojects is akin to international trends. The Ministry of Statics and Programme Implementation (MoSPI) of the Government of India uses the term "megaprojects" for those that cost US$ 156 million and above. In India the number of megaprojects has increased by 40 percent from 2012 to 2016. Forty five percent of the projects, on the average, are delayed. The time overrun ranges from 2 months to 24 months

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(Mevada & Devkar, 2017). Although, the cost implications owing to these time overruns are not monitored by MoSPI, they are substantial. In this context, this paper aims to analyse the mechanisms adopted for managing complexities and uncertainties in Indian megaprojects. The outcome of this analysis will be helpful to policy makers for improving the existing mechanisms.

This paper is structured into six sections. The following second section provides an overview of literature on complexity and uncertainty management in megaprojects. The case study research method adopted in this reported work is described in the third section. The background of Indian megaprojects and a case study analysis is presented in sections four and five respectively. The sixth section provides the summary and discusses the future scope of research.

2. MEGAPROJECTS AND COMPLEXITY: AN OVERVIEW

The management of complexities and uncertainties for effective megaproject implementation has been widely discussed in literature. Apart from papers specifically focusing on complexity from the viewpoint of megaprojects, there is a growing body of knowledge in the area of implementation of complex projects or complex project management. He *et al.* (2015) reviewed the key papers of both types and derived a six category complexity framework that included technological, organizational, goal, environmental, cultural and information complexities. Each complexity was conceptualized as a factor and the factors were measured with sub factors associated with each complexity. The number of factors associated with each complexity were as follows: technological (4), organizational (4), goal (4), environmental (7), cultural (4) and information (5). This framework not only maps the complexity categories but also maps measures / concepts for each complexity mentioned in different papers. Therefore, this complexity framework has been used as a reference in this study.

Giezen (2013) states that “complexity is often considered to be a problem, it is uncertainty built into that complexity that is the true source of worry”. The decision maker's conceptualization of this uncertainty plays an important role in design, adoption and monitoring of these approaches. Giezen (2013) conceptualized uncertainty into three categories: risk, structural uncertainty and unknown uncertainty. Sanderson (2012) adopted the "cognitive approach" for providing alternate explanations to nature of the future in megaprojects. This involves two categories of risks and uncertainties. Risk Category - 1 is mathematically derived probability while Risk Category - 2 is based on empirical data about a certain class of events in the past. Uncertainty Category - 1 is based on the decision makers’ beliefs or expectations grounded in subjective probability of various possible future events or outcomes; it is also called “known unknowns”. Uncertainty Category - 2 describes the situation in which the nature and range of future events or outcomes is unknown and unknowable and is called “unknown unknowns”.

The decision maker’s obvious step after identifying and understanding the complexities associated with a megaproject is the design of treatment and/or strategies for management of complexities or governance of megaprojects. Researchers have typically viewed megaprojects through the lens of “governance”, and show two streams of thoughts for governance mechanisms for managing complexities faced by megaprojects. There is significant similarities between the concepts proposed by Sanderson (2012) and Giezen (2013). Risk refers to Risk Category - 1 and Risk Category - 2 while structural and unknown uncertainty refers to Uncertainty Categories -1 and 2 respectively. Risk as mentioned by Giezen (2013) and Risk Category - 2 as mentioned by Sanderson (2012) can be dealt with by ex-ante risk analysis and management plan, and adopting various ex-ante measures. The first stream postulates that uncertainties owing to Structured Uncertainty as mentioned by Giezen (2013) and Uncertainty Category - 1 as mentioned by Sanderson (2012) can be managed by design and creation, at the front end of the project, of mechanisms to enhance ex post governability.

The second stream of thought on governance of megaproject has been increasingly gaining importance; it focuses on Unknown uncertainty as mentioned by Giezen (2013) and Uncertainty Category - 2 as mentioned by Sanderson (2012), which can be dealt with by appropriate design and creation at the front end of the project, with a shared culture to encourage collaborative and coordinated behaviour for handling emergent turbulence and uncertainty Giezen (2013) mentions that risk, structural uncertainty and unstructured uncertainty can be managed by adaptive capacity - to respond to change (in the context) and the deadlock (in the process), and the strategic capacity focusing on organization of planning and decision making process.

3. RESEARCH METHODOLOGY

This paper adopts the case study research approach. Yin (2003) mentions that this approach is appropriate when the research does not have control over the events, contemporary phenomenon is being investigated and the form of research question is how and why. Considering the objective of this research study, the research question is: How do complexities influence the implementation of megaprojects and what are the mechanisms adopted for complexity management?

We selected two megaprojects in India to address these questions. Both projects are in urban transportation sector, one being the urban rail project while the other is a sea bridge; the commonality of sector ensured controlling of sector specific variables in the analysis. The data pertaining to these case study projects was collated primarily from the secondary sources like detailed project report, contract agreement, newspaper clippings and websites. We approached the client organizations associated with the megaprojects, although, the officials were reluctant to share exact / factual details of projects citing confidential nature of information. In this scenario, we looked for opportunities of interaction with the key officials involved in these projects during presentation and discussions about these projects in public forum. It assisted in gathering relevant primary data pertaining to project shaping, mechanisms and challenges faced in project execution. However, we relied substantially on secondary data to corroborate the evidences from primary sources of data. We have taken extra care to "triangulate" any facts, figures and evidence from different sources. The next section provides the brief case histories of the two megaprojects, with particular emphasis on mechanisms adopted for management of complexities. Subsequently we have discussed the findings from these cases.

4. BACKGROUND OF CASE STUDIES

Ahmedabad metro project provides metro rail network within Ahmedabad, one of major cities in Gujarat state and India, and connectivity with Gandhinagar, the capital of Gujarat state. The detailed project report for Ahmedabad metro was prepared in the year 2004, however, the concept did not take off owing to challenges in mobilization of financial resources. The Government of Gujarat (GoG) established a dedicated organization - Metro-Link Express for Gandhinagar and Ahmedabad (MEGA) Company Ltd.in the year 2010 for implementing this project. A fresh DPR was prepared in the year 2014 and this was further revised in 2015 owing to change in alignment (DMRC, 2014, 2015). This project is divided into two phases. Phase 1 costs USD 1619.3 million and scope of work comprise of North South Elevated Corridor (18.522 kms) with 15 elevated stations, and East West Corridor with 14.737 km and 6 km of Elevated and underground section respectively and, and 4 underground and 13 elevated stations. The construction work for Phase 1 commenced on March 2012 and is expected to be completed by 2020. The percentage rate contract has been adopted for construction / civil work while rolling stock, fare collection system and other electrical mechanical work have been procured with design, supply, installation and commissioning contract. The funding for Phase 1 is mobilized from Japan International Cooperation Agency (JICA), Government of Gujarat (GoG) and Government of India (GoI). Phase 2 consists of elevated corridor of length 34.59 km and 24 elevated stations, and it provides connectivity to important locations like Gandhinagar, Ahmedabad airport and Gujarat Interntional Finance Tech (GIFT) city. This phase was approved by the GoG in October 2017 and the proposal has been sent to the Central Government for approval and possible funding.

Bandra Woli Sea Link project provides connectivity between Bandra - Western suburb and Worli - Central part of Mumbai - the financial capital of India as well as capital of Maharastra state. The scope of work involved construction of flyover, cloverleaf interchange, approach road improvement and cable stayed bridge. The Government of Maharashtra entrusted this project for execution to Maharashtra State Road Development Limited (MSRDC) - an organization established and fully owned by the Government of Maharashtra. The MSRDC was entrusted with rights for toll collection on sea Link Bridge under build, operate and transfer (BOT) model, for a duration of 40 years. The estimated cost and duration of project was USD 100 million and 3 years respectively. The construction began in the year 2000, however, the project experienced cost and time overruns owing to public litigations, poor progress by contractor, change in consultant and major technical design changes (Government of Maharashtra, 2007). The project was completed at USD 196.31 million and it became fully operational in 2010. The project management services were provided by Sverdup from the year 1999 to 2002, and new consultant - Dar Al-Handasah roped in from year 2003 to 2010. The construction of cable stayed bridge was a vital component of this project and it was executed by Hindustan Construction

Company (HCC) limited. The funding for this project was mobilized from Government of Maharashtra, Mumbai Metropolitan Regional Development Authority, and Market Borrowings.

5. ANALYSIS OF CASE STUDIES

Based on the data available on these projects, a brief write up of project and chronology of events was first prepared. Then, the evidence pertaining to different types of complexities was analysed with reference to complexity framework formulated by He et al. (2015) and governance mechanisms proposed by Sanderson (2012). The case study inquiry focused on two aspects: (1) how are complexities manifested in the megaprojects and (2) What are the strategies adopted for management of these complexities. The first aspect provided indication on views of decision makers, involved in megaprojects, about complexities, based on typology provided by Sanderson (2012) which is Risk Categories - 1 and 2, and Uncertainty Categories - 1 and 2. Further, the second aspect provided indication on strategies followed to deal with these risks and uncertainties. The explanation of these views and strategies is provided in the second section of this paper. The case study evidence, which includes nature of complexity as well as strategies adopted for each factor associated with a complexity are reported in Table 1. This analysis is discussed below.

5.1. TECHNOLOGY COMPLEXITY

The decision makers involved in Ahmedabad metro project sought technologies that had been adopted elsewhere in India and proven. The technological complexity was envisaged as "Risk Category – 2", involving ex ante analysis of different technological options adopted in India as well as worldwide, and finally decision on technology in line with project requirements. Therefore, the technological complexity was contained within the confines of "optimizing", as mentioned by Sanderson (2012), in the Ahmedabad Metro project. The decision makers involved in Bandra Worli Sea Link project, being India's first sea link, were in the unchartered territory of selecting technologies in line with the marine environment of Mumbai. The lack of experience on sea bridge construction in India led decision makers into the cognition of "known unknowns". The technical information was gathered with investigations in the areas of geotechnical, marine, environment and traffic. International experts having expertise in Sea Bridge construction used their prior experience and technical information to arrive at appropriate design and construction process. However, the scenario planning of possible unknown future events was not given due importance and thus, the governance arrangements were not geared to deal with the situation of "unknown unknown". The design changes and consequent changes in construction methods that occurred in the Bandra Worli sea link project resulted in setbacks in completing the project within the existing time deadlines and cost targets.

5.2. ORGANIZATION COMPLEXITY

The organizational complexity in the case study projects was dealt with by the creation of dedicated organizational set up with the aim to create a right mix in house and out sourced human resources to fulfil requirements of project. The power in these project implementation agencies was created not only with supporting institutional framework but also by staffing them with officials from prestigious Indian Administrative Services in key administrative positions and deploying domain experts for discharging technical / engineering roles. The push for "optimizing" the utilization of human resources resulted in the involvement of external experts and consultants, according to the phase of project. However, the capacities for effective utilization of these consultants as well as anchoring the suggestions and services provided by them in overarching project goals were not particularly analysed in the organizational design. The evidence from Bandra Worli Sea Link project shows that the changes in design and project management consulting firm at critical juncture of project as well as adverse implications of suggestions provided by the newly appointed firm were not given due attention. Therefore, project implementation organizations had to create governance mechanism for dealing with "unknown unknown" situations apart from traditional set up focusing on "ex ante analysis" and "known unknowns".

5.3. GOAL COMPLEXITY

The shifting of goal is a common feature of megaprojects and is observed in the case study projects as well. The alignment of Ahmedabad metro was changed providing rationale of increased ridership across new route and avoiding congestion of already congested urban zones as well as land acquisition and resettlements. Changes in the Bandra Worli sea link project occurred due to opposition from fisherman and aesthetic rationale provided by a newly appointed design consultant. Although it cannot be denied that these changes in goal created "value" for associated stakeholders, it is necessary to put in place governance mechanisms for steering through these "unknowns" in the megaprojects. The goal change in the Ahmedabad metro, in terms of alignment change, happened at an early phase of project. Therefore, it forced the project implementing agency to revisit the earlier analysis and detailed project report, and start afresh on meeting financial and technical challenges. The natural outcome of these changes were time overruns and upward spiraling of project costs as well as skepticism among Ahmedabad residents over inordinate delays. It has been observed that collaboration between key government, funding and technical agencies ensured the revision of the detailed project report, tying of required funding and speedy approvals. However, the changes happened at a very advanced stage of project shaping in Bandra Worli Sea link project and disrupted the construction process. Collaborative behavior and coordination were missing in dealing with "unknown unknown" situation faced in Bandra Worli Sea Link project, opening a Pandora's box of issues and problems. Project implementation agencies faced difficulties in keeping the project on course and this resulted in standoffs between contractor and design / project management consultant.

5.4. ENVIRONMENTAL COMPLEXITY

The scenarios in the Ahmedabad metro and Bandra Worli sea link project are different in terms of dealing with complexity. The societal and environmental implications of metro rail project was well thought in the governance mechanism of Ahmedabad metro. The environmental impact assessment report was prepared, although it is not mandatory for metro rail projects in the prevailing environmental regulations. The quires and concerns of the project that affected people were dealt with effectively in the design and construction phase. Therefore, the mechanism was geared, by doing ex ante analysis, to deal with the situation. Bandra Worli sea link project showed lack of this ex ante analysis even though the project was implemented in an environmentally sensitive marine environment. This gap had a spiraling effect on goal and technological complexities, for which governance mechanisms were not designed.

5.5. CULTURAL COMPLEXITY

The Ahmedabad metro project was able to garner unwavering support from politicians and funding agencies owing to silent and key championship provided by bureaucracy. The challenges like changes in route alignment and episodes of malpractices were handled evenhandedly by key administrators. This indicates that that the bureaucracy was, perhaps, well equipped to deal with "unknown unknown" in the project. The Bandra Worli sea link project, on the other hand, was not anchored well enough within the administrative as well as political machinery. This created a sense of helplessness at many junctures in the project execution process.

5.6. INFORMATION COMPLEXITY

It has been seen that the information complexity was not afforded due attention in the case study projects. In the Ahmedabad metro project, steps were undertaken to put in place systems focusing on information exchanges during the operation phase, however, there is a little evidence on how it was handled during the construction phase. A similar scenario is observed in Bandra Worli sea link project, wherein, lack of adequate information affected design, scheduling and contract administration.

Table 1. Complexity Mapping of Case Study Projects

Technology Complexity	
Ahmedabad Metro	Bandra Worli Sea Link
Diversity of technology in project	
• Light capacity metro system to cater PHPDT of 15000 to 25000 • On Grade of Automation (GoA 2) • 750 V DC third rail traction power system • Track system: ballast less on main line and ballasted on depot	• Construction of longest open sea cable stayed bridge • Precast construction • Heavy lifting for relocation of launching trusses • Deep foundation for pier and pylon
Dependence of technological processes	
• Ensured interface between major metro rail systems: track, rolling stock, signaling, telecommunication, traction power and train control • Future expansion of metro was considered, such as conversion of a 3 car train to a 6 car train, signaling system can support up to GoA 4	• Foundation design and construction depended on rock / soil strata • Changes in bridge design had implications on erection technologies • Design changes affected the time and cost performance of project
Interaction between the technology system and external environment	
• Proven technology used, all the technologies were already under operation phase across Indian and International metro rail projects	• Open sea affected the project schedule, supply chain and posed challenges in construction process • Ground stabilization for establishment of pre-casting yard near seashore
Risk of using highly difficult technology	
• Adoption of a stable, tested and reliable metro technologies	• Most of technologies, in the areas of open sea construction, piling, heavy lifting, cable stay, are used for first time either in India or at large scale in India environment
Organizational Complexity	
Number of organizational structures hierarchies	
• Creation of lean yet effective organizational structure with fewer hierarchies • Clarity in hierarchies on the basis of executive, functional and technical decision making powers	• Lean organization structure with executive wing, at higher level, with subsequent divulging powers and roles / responsibilities to functional departments
Number of organizational units and department	
• Created in-house departments based on functional areas and project lifecycle • Design, engineering and programme / project management were outsourced	• Creation of departments in consideration to functional domains like administration, engineering, toll monitoring, land, accounts & finance • Services like design, project management were sourced from market based on project location and requirements
Cross-organizational interdependence	
• Cooperation was required of various governmental arms / departments of urban local bodies, state government, central government • Reliance on general engineering consultant in the areas of design, engineering and project management	• Coordination with state government entities, urban local bodies for effective project implementation • Design and technological innovations in bridge construction resulted in overdependence on design and project management firm as well as contractor
Experience and social background of organization members	

• MEGA was headed by a senior bureaucrat from prestigious Indian Administrative Services (IAS), having extensive knowledge and influence over bureaucratic and elected arms of governments • Sectoral knowledge was tapped by the deputation of senior Indian Railway Services (IRS) officials and involvement of consultants having experience in Indian and International metro projects	• Higher level management comprised senior bureaucrats, representing key state government entities, having extensive knowledge of project implementation • Professional with relevant functional expertise were hired on tenure / contract basis or deputed from public works department and other state government offices
Goal complexity	
Uncertainty of goals	
• Change in metro route/alignment over project timeline were cited as being caused by economic and technical reasons	• Change in alignment and design of bridge were cited as being a result of opposition from fisherman and aesthetics considerations.
Uncertainty of project management methods and tools	
• Project management of different work packages was carried out by the appointment of general engineering consultant	• Change of guard in design and project management services were provided by consulting organization • There were revision of design and construction methods mid-way in the project implementation • Project shaping and implementation were embroiled by stand offs among participants like client, contractor and consultants
Availability of resources and skills	
• Funding was tied up with partners – Gujarat Government, Government of India and Japanese Bank of International Cooperation • Sourcing of required skills was performed using a combination of strategies like deputation of Indian railway officials, contractual appointment and engagement of consultants	• Finance was sourced from grant, loan from MMRDA, market borrowings (bonds & term loans) • Skills were sourced from across the work, as project being first of its kind in India
Diversity of tasks	
• Metro construction and operation involved multitude of tasks in the domain of civil, mechanical, electrical, information technology • Extensive interface with citizens was carried out during construction and operation phase	• Project involved different construction packages for flyover, cloverleaf interchange, approach road, road improvement and cable stayed bridge • Construction in the open sea and along shore line posed engineering challenges
Dependence of relationship among tasks	
• Sequencing and coordination between different work packages were conducted during the construction phase • Interface management among metro systems was put in place during the operating phase	• Coordination of work packages was carried out to put facility in use at right juncture • Task scheduling and execution was carried out in consideration of monsoon and restriction of marine traffic
Environmental complexity	
Multiple stakeholder	
• Project implementation in urban setting resulting in extensive stakeholder consultation with stakeholders with diverse background and interests • Involved multiple firms like contractors, subcontractors, and designers	• Challenges in addressing concerns of Fishermen community, nearby residents, civic groups and NGOs • Misalignment of views of three key stakeholders – client, consultants and contractor during design and construction phase
Environment of changing policy and regulation	

• Delay in project commencement occurred due to delayed decision over funding mechanism • Alignment changes happened during an advanced stage of project	• Forced to address environmental and societal concerns at advanced stage in the project
Environment of changing economy	
• Route / Alignment change was based on the rationale of reduced demand • Financial assistance from developmental organization was obtained at lower interest rate and longer repayment period	• Increased cost of project and delays caused worries and challenges in terms of mobilization of additional financial resources and forfeiting of toll revenues
Environment of changing nature	
• Environment was affected by metro construction and operation • Environment management was put in place to mitigate environmental hazards	• Construction schedule was at the mercy of monsoon season and sea weather • Alignment shifting by 150 meters towards sea exposed the land reclamation and construction activities to harsh marine environment
Environment of changing technology	
• Advanced technologies were adopted	• Bridge was designed to last 100 years
Cultural complexity	
Multiple participating countries	
• There was involvement of financiers, contractors, suppliers and consultants from across the globe	• Engineers and technicians from different countries like China, Egypt, Canada, Britain, Hong Kong were involved for sea link construction
Project team's trust	
• There was unwavering support by political champions and bureaucrats in project shaping and implementation process	• Questions were raised by contractor over change in design and project management consultant • Disagreements occurred between client / consultant and contractor
Sense of cooperation	
• Key stakeholders were represented in the decision making process • The project was reinforced with championship of political leaders	• Sense of helplessness among administrative machinery for resolution of disagreement and intervention of cabinet committee was sought
Cultural differences	
• Personnnel having experience of metro project in Asia / India were involved and a consortium with trusted Indian partners was created	• There were clashes in terms of practices followed between the contractor and project management consultant
Information complexity	
Information uncertainty	
• Detailed project reports were revised based on changed alignment • Establishment of electronic data management system	• Designer and contractors faced challenge in geotechnical, marine and construction engineering
Level of processing information	
• There was no evidence on extensive use of building information modeling (BIM) and other similar platforms • Delays occurred due to underground utilities and land acquisition	• Information asymmetry resulted in reaching common grounds over claims made by contractor as well as project management consultant
Capacity of transferring information	
• Design of metro system ensured seamless interface among metro systems • No evidence on extensive use of BIM and other similar platforms	• No evidence on extensive use of BIM and other similar platforms
Degree of obtaining information	

• Vendors, contractor and client used customized ERP/MIS systems, however, there is little evidence on interface among these systems	• No evidence on common platform for information sharing
Integration of more than one system or platform	
• No evidence on integration of different platform • Fragmented information repositories and processing	• No evidence on integration of different platform • Fragmented information repositories and processing

6. SUMMARY

The analysis of two case studies indicates that complexity is an inherent feature of megaprojects and it is necessary to provide due importance to all types of complexities, as mentioned in the framework developed by He et al. (2015), in planning, design, construction and operation of megaprojects. The factors resulting to complexity are the large-scale, long time span, multiplicity of technological disciplines, number of participants, multi nationality, political interests and interests of stakeholders. These factors were evident in the case study megaprojects. It was seen that the effective implementation of megaprojects depends on putting in place governance mechanisms to deal with these complexities. Overall, decision makers involved in case study megaprojects have viewed the future as "Risk" and responded with ex-ante risk analysis and management. It is important to comprehend dynamic nature or complexity, which transcends from "risk" to "uncertainty". The complexities were effectively dealt with in megaprojects wherein governance mechanisms focused not only on dealing with risks but also uncertainties that were known as well as unknown.

Presently, megaprojects are becoming a common feature of infrastructure development and policies in developing countries. As mentioned by Flyvbjerg (2014), time and cost overruns and extensive - prolonged stakeholder engagement has been hallmark of these megaprojects. Developing countries must put into place, governance mechanisms for managing complexities associated with megaprojects. These mechanisms should strike a right balance between both ex ante analysis, which is designed to deal with risks, and shared culture and collaboration among project participants for managing emergent unknowns. It is very important to anchor these mechanisms in the intuitional culture and practices surrounding megaproject. This research is the first step in the direction of understanding complexity and its management in Indian megaprojects. Future research work can focus on complexity modeling with improved governance mechanisms for megaprojects.

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