Driving PPP Projects through AI Standards: A Review

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Review Article

ABSTRACT

Infrastructure projects in general have faced project management challenges since long. PPP projects that involve greater complexities of risk allocation and management, therefore, have not translated into executable projects in many instances. While research confirms potential benefits from employment of artificial intelligence and other technology in speedy decision making at different stages of PPP projects, industry standards on data sharing, transparency and cyber security will first have to gain momentum with increased cooperation between national and international authorities. This finding has been reached based on the information available in the public domain on the progress being made towards development of the ecosystem for adoption of AI in different countries/regions. While many countries have formed national strategies for AI, there has not yet been adequate thrust towards instituting processes that will lead to nationally and internationally acceptable AI standards in many countries.

1. INTRODUCTION

Public Private Partnership (PPP) projects are now common in both developed and developing countries. India, too, has invested heavily in laying down the infrastructure for enabling the formation of PPPs, studying their feasibility and even financing them. A dedicated website set up

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by the government provides complete information on PPPs in India, their monetary value, the names of public and private partners, distribution of these projects across states in India, guidelines on formation of PPPs in India and even model concession agreements. Many states, too, have their own dedicated websites and other infrastructure to assist the formation of these partnerships. Nonetheless, it is a known fact that formation of these partnerships is a highly time-consuming activity. For the government, identification of the project and its objectives, identification of the public institution and finally the selection of the private partner consumes a lot of resources. Governments, inevitably, face a lot of competing priorities for social expenditures and it may be innumerable inter-departmental meetings before the final projects are selected. While the identification of the public institution may be relatively easy, the selection of the private partner could take many months. Invitation of bids through Request for Proposals (RFPs) and evaluating these bids on defined criteria could become more complicated in case of complex or high-valued projects. Cases of tenders or bids being cancelled in such projects are not unheard of. Such instances put tremendous pressures on the fiscal health of governments. Further, even if the bids do get selected, project completion times get extended with each party blaming the other as the cause of the same. This work studies the models

suggested by researchers over time in the available project management literature and current industry developments to arrive at conclusions on AI adoption that have the potential to greatly impact the success of PPP projects.

2. AI IN PROJECT MANAGEMENT OF PPP PROJECTS

Project management has become a serious business that is attracting the best talent. The latest talent to have entered this field is Machine Learning and Artificial Intelligence. Artificial Intelligence (AI) has powered ahead of Blockchain Technology in the myriad uses and applications across different sectors. In project appraisal, artificial intelligence is being employed for bid preparation & bid selection, identifying appropriate suppliers and monitoring their performance. All this can be highly beneficial in driving the formation and pace of PPPs that will prove so crucial for infrastructure build-up. Some countries, therefore, are setting up regulatory and legal frameworks for the employment of AI. At the World Economic Forum, in July 2019, there was acceptability on adoption of AI guidelines that focused primarily on ethical innovative practices. Specific guidelines on procurement and the principles governing them in the White Paper issued by WEF [1] were as follows:

Guideline	Principles
1. Use procurement processes that focus not on prescribing a specific solution but rather on outlining problems and opportunities and allow room for iteration.	a. Make use of innovative procurement processes to acquire AI systems. b. Focus on developing a clear problem statement, rather than on detailing specifications of a solution. c. Support an iterative approach to product development.
2. Define the public benefit of using AI while assessing risks.	a. Set out clearly in your RFP why you consider AI to be relevant to the problem and be open to alternative technical solutions. b. Explain in your RFP that public benefit is a main driver of your decision- making process when assessing proposals. c. Conduct an initial AI risk and impact assessment before starting the procurement process, ensure that your interim findings inform the RFP, and revisit the assessment at decision points.

3. Align your procurement with relevant existing governmental strategies and contribute to their further improvement.	a. Consult relevant governmental initiatives such as AI national strategies, innovation and/or industrial strategies, and guidance documents informing public policy about emerging technologies. b. Collaborate with other relevant government bodies and institutions to share insights and learn from each other.
4. Incorporate potentially relevant legislation and codes of practice in your RFP.	a. Conduct a review of relevant legislation, rights, administrative rules and other relevant norms that govern the types of data and kinds of applications in scope for the project and reference them in the RFP. b. Take into consideration the appropriate confidentiality, trade-secret protection, and data-privacy best practices that may be relevant to the deployment of the AI systems.
5. Articulate the technical and administrative feasibility of accessing relevant data.	a. Ensure that you have proper data governance mechanisms in place from the start of the procurement process. b. Assess whether relevant data will be available for the project. c. Define if and how you will share data with the vendor(s) for the procurement initiative and the subsequent project.
6. Highlight the technical and ethical limitations of intended uses of data to avoid issues such as historical data bias.	a. Consider the susceptibility of data that could be in scope and if usage of the data is fair. b. Highlight known limitations (e.g. quality) of the data in the RFP and require tenderers to describe their strategies on how to address these shortcomings. Have a plan for addressing relevant limitations that you may have missed.
7. Work with a diverse, multidisciplinary team.	a. Develop ideas and make decisions throughout the procurement process in a multidisciplinary team. b. Require the successful bidder(s) to assemble a team with the right skill set.
8. Focus throughout the procurement process on mechanisms of algorithmic accountability and of transparency norms.	a. Promote a culture of accountability across AI-powered solutions. b. Ensure that AI decision making is as transparent as possible. c. Explore mechanisms to enable interpretability of the algorithms internally and externally as a means of establishing accountability and contestability.
9. Implement a process for the continued engagement of the AI provider with the acquiring entity for knowledge transfer and long-term risk assessment.	a. Consider during the procurement process that acquiring a tool that includes AI is not a one-time decision; testing the application over its lifespan is crucial. b. Ask the AI provider to ensure that knowledge transfer and training are part of the engagement. c. Ask the AI provider for insights on how to

	manage the appropriate use of the application by non-specialists.
10. Create the conditions for a level and fair playing field among AI solution providers.	a. Reach out in various ways to a wide variety of AI solution providers. b. Engage vendors early and frequently throughout the process. c. Ensure interoperability of AI solutions and require open licensing terms to avoid vendor lock-in.

Fig. 1. Guidelines and Principles for AI Procurement
Source: World Economic Forum (2019)

2.1 Ai in Project Procurement

Many companies have developed procurement software that helps in different phases of procurement of infrastructure projects. The following graphic covers the different purposes for which AI is employed in procurement software:

CONTRACT MANAGEMENT:
Example: contract lifecycle management software that scans contract contents with *natural language processing.*

SUPPLIER RISK MANAGEMENT:
Example: *big data* powered supplier risk monitoring software that identifies risk positions in real-time based on publicly available information.

STRATEGIC SOURCING:
Example: *cognitive sourcing* software that guides or takes control of strategic sourcing processes.

PURCHASING:
Example: purchasing *virtual assistant* that allows employees to order office supplies without requests or approvals.

SUPPLIER IDENTIFICATION:
Example: *big data* powered supplier database identifying benchmarks and new supplier recommendations.

PAYMENTS:
Example: *machine learning* payment tracker that identifies errors or potential fraud in large amounts of automated payments.

SPEND ANALYSIS:
Example: *machine learning* classification of spend data into standard taxonomies.

CONTRACT MANAGEMENT
SUPPLIER RISK MANAGEMENT
STRATEGIC SOURCING
PURCHASING
NEW SUPPLIER IDENTIFICATION
PAYMENTS
SPEND ANALYSIS

AI IN PROCUREMENT SOFTWARE

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Fig. 2. AI in Procurement Software
Source: https://sievo.com/resources/ai-in-procurement

2.2 AI in Energy Industry

Each of these phases is highly crucial to the success of the original procurement plan drawn up for the project. As the use of software grows in the private sector, their use in PPP projects is also likely to grow over time. The important thing then would be to follow the guidelines and principles strictly in all public procurement. AI, of course, is creeping into all kinds of projects, including power projects that have come increasingly into the PPP fold. The energy industry produces massive amounts of data as energy is derived from diverse sources such as wind, solar, electricity, etc. making network management more complex which only the AI can handle. The figures below show the increasing use of AI in the energy industry:
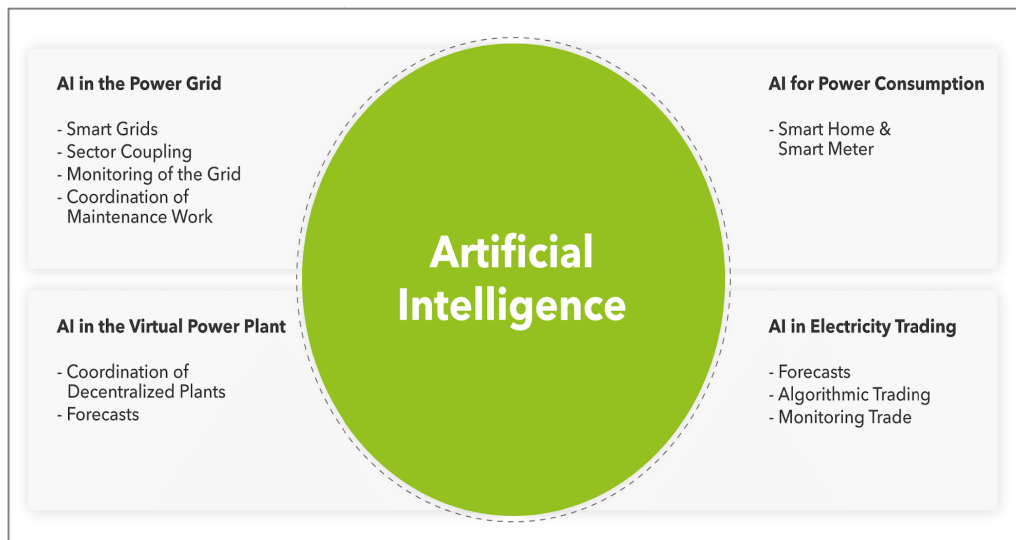
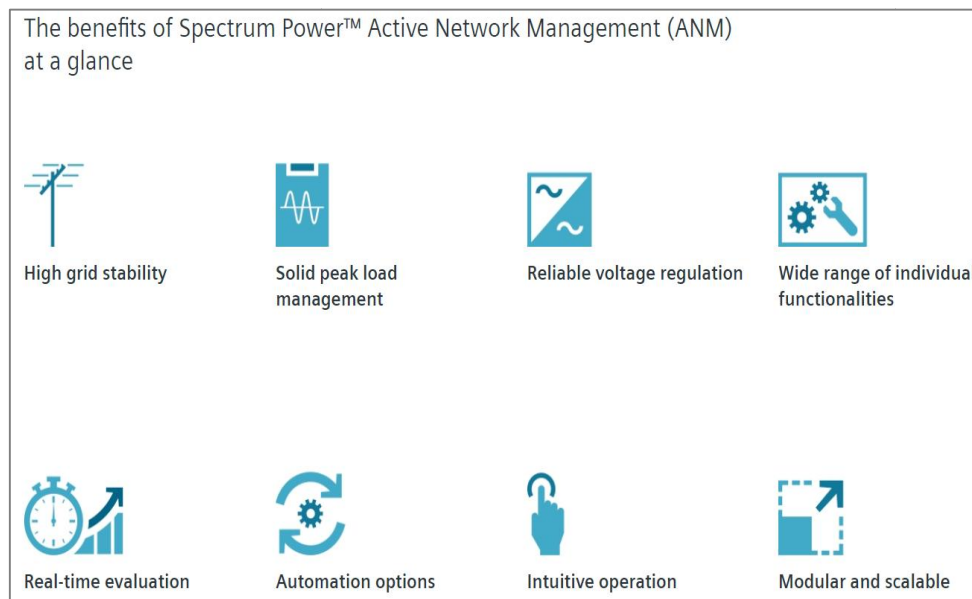**Fig. 3. Artificial intelligence in the energy industry**
Source: https://www.next-kraftwerke.com/knowledge/artificial-intelligence

Fig. 4. Active network management at siemens
Source: https://www.next-kraftwerke.com/knowledge/artificial-intelligence

The procurement of such AI functionalities could be a big challenge for the public sector in India as rules & regulations for procurement of innovative products are still evolving. Certainly, the 'least cost principle' is not applicable in the case of procurement of AI or any other innovative solution. That is why the Indian government has adopted the QCBS or the Quality and Cost Based Selection approach to evaluating bids, particularly from start-ups. The Government e-

Marketplace Startup Runway is a new initiative begun in February 2019 to permit startups to participate in government procurement based on innovativeness in design, process or functionality. These firms are exempted from otherwise stringent pre-conditions such as prior experience, prior turnover or earnest money deposits. Buyers can rate the products and services offered by these firms. Firms registered on this platform can also participate in challenges

and hackathons organized from time to time with defined funding opportunities. Canada, too, has a highly structured set of rules for procurement of innovative solutions to address challenges being faced by the federal government and related agencies. Innovative Solutions Canada (ISC) Program supports the development of early-stage pre-commercial innovations by small businesses that have less than 500 employees. The ISC program is a multi-stage program starting at the earliest level of technology. Eligible small businesses may receive up to $150,000 to develop and deliver a proof of concept within a maximum period of six months. Small businesses that successfully complete Phase I of proof of concept go into the next stage of prototype development for which they may get up to $1000,000 within a period of maximum two years. The next phase is that of creating a pathway to commercialization for those who successfully develop the prototype enabling them to get additional funding for research and development. The UK, too, uses public procurement as a method to drive innovation at Proof of Market, Proof of Concept and Prototype development stages. At the Proof of Market stage, the funding is generally for direct commercialization activities like market testing, market research & development or IPR/brand

acquisition/protection, etc. Innovate UK funds both competitive and non-competitive proposals through grants and loans. A short description of all proposals accepted for funding is available for public viewing on its website. This enhances transparency in the selection and funding of projects, though the criteria used for selection could vary from project to project. Evaluating innovative projects does have a fair amount of complexity requiring employment of multiple variables for assessment. Mitchell et al. [2] designed a multi-factor scoring model that may be adopted at different stages of the project. The parameters on which the project was scored included NPV, strategic alignment, value differentiation, competitive advantage, market attractiveness, fit to existing supply chain and technical uncertainty. Each parameter could have a separate scale with the midpoint of that scale acting as a benchmark that needs to be crossed. The overall project score could be the average score of the seven parameters, though as per the structure of the tool, it needs to be further decided if the scores will be added or multiplied. Further, the authors also recommend each project be rated under a worst-case assumption and a best-case assumption as represented in the visualization figure below.
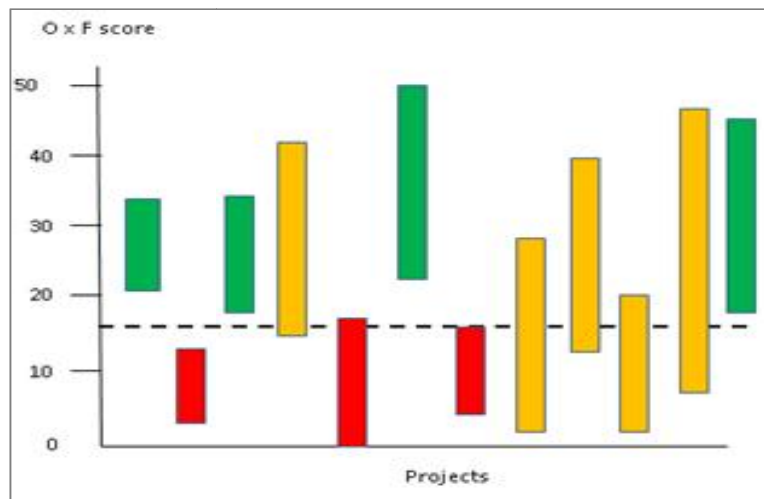

Fig. 5. Alternative opportunity-feasibility visualization
Source: Mitchell et al (2018)

The green projects in the figure above are ones that score well both on opportunities and feasibility parameters and hence will generally be picked easily. The orange projects would require additional information to assess possibilities of their moving into the positive trajectory.

A number of research studies in the literature survey below show that AI can be particularly helpful in procurement of innovative products and services, including for PPP projects wherein almost all processes vary from project to   project.

3. LITERATURE SURVEY ON AI IN PROCUREMENT

One of the earliest studies on the impact of AI in procurement tested the minimization of subjectivity in procurement of the State of Utah in the USA [3]. In this study, it was found that unlike other best value processes, the Public Information Procurement System (PIPS) minimizes the decision-making and subjective bias of the owner's representatives. This yielded in minimum construction management requirements and high customer satisfaction. That is why, in complex PPP projects, the use of technology can make a significant difference to project effectiveness. Hashmi et al. [4] studied PPP performance in Malaysia and found that the issues and challenges related mainly to human, technical and financial factors with the most dominant being the technical factors. The authors recommended that performance measurement assessment approach should be reviewed regularly and long-term relationships managed to return value for money. Alinaitwe et al. [5] found that there was only a moderate relationship between factors causing time delays to those causing cost overruns. Yaseen et al. [6] developed the hybrid Random Forest and Genetic Algorithm (RF-GA) to predict delays. While political instability led largely to time delays, inadequate project documents caused largely cost overruns in Uganda's public sector construction projects. Some researchers like Cerquides et al. [7] elaborated on how some AI software like Quotes may be used for a set of activities crucial for PPP project evaluation. This set of activities includes Request for Quotation/Proposal (RFQ/RFP) Elaboration; Provider Selection for RFQ/RFP delivery; Automatic/Manual Offer Generation for Indicative/Firm Quotes; Negotiation through offer/counter-offer interaction for same or additional items/services or reverse auction and Selection of best offers. Chopra et al. [8] in their study mention that the goal of procurement goes beyond least cost pricing to include aspects like optimization of total cost of procurement, internal process optimization, securing supplies, maintaining quality parameters, visibility in cost transparency, minimizing warehouse costs, reduction in the number of suppliers, product development with suppliers, outsourcing of operative procurement processes and if possible, outsourcing of strategic procurement processes. The role of IT in procurement would, therefore, depend on the objectives of procurement and the nature of business of the organization. Al-Jawhar

and Rezouki [9] had pointed to the need for selecting an appropriate procurement method. New procurement methods such as Design and Build, Design and Manage, Turnkey, Construction Management, Management Contracting in addition to Two-Stage Tendering and Negotiated Tendering must all be carefully studied and compared with the traditional method of procurement before selecting the most appropriate method. Lam and Chan [10] also talked about the increasing tendency towards appointment of a construction manager who enters into direct contracts with contractors for procurement purposes. It is said that the procurement method alone may have a 5% impact on the procurement costs [11]. The study by Quelin and Duhamel [12] had shown that organizations may have multiple objectives for outsourcing procurement. Examples of such objectives stated were reducing operational costs, focusing on core business, reducing investment of capital, improving cost measurability, access to outside expertise, transforming fixed costs into variable costs and regaining control over internal departments. Certainly, data and data management are the key to making good project management decisions. Lee and Kim [13] on AI-based big-data decision-support systems focused on the development of intelligent decision-making applications such as predicting design costs, analyzing design errors, change orders, bidding documents and plant equipment prediction maintenance with the help of Enterprise Resource Planning (ERP), Project Management Information System (PMIS) and commercial & public data from the engineering & construction companies. These AI-based decision support systems are particularly helpful in situations of data management failures by project companies. Beverly Rich [14] has elaborated on the way in which AI is transforming the world of contract management. Earlier, due diligence meant only a legal review of the contract documents. Today AI extracts key variables and clauses based on pattern recognition in contract documents in multiple languages and, thereby, helps in the management of complex, onerous contract documents, especially in PPP projects. AI also helps bring in consistency and standardization in the meaning of technical words and phrases across all divisions of a firm.

So, while AI contracting technology in a blockchain model may be of help in the drafting and review of contract documents by all parties,

the other main use may be in the evolution of contracting standards. Chou and Lin [15] compared classification models such as regression trees (CART), C5.0, decision list, support vector machines (SVMs), artificial neural networks (ANNs), discriminant analysis etc. to predict disputes in PPP projects. Experimental results in their study showed that an ensemble technique (SVMs+ANNs+C5.0) provided highest prediction accuracy. Some researchers have also referred to the AI-based approach to procurement as a case-based approach. Lewis et al. [16] developed a case-based reasoning software-engineered platform as an innovative procurement selection mechanism, which would be further validated and verified through a Delphi process. O'Leary [17] had elaborated on the crucial role of AI in Info Age retrieval strategies. The AI technologies mentioned in his paper included Natural language processing (concept-based internet search); Machine Learning (Web Watcher); heuristic rules for establishing preference (Letizia); rule-based/heuristic natural language processing (Contact Finder, FAQ Finder, Globenet; and neural networks (Autonomy).

Marzouk et al. [18] developed a framework consisting of fault tree, artificial neural networks and analytical network process to predict the internal rate of return (IRR) for PPP projects given probabilities of given risk elements. The public sector can have different considerations and early experiences while setting up any information technology system. Goldfinch [19] in his study, showed that the larger the information system development in the public sector, the more likely it was that it will be unsuccessful. According to Heeks and Bhatnagar [20], the most plausible factors for the lack of success have been data inadequacies, technical problems, skill shortage, political infighting, cultural clashes and external environmental factors. Governments, of course, in tune with the dynamism of the changing times, are changing fast – a fact that has been recognized in the 2019 study of OECD on use of emerging technologies in the public sector [21]. Desouza [22] also talked about the adoption of Cognitive Computing Systems (CCSs) in the public sector. The authors made the argument that the public sector has the capability to go beyond low-hanging fruits from the use of technology as it can draw on technical and managerial expertise from external partners to reduce risks in the project and has the

infrastructure to ensure transparency in decision-making. The key thing would be to ensure a strategic fit into the organization to draw high value. Governments are now supporting new technologies as conveners by adopting national strategies on AI and other technologies as financiers, direct users, co-developers and regulators. India has been at the forefront of accelerating the employment of AI and adopted its national strategy in 2018. The ambition is 'AI for All' that focuses on responsible AI, i.e., AI that ensures adequate privacy, security and IP related concerns and also balances ethical considerations with need for innovation.

AI in the Construction Industry has moved at a rapid pace with innovations being introduced in different processes. As per the 2017 report of the British Columbia Construction Association [23], innovations are being introduced in multiple ways: by production technology, modularity or open and changeable modular designs using a kit of interchangeable components, transfer of technology used in related industries like ship-building and aircraft construction, performance measured through concepts such as energy efficiency or internet of things (IoT), incremental adaptation and improvement, overlay or introduction of new processes or familiar products being made by unfamiliar companies or customer collaboration through user surveys and post occupancy evaluations. Different cloud-based software such as BIM (builder information management) 360, Procore, Buildertrend, Smart Service, Co Construct, AccuLynx etc have been developed by technology companies for use in different facets of project management. Apart from schedule management and monitoring the flow of work, such software is also being used to generate different permutations of the design of the building given inputs such as nature of the physical location, work style preference, productivity, daylight, views to outside, adjacency preference, etc. Similar options are generated for risk and safety management of workers and equipment. However, the use of this software is still largely restricted to the private sector. That is why its use is being seen more in subcontractor selection as opposed to contractor selection in PPP projects. The subcontractors are usually assigned a risk score taking into account their past performance, nature of current assignment and importance of the assignment, etc.

Otherwise, immense work is being done in the public sector for developing the guidelines for procurement of AI and setting up standards for the same. It has been seen from Fig. 1 that the focus of the guidelines is on generating alternative innovative solutions in consonance with national AI strategies, interoperability and open licensing of AI solutions to prevent vendor lock-in, transparency of procurement by multidisciplinary teams bringing out clearly the need for the AI solution and its risks. That is why there is a need for developing AI standards which, once instituted, will themselves spur innovation. China, USA, Europe are all developing AI standards under various models. In India also, there is a concerted effort towards formulation of AI standards through a collaborative venture of public sector, private sector and non-government organizations. Ethics, in India, would revolve around equitable distribution of AI benefits among all sections of society. This, along with issues relating to data security and data privacy needs to be taken into account in AI standards formulation. Specialized data platforms and open source AI labs with clear regulations on data ownership, safety and use, for example, on PPP projects will spur the use of AI for PPP project contracting. At present, not enough data is available, for example, on variables considered in the pre-planning phases of different PPP projects or those used in the preparation and evaluation of bids or even those used in the prediction and resolution of disputes. The following figure from [24] identifies the illustrative areas for effectiveness of standards in public procurement:
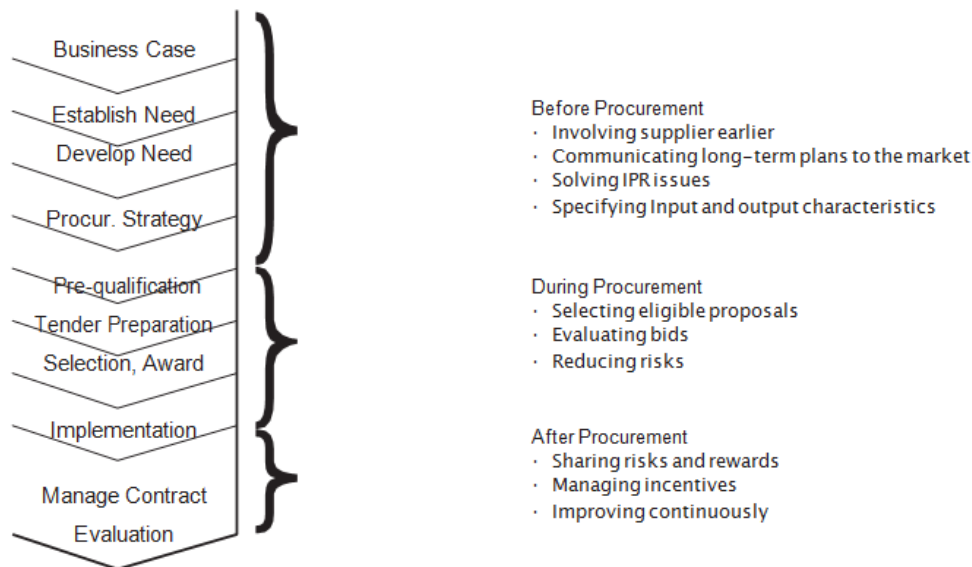
Fig. 6. Role of standards in public procurement
Source: Blind, K., 2009. Standardisation as a Catalyst for Innovation, pp 26

The WEF 2017 White Paper on Technology and Innovation for the Future of Manufacturing [25] has reported that AI-as-a-service platforms have lowered entry barriers and enabled companies to operate under zero marginal cost settings. Further, dematerialization of production systems has occurred due to wider use of robotics and 3D Printing. However, the report also notes that despite a lot of discussion around IoT, 85% of potential assets remain unconnected due largely to the absence of industry standards on transparency and cyber security of IoT. Cihon [26] of the Future of Humanity Institute emphasized on formulating international standards to enable global coordination in AI research & development. Internationally, IEEE (Institute of Electrical and Electronics Engineers) and ISO (International Organization for Standardization) are the foremost standard setting bodies aimed at improving market efficiency and developing AI that benefit all. It is recognized that standards must aid in furthering policy objectives and, thereby, act as global governance tools. Towards this objective, the author stresses on technical expertise, financial resources, timely information and building effective institutional knowledge within national bodies for meaningful participation in the proceedings of the international standards bodies. Individual organizations in different

countries may engage directly through development of software libraries, measurement benchmarks or best practices procedures. Some of these national bodies, through the power to nominate experts in the international standard-setting committees, also participate indirectly in the standard-setting process. Membership of international organizations also helps in obtaining timely information, building institutional knowledge and keeping technology and the processes that shape it apolitical. Object Management Group (OMG), a non-profit organization including IT architects, business analysts, government, vendors and end-users as members, also draws up standards that enable software interoperability for a wide range of industries. Business Process Model and Notation (BPMN) is one such standard for business process modelling that is being developed by the group [27]. This standard attempts to support both technical users and business users by providing graphical notation and execution semantics for processes in a Business Process Diagram (BPD) that is akin to a traditional flow chart. The Data Distribution Service (DDS) standard, also created by the group, introduces a Global Virtual Space to applications to share data by simply reading and writing data objects [28]. Similarly, Canada's CIO Strategy Council, a not-for-profit organization with over 100 experts and 40 member organizations, is currently developing management process standards to attain openness and transparency in AI. Apart from studying the suitability of AI or the automated decision system for the task at hand and the extent & timing of human training / intervention required, potential risks of deployment of automated decision system at each stage need to be identified and processes laid to address them. Besides, there need to be measurement systems to identify & address ethical and legal challenges, measure the impact of negative outcomes, monitor and track occurrences of unintended or unforeseen outcomes, determine triggers/thresholds to conduct a new or update an ethical impact assessment including negative impact on rights of individuals, particularly of disadvantaged groups like children, elderly, racial groups, women or LGBT. Similarly, technology or specifically AI bias will need a serious consideration in process standards as AI can magnify the bias and the impact of bias. Some researchers, therefore, now advocate a technology cost-benefit analysis on the lines of project cost-benefit analysis before being adopted in projects.

4. CONCLUSIONS

India is among the top nations in the world pursuing AI adoption aggressively in pursuance of its policy objectives. In that sense, it has already acquired the status of a governance tool for both Central and State governments. This paper has focused on AI's role in governance of PPP projects by assisting decision-making in each phase of the project including conception, selection, monitoring and risk management throughout the life of the project. The paper, however, argues that AI's role in PPP projects will become more effective once the infrastructure for framing and reviewing & updating AI technical and management process standards is in place. In India, too, this would require widespread collaboration between technical and non-technical actors both within and outside the country.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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