Artificial Intelligence (AI) to Inform Executive Decisions for Megaprojects

One third of the reason why mega-projects fail are due to "out of hand" uncertainty. The proposed framework for Artificial Intelligence (AI) as a monitoring system can help executives manage and reduce uncertainties impacting the project from external domains, such as economics, finance, or geopolitics. Accounting for different risk perspectives and incorporating accurate and reliable forecasts at early stages can help risk-management practices by information decisions based on foresight intelligence.

Large engineering projects or LEPs, also known as mega-projects, are "endeavors characterized by large investment commitment, vast complexity, especially in organizational terms, and long-lasting impact on the economy, the environment, and society" (Brooks and Lokatelli 2015). Generally, projects requiring over $1 billion in financing are considered mega-projects. The main objective of LEPs is to create long-term economic benefits for the societies and countries, in general. Nevertheless, as the number, complexity, and scope of LEPs increases worldwide, their vast stakes may endanger the survival of corporations and threaten the stability of countries that approach these projects unprepared (Millar et al. 2001).

The challenges facing LEPs stem from a number of sources; firstly, since typically several private and public entities are involved in LEPs, the failure of any these entities could lead to the failure of the project as a whole. For example, the failure of a big bank that finances LEPs or poor financial performance of counter-parties vested in the project can make the project exposed (Hassan et al. 2013). Secondly, poor economic conditions, such as, high sovereign debt or pessimistic growth outlook, can disrupt public-private partnership (PPP) projects, especially in the oil and gas and power-grid sectors (Rao et al. 2014, Platon et al. 2014, Xing and Guan 2017). Similarly, political events, such as, terror attacks, government instability, coups, policy uncertainty, and rigid business regulations, can destabilize LEPs in the construction sector (Deng et al. 2014, Larsen 2017). Corruption is more likely to endanger LEPs that are unique and complex in nature (Locatelli et al. 2017).

In addition to accommodating for uncertainties from different domains, an important risk component for LEP's is accommodating different stakeholders and their risk perspectives. The stakeholders could be a CEO of a company, Department Director, Manager at multi-national corporations (MNC's), executives at international banks, officials at government agencies, sub-contractors, or investment fund advisors. Of interest are the decisions facing executives such as whether to invest in a location (or country) or resource allocation decisions concerning protection of tangible (or intangible) assets from potential external threats. The different risk perspectives entail that the same shock to a mega-project will be viewed differently by different stakeholders. Decision-maker from lending institutions are concerned with impact on their banks' financial performance, the government stakeholders are concerned with geopolitical threats and impact on economic and development outcomes, and executives at companies in proximity to the LEP care about the economic impact on their business.

Decision-makers are interested to learn how to use monitoring technologies for risk management purposes, as executive-decision makers are confused about how to operate in an ever-more complex and uncertain global environment (Diehl 2017). Moreover, the availability of large-scale data is adding more noise and complexity that may trigger unintended societal events, indecisiveness for executives, and potential failure to adopt to long-term risks (Strauß 2015, Kenny 2015). The complexities in domain knowledge, computational limits, knowledge fusion, and interdependencies among domains pose a challenge to design a flexible risk management framework. As a result, recent technological advances in machine learning (ML) and artificial intelligence (AI) are rapidly transforming business operations and how executives take decisions. Although, many executives are concerned how to best adopt these technologies to aid decision-making.

Organizational culture, transparency, and trust are major concerns of the executives regarding these technologies; these new technologies also provide new opportunities to improve risk management and project-related executive decision-making. For example, it is anticipated that executives will have a broad view of new information that did not exist before and economic theory suggests that AI will substantially raise the value of human judgment (Agarwal et al. 2017). Judgment is the process of how we work out the benefits and costs of alternative decisions in different situations (Agarwal et al. 2017). It is expected that human judgment will increasingly specialize in weighing the costs and benefits of different decisions, and then that judgment will be combined with machine-generated predictions to make decisions. Hence, cheaper predictions will generate more demand for decision-making to exercise human judgment related to mass movements in finance, economies, political, or technological changes (Agarwal et al. 2017, Ransbotham et al. 2016). These mass movements denote large shifts in domain-specific trends, i.e., short or long-term directional change in market, population, or price movements. Consequently, CEOs and their boards, as examples, need to monitor these aspects very closely and promote use cases for practical applications and validation to enhance the decision-making process (Schrage 2017).

AI for Risk Management of Mega-Projects

In order to be able to understand the risks associated with LEPs, the sources of the threats and opportunities facing them need to be defined. The threats and opportunities associated with LEPs can be both internal, i.e., organization specific, or external, i.e., not directly related to the organization. Regarding the former, it is estimated that nine out of ten mega-projects go over budget (Flyvbjerg 2014); while an example of the latter is the metro systems in Salvador and Brazil which took a dozen more years to be functional (Kennedy et al. 2014, UN Habitat 2013). On the other hand, there are also growing opportunities for LEPs. The world needs to spend about $57 trillion on infrastructure alone by 2030 to enable the anticipated levels of GDP growth globally (McKinsey 2015); and two-thirds of this investment will be required in developing economies, where there are rising middle classes, population growth, urbanization, and increased economic growth (Garemo et al. 2015).

At the same time, LEPs face a number of uncertainties during their lifecycle; the four primary sources of these uncertainties are: the mission of the project, political and social conditions, economic and financial conditions, and technical conditions related to untested technologies (Bertolini and Salet 2007). For instance, opting to use uncertain technologies will effectively negate the benefits of the solutions for cost overruns in mega-projects such as reference class forecasting (Flyvbjerg 2013) simply because there are too many unknowns (Sommer and Loch 2004). For example, the Dead Sea mega-project was encumbered by ample uncertainties. In the early coverage of the project, uncertainties were dominated by economic feasibility of the project and raised primarily by politicians; while more contemporarily, they were dominated by ecological uncertainties voiced by environmental non-governmental organizations. The strategies most often used to address uncertainties is still ‘uncertainty reduction’ and to a lesser degree ‘project cancellation’ (Fischhendler et al. 2013).

All the above uncertainties amplify the magnitude of the impacts of LEPs which can be felt across governments, non-governmental agencies, private corporations, and citizens or consumers; or a combination of all of these entities. Even for a country as large as China, analysts had warned that the economic ramifications of an individual mega-project, such as the Three Gorges Dam “could likely hinder the economic viability of the country as a whole” (Salazar 2000); while the nuclear tragedy at Fukushima in Japan impacted the national economy negatively, the cost of decommissioning the plant would rise from the US $690 million per year in the first five years to several billion US dollars per year in preceding years costing the Japanese taxpayers in excess of $100 billion, socio-political disruptions, indirect cost of increased imports of fossil fuels that resulted in deteriorating trade balance (METI 2016, ASME 2016, Nanto et al. 2011, NEA 2017, Ferris and Solís 2013, Harding 2016, McCurry 2017). LEPs can also be economically transformative. Consider the Panama Canal which accounts for a significant share of the country’s GDP; and Dubai’s international airport which accounts for 21 percent of Dubai’s employment and 27 percent of its GDP. Hong Kong would grind to a halt without its clean and speedy subway system, named the MTR, which has enabled the densely packed city to build beyond the downtown districts (McKinsey 2016). Furthermore, LEPs can have direct social impact by influencing the pattern of city growth and the lifestyle of the population. For example, projects such as Atlantic Yards in Brooklyn, New York City or the larger Thames Gateway in London; and Amsterdam South (Zuidas) will have significant impact on the evolution of these cities.

Transparent and Constant Monitoring of Reliable Forecasts

Accurate and reliable forecasts can aid the executive decision-making process related to managing mega-projects by bringing awareness to uncertainties associated with potential external opportunities and threats. The forecasting capabilities and collective forecasts provide a basis for monitoring technologies that can be deployed for managers to monitor the state of key indicators and prognostics for the system of their interest. According to Georgoff and Murdick (1986), the holy grail for all professions, from financial trading activities to management science, is the constant monitoring of forecasting for the external environment has been identified as key to successful executive decision-making. Therefore, applying the resulted predictions, with transparency to their error provided together for multiple domains, will help make these problems of uncertainty-management more manageable. For example, in an energy mega-project that is being planned for across the nation, it will be significantly beneficial if the executives engaged, across multiple organizations, in the project had access to a common-pool of knowledge that provided them with forecasts for different time-horizons and for various pertinent domains. These forecasts could include financial performance of contractors, governance, economic growth, jobs related to the energy sector, trade, social and economic development related to the districts and the nation. Furthermore, the application of the prediction models will be of greater value to executive-decision making when integrating different domain-forecasts related to the country and geolocations of the given mega-project and assets related to the project. In this manner, cross-domain forecast feedbacks can be monitored for different time-frequencies simultaneously.

Multi-Sector Uncertainty and Decision-Making

There are few success cases for such monitoring technologies, a good example is applications in global climate policy. Organizations such as National Oceanic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), or National Aeronautics and Space Administration (NASA), as well as defense laboratories such as Sandia Labs or Applied Physics Lab (APL) are leading innovative new work to directly aid various catastrophic risk management techniques using monitoring technologies for climate policy-related decision-making. Moreover, monitoring technologies are also used in engineering systems; such as: off-shore wind-farms, large-power plants, industrial robotics, and for maintenance and prognostics of varied large-scale complex engineering systems. However, the application of such monitoring technologies for complex and dynamic decision-making concerning international business and policy strategy is at a nascent stage of study, especially in context of high-level executive decision-making (Schrage 2017, Aggarwal et al. 2017).

In the modern-day business environment, executives have to perform important and dynamic functions for mega-project management including fostering new partnerships and orchestrating large-teams and various stakeholders. They also need to be cognizant of potential tipping points, risks and opportunities, from the perspective of multiple stakeholder. Increasingly, executives have to operate in an even-more dynamic and uncertain global environment; hence, the best executives are made of certain traits and qualities, that include incorporating monitoring feedback systems to inform uncertainty-adjusted decision-making throughout the life-cycle of the project (Laufer 1997).

Foresight Intelligence in Project Management

Foresights include forecasts but are not dependent on forecasts alone. Foresight includes both cross-disciplinary forecasting, and the process of getting the forecast into the decision-making process. Lot of attention has been given to the former since the 1980's but little attention has been paid to the latter (Grant 1988). Hence, an important element to foresight is to anticipate the different risk perspectives of the multiple stakeholders engaged in the mega-project. For example, a country manager needs to be aware of broad macroeconomic trends like economic growth, inflation, or real-effective exchange rate prospects; an investment bankers or trader may be interested more in the stock performance of companies on new deal assignment, interest-rate parity, or cross-currency basis; governments' interest may be more on the potential political threats, uncertainty concerning geopolitical tensions, central bank policy moves, and strategies to diversify their sources of income by economic diversification; and, finally, local population i.e. the beneficiaries of the mega-project, may have concerns about the impact of these projects on jobs, social, and economic development in the city. Consequently, visualizing, anticipating, foreseeing and perceiving these different factors from different risk perspectives becomes crucial for successful managers.

In addition, foresights can aid important decisions-making throughout the lifecycle of the project. Foresights should be generated particularly at the inception of the project cycle, but also during and after the project. The impact of the executives' decisions on the project's cost performance declines dramatically as the project progresses and the maximum potential for influencing the project's cost occurs in the conceptual and definition phase (HBR 2016, Laufer 2012). Moreover, it is important to note that more than one third of the reasons why projects fail is out of the manager's hand (Laufer 1997). There are the external threats and opportunities that are unaccounted for; thus, this research can help in reducing this "out of hand" uncertainty.

Examples

A simple example of how foresights can aid decision-making on mega-projects can be the following case. Consider, that a reliable forecast for variables that could include household-income, growth in software-engineers and network scientists' occupations, living costs…etc. of different districts and cities in a given country, will aid the decision-maker during the planning stage as to where to set up the mega-project like a data-center. The executive could understand the cases by running simulations of the potential opportunities and threats in that city or country based on foresights of various measures of interest. Similarly, such foresight monitoring technologies should be used during the life-cycle of the project and assets related to the project, as new data is received to improve the short, medium, and long-run foresight capabilities.

One of the only data sources of mega-projects is the World Bank (WB) projects which contains over 17,000 large global projects executed between 1947 – 2017; ranging in size between $1 million with largest individual projects approaching $4 billion in over 173 countries. These projects range across sectors such as: agriculture, forestry fishing, education, energy and extractives, finance, information and communication technologies, transportation, infrastructure, and water and sanitation. Now using ML and AI models, we were able to predict with almost 99 percent accuracy which WB project will be closed i.e. success or dropped i.e. fail. Furthermore, we looked at specific case of the Luhri hydro dam project that was dropped in 2015 by the World Bank due to many concerns including ecological protests, disruptions of 72 villages that would be impacted by the project, the poor stock price performance of the main contractor for the project, and so on.

Conclusion

From a mathematical perspective, it is impossible to come up with probability of rare (or unseen) small event, especially in the fat tail domain (known as the problem of induction). In Arabic, predictions are called "prophecies", and indeed, forecasting is like prophesying which has many psychological aspects. Any economic number from oil prices to GDP growth forecasts from most forecasters have been incorrect; however, people still pay attention to it. The methods, results, and applications offered in this research could either end up adding or reducing redundancy to the system, where technology itself should be a domain of risk. There are heuristics and simple solutions that have implications for human judgement that require a system for orchestration of information and knowledge between man and machine, and vice-versa, "externalities" that this research has identified.

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