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Book

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Foreknowledge
and the management of megaprojects

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Introduction

This note is devoted to the issue of *megaprojects*. Following the definition of Flyvbjerg *et al.* (2003), megaprojects are complex infrastructure projects characterized by their unusual size - leading to exceptional costs, uncertainties and management difficulties. They are generally commissioned by the public sector, involving specific political stakes, and they are delivered through partnerships between public and private organizations. The socioeconomic evaluation of megaprojects (Lehtonen et al., 2017) is of higher interest because of the economic, political and social stakes. There is a specific pathology of megaprojects, very well summarized in Flyvbjerg (2009) title: "Why the worst infrastructure gets build", or expressions like "the survival of the unfittest". The explanation lies in the very complex, multi-actor and bureaucratic way of designing and implementing megaprojects.

The process of creating such large infrastructures is far from being *rational* in the sense of usual economic rationality. The H. Simon concept of *bounded rationality* does certainly apply here. What sort of *knowledge* is then to be considered in the design and preparation of megaprojects if we want to escape as far as possible the evoked dangers? A recent conference (ANDRA, 2016) has brought interesting intellectual matter on that point, using the notion of *Foreknowledge*.

Before presenting in a series of bullet-points the learnings from the conference, we want to underline the interest of the subject *megaproject* in relationship to *innovation studies*. Megaprojects are not necessarily *innovative* by nature – at least not basically linked to technological progress. The French EPR nuclear reactor is a typical example of technological megaproject. The Berlin Brandenburg Airport is supposed to be "futuristic", but cannot be a priori put in the *technoscientific* category. Both have in common the impossibility to respect the Iron Triangle rule: delivering in time, within the budget and according to specification. A very general common characteristic is the unusual size of the project. In such extreme circumstances (cost, time, multi-actor management, societal and political aspects…) usual project management models cannot apply. We are in a typical innovative situation because we do not properly control knowledge. The collective creativity process is progressively revealing information about the goal, the preferences, the means, the constraints, the various impacts and even the procedure.

Old issues; new tools and practices

- Foreknowledge is about *designing relevant knowledge for action* (strategic action of micro actors or policy planning and governance). It generally applies to the case of *complex systems*, often considered in their long run evolution.
- The domain of foreknowledge is akin to other conceptual approaches and practices: *anticipation, prediction, forecasting, system modelling* and *simulation, foresight* (in particular scenario building), *policy evaluation*, *technology assessment*, etc.
- Therefore the notion is linked to issues that have already been considered in the past, particularly the interactive relationship of the following cognitive activities:
  - *Strategic foresight* understood as distinct from futurology or science fiction: a method for (collectively) building relevant representations of the future before choosing among strategic options - for planning or monitoring the system.
  - *Policy evaluation*: knowledge, data (indicators) and models that can be used for evaluating policy in various conditions: *ex ante, in itinere*, *ex post.*
  - *Assessment of the system*: besides the knowledge of the possible futures of the system and the knowledge about its efficiency, reflections about social acceptability are needed.
- The procedural approach for interfacing the preceding commitments is linked to the idea of *distributed strategic intelligence* (cf. the European PRIME research project in 2002-2003: "Policies for Research and Innovation in the Move towards the European Research Area"), which leads to involve many various sources of knowledge and relies a more complex understanding of the concepts of "expertise" and "governance" than the usual policymaking procedure.
- What seems to be new in the present context is the explosion of data collection and the revolutions in data processing (e.g. machine learning methods). All the preceding issues are transformed by the numerical transformation of the society:
- More data for the description of the system
- More instruments for controlling the system
- Paradoxical increase in the difficulty to master all the information and cast a "meaning" on statistical patterns
- New (problematic) context for involving citizen's representation in the process.

Epistemological approach

- *Etymology*: Foreknowledge is mostly the privilege of God who knows in advance what will happen. God's knowledge is close to God's will.
- In the Western philosophical tradition, Foreknowledge is linked to *Free Will* in a problematic (and even theologically contradictory) way: if everything can be foreseen - from God's viewpoint or for the great expert running a megaproject -, then Man's freedom does not exist.

- Transposition in contemporary views:
  - Even in natural sciences, it is no more acceptable to postulate that all observable events can be brought under the law of universal causation. Exact scientific prediction is a myth.
  - Exact prediction is all the less possible in complex socio-economic systems. Pure scientific determinism certainly does not apply - particularly when entrepreneurship, innovation and global qualitative change are considered.
- *Foreknowledge* has nowadays two meanings: (1) prior knowledge; understanding of future situations; (2) prescience; vision of possible future
  - (1) Prior knowledge can be designed on the basis of past observed regularities and it is a help in decision making. The related concept of *foreknowledge* in this meaning is analytic and predictive.
  - (2) Visions are mental representations that can lead to action (particularly in the case of entrepreneurship). The related concept of *foreknowledge* is visionary and normative
- *Causality* issues involved in any foreknowledge exercise are complex ones because the concept has several meanings: For instance, Aristotle considered four types: Formal Cause, Material Cause, Initial (efficient) Cause, and Final Cause. Example: the laws of nature are the material cause of the house; the intension (willingness, desire, vision) of the future owner is the final cause.
- *Material cause*: it is of central importance in science and engineering; on that ground, model building is possible in order to provide predictions, simulations, a priori evaluation, etc. Foreknowledge tools based on such causal reasoning can be used when the *goals* as well as the *means* of the project are relatively well known. We are in a "problem-solving" sort of analysis. Previous knowledge is *exploited* in order to anticipate what will exist.
- *Final cause*: here, the project is driven by the entrepreneurial spirit; in terms of project management, the intellectual model is *effectuation* in the sense of S. Sarasvathy (theory of entrepreneurship). Intermediate goals and means are discovered on the way, because visions are not yet precise goals. Knowledge is gathered along the process (*exploration*) - several sorts of knowledge: about possible and desirable goals, and about the system and its reactions.

The nature of knowledge involved in megaprojects

- *Situated knowledge*: it is not knowledge for knowing (as in S&T or any academic activity), but knowledge for action in a specific situation. Interfacing several disciplines and several fields of know how is inevitable.
- *Designing an architecture of knowledge*: knowledge about *facts* (increasingly using big data techniques); knowledge about *laws* (correlation between variables, and if possible causal relationship - which is more difficult to get from big data); knowledge about *desires* and *acceptance* of the actors; and last but not least: *knowledge about knowledge*. The latter is a meta-competence of the project carrier in an operational way, but can also be considered in a more philosophical way - *wisdom*).
- *The limits of knowledge*: every megaproject involves aspects subjected to *computable risk* and others to *radical uncertainty*. In the latter case no objective law of probability applies. Econo-

mist/engineering methods of optimization must be replaced by other types of strategic decision tools. Knowledge exploration must be substituted to knowledge exploitation.

  - In the case *of aleatory uncertainty* (frequentist perspective) many models have been developed. One of the main problem in the implementation of the models is the lack of effort to document thoroughly the nature and size of uncertainty and to communicate on it. There is also a problem with the users: non experts (like policy makers) do not like answers to their problems in probabilistic terms. Hence the success of threshold setting: the complexity of decision under uncertainty is transformed into a 0/1 decision rule.
  - *Epistemic uncertainty* is of course more difficult to be managed by the experts (than aleatory variables like Gaussian distribution of errors), but there are possible framing approaches using Bayesian methods and extra-probabilistic analyses.
  - When knowledge is very weak and strongly qualitative, the expertise cannot be done beforehand. The project's process itself will create part of the necessary knowledge. It must then be designed in a flexible and participatory way.

- Uncertainties are not only negative: they can generate opportunities. In such cases, we are more in the *effectuation* paradigm than in the economist/engineer problem-solving situation. Exploring possible future goals is as important as doing the classical job of the economist/engineer who tries to find the optimal way to meet assigned goals. Exploring possible goals and looking for unexpected consequences is closer to radical innovation (creativity) than classical R&D.
- About risks:
  - Types of risks: technical, institutional (for instance regulatory), social, political, financial… Those are present in every project. In addition, there are more specific risks like archeological risk in the construction business, or combination effects in toxicology.
  - Risks in megaprojects are almost always underestimated. Typically, the overall cost previsions. This "optimistic bias" is a sort of *natural law* for megaprojects… We will discuss the point below, by considering the aspects of "rationality" in megaprojects.
- About positive uncertainties
  - Specifically in the long run, many new applications of a project can be found. This fact is at the same time important to have in mind and very difficult to deal with. In their cost-benefit analysis, the Romans could of course not include the fact that an aqueduct would become a touristic attraction (Le Pont du Gard) 2000 years after its construction…
  - Even in the context of contemporary socio-economic setting, no large public facility has just one function. Some of the functions will be revealed *in itinere.*
- Focusing on the *uncertainties* at the very beginning of the decision process
  - Assessment of uncertainties can start with the "known unknowns": a typical example in the case of waste depositories is human intrusion in the future. This is a big uncertainty, but the engineers in charge of the project are perfectly aware of this issue (and even scarred).
  - A quite more difficult issue is the "unknown knowns": for instance, the historic marking stones in the Fukushima region that should have been considered when assessing the risk of tsunami.

The rationales of megaprojects

- *The Iron Triangle of large projects* (delivering in time, within the budget and according to specification) is most of the time not respected – and sometimes by large. The paradoxical situation is when the project selection dynamics favors "the survival of the unfittest". The rational explanation of the strategic misrepresentation is often the rent-seeking behavior of planners and policymakers. The real objective is not public welfare in the long run, but:
  - Maximizing the chance of winning public funding
  - Short run considerations, including the fact that project officers will no longer be in office when the project will be reliably assessed
  - Shifting means and objectives: job creation, business opportunities for suppliers, image and reputation, etc.
- A possible (voluntary or unvoluntary) remediation consists of having a long process of project design. More actors and a variety of rationales can be progressively included. A sort of balance must be found between "opening up" and "getting things done".
- Shifting the "Iron Triangle" into a "Velvet Triangle": Open and flexible project culture; Fostering multiple rationalities; Managing uncertainties through vagueness and complexity.
- Sometimes, megaproject failures come from a weak starting point. It is therefore important to put more stress on the *Front-end analysis* of decision making.
  - Logically, the process should start with a broad and open view of what might be the preferences and the possible solutions, and then, progressively, the decision process would lead to the final precise choice
  - In reality, the opposite is quite common: a specific project is taken as the point of departure, without exploring alternatives.
  - Remediation is possible during the development phase of the project (possibly through confrontations and debates that were not anticipated by the project planners), but path dependency always carries the risk that initial design weaknesses will contaminate the whole process.

Last remarks on societal aspects explaining the complexity of decision

- Decisions are a mix of purely scientific controversies and political disputes (even if scientific consensus exists, it is not sufficient to trigger political action). We are very far from the problem-solving paradigm and the *ex ante* expertise process.
- Sometimes, prevision methods do not really produce knowledge about the facts, but behavioral norms (example of crime prevision and controlling).
- The rationale of decision making is more than a process of "satisficing" (Simon's theory of organizational choice): we should complement the notion of *bounded rationality* with the idea of *"multiple rationalities"*. Therefore, citizen participation is essential for improving the evaluation of socio-economic impact. At the end we don't get a "better optimized" situation, but a more robust situation.

- Qualification of uncertainties is essential at the beginning of the project (and during the development, because knowledge issues will change). Acknowledging complexity is also important: it gives room for negotiation – and a large part of the knowledge is revealed through the negotiation.
- Along the development of the megaproject it could be helpful to build and look carefully at two indicators, describing respectively the evolution of *knowledge* and the evolution of *trust*.

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