Assessing and Managing Investments into Infrastructure Mega-Projects in Developing Countries: A Novel Methodology

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1 Introduction

Over the last couple of decades, the world has witnessed a major turn of central governments towards conceiving and implementing very large-scale, coined as 'mega-,' infrastructure projects. Some illustrative examples, planned or realised, can be seen both in the developed and developing countries: Big Dig, Channel Tunnel, Oresund Bridge, Trans-European Networks, Nord and South Streams, Nabucco Pipeline, TRACECA, high-speed rail systems in China, the UK and the US. Be it transportation, telecommunications, pipelines or power grids, those infrastructures have been envisaged as national or transnational corridors and networks which typically involve irreversible investments in the order of billions of euro. Clearly, such extensive developments could substantially benefit a particular country in socio -economic terms; however, they also imply an ever increasing complexity of planning and managing, being normally implemented under a high degree of uncertainty, especially in emerging economies. Hence, their governments envisaging an infrastructure mega-project face the need for a comprehensive decision support framework that would help to capture positive opportunities whilst avoiding possible colossal damages to the weak economies.

2 Critical Analysis of Existing Methodologies

Large-scale infrastructure investments, considered by many scholars as a very important component of revitalising the crisis-hit economies [1], often fail to bring the expected returns [2]. One of the reasons behind this is that the government, required to optimally ration nation's scarce resources amongst competing opportunities, usually acts irrationally by strongly pushing mega-projects with overabundant optimism or vested interest [3], notwithstanding their disastrous performance history [4]. In emerging economies, the instance is accentuated by the volatile markets and largely unpredictable government's macroeconomic course. To guarantee public capital productivity maximisation, authorities and project managers are now practically obliged to use some form of a sophisticated investment decision support system. However, our research shows the abundance of flaws in and overall scarcity of dedicated decision making tools that would support infrastructure strategists and managers in developing countries.

In theory and practice, both in the developed and developing worlds, infrastructure investment project appraisal is predominantly facilitated by the Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA) [5]. However, these frameworks lack in capturing system dynamics, uncertainty, and managerial decision flexibility, being also awkward in evaluating cohesive infrastructure networks rather than isolated projects [6]. In addition to the above drawbacks, we have identified the following methodological gaps specific namely to a developing country case:

1. 'now or never' type of evaluation, without indicating specific conditions which would improve project feasibility;
2. overestimation of demand, hence the need for more rigorous attachment of nation's prosperity level and purchasing power;
3. developing country's much higher uncertainty, ambiguity and volatility along with tight budgets assume non-simultaneous, multi-stage development of network segments with a certain project sequencing procedure and degree of flexibility involved;
4. meeting demand for missing entirely new national infrastructures, rather than for existing isolated links improvement, implies widening the assessment scope to take account of systemic and scale effects;

5. increasing private sector involvement and greater necessity for government's accountability in the recession times forcefully urge to assess real capital productivity and project risk for any infrastructure initiative;

6. enormous amount of trustworthy data required whilst computational costs are often prohibitive.

3 Model Development

To tackle the afore-mentioned issues, we propose a new simulation-optimisation holistic approach to appraising, planning and managing the investment process in infrastructure mega-projects. To this end, we have developed a dynamic model of the transportation system, based on Monte Carlo simulations of crucial uncertain variables, expressed as modified Wiener continuous stochastic processes with jumps. We analytically formulate and incorporate an optimisation algorithm for the sequencing of interdependent infrastructure elements. In order to explicitly allow for decision flexibility at each project stage, the real options theory is utilised. On the demand side, the gravity and simple mode choice models are employed to elicit the expectations on infrastructure usage. We also attempt to capture transport network effects by broadening the spatial boundaries of the conventional project evaluation scope. In this regard, the model facilitates both a nation-wide network and transnational integration setting and offers a rational degree of network expansion in terms of both the return on investments and mitigation of risks. The overall project risk value is estimated and attached to all strategic choices within the decision making framework.

4 Model Application

We then successfully test the proposed methodology with the cases of high-speed rail development in Eastern Europe (Ukraine and Russia) within the established framework of Trans-European Transport Network [7]. Compared to the conventional, static and deterministic, infrastructure investment appraisal methods such as CBA and MCA, the reported stochastic dynamic model appears suitable not only for ex ante project evaluation, providing a strict feasibility verdict for now, but also for being employed amidst project implementation, emphasising conditions of when it is best to initiate, defer or discard a certain infrastructure construction stage.

5 Concluding Remarks

We have developed a novel integrated methodology for evaluating and managing infrastructure investments, also enabling decision makers to examine possible intra- and international infrastructure expansion strategies based on a trade-off between their financial performance and quantified risk. Such a holistic tool can be of particular value to decision and policy makers in emerging economies which have to deal with the strategic issues of national infrastructure implementation, expansion and integration. As an outcome of further experimenting with the presented model, a number of research motivating findings and policy implications can be elaborated as well.

References

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