'Future-proof' infrastructure design

The needs for new infrastructure, including transportation systems, utility networks, and social assets, have grown dramatically in recent decades due to a conflation of factors: population increase, migration flows, deterioration of existing assets, and the globalization of supply chains.

The OECD has suggested that there is a massive infrastructure gap requiring expenditure of $53 trillion up to 2030 to bridge the gap. To deal with this, nations have, as one option, recourse to privatization and private finance initiatives. However, a problem at the core of private development of infrastructure is how to design affordable infrastructures that can be adapted economically to external change.

'Future-proof' infrastructure does not become prematurely obsolete despite those changes during its operational lifetime. When capital was readily available, designers sought to 'future-proof' infrastructure by designing-in provisions for foreseeable needs. For example, a Lisbon suspension bridge was engineered in the 1960s with two options left open: first, to increase capacity from four to six lanes for car traffic; and second, to add two railway tracks.

Both options were exercised thirty years after the bridge opened to the public. But, when scarcity of capital and profit-seeking interests underpin design decision-making, developers need to balance provisions to future-proof infrastructure with affordability, i.e. the capital that the profit-seeker can spend at a rate that generates a specified rate of return on investment.

The application of strategic option-like thinking enables clients and designers to efficiently 'operationalize' design for future-proofing. In this context, an 'option' is the right but not the obligation to choose a course of action and obtain an associated payoff. A study of airport design practices by Nuni Gil reveals how designers apply option-like thinking intuitively as they search for modular architectures.

Modularization involves physically decoupling functional elements, agreeing the interface rules, and validating the interfaces. In the main building at Heathrow Airport's Terminal 5, the external roof and façade were decoupled from the floor plate superstructure for the sake of adaptability. Modular functional elements can also be readily available at the project onset, such as lifts, escalators, and baggage carrousels.

Yet some functional elements can exhibit integral architectures that are hard to modularize. In these cases, infrastructure designers can future-proof by incorporating safeguards, i.e. design provisions that leave open the capability to accommodate foreseeable change.

Passive safeguards consist of design instructions that do not require physical execution to leave the options open – a developer can simply acquire land adjacent to a new facility and design occupancy details in the master plan. Conversely, *active* safeguards are instructions that need to be physically executed to leave the options open. With Terminal 5, an underground train tunnel and two additional platforms – unneeded at present – actively provide a safeguard against the future need to add another line.

PFI contracts that allow agencies to request bidders to price strategic options in their proposals, called option fees, should soon become available. The use of the modularity and safeguarding approaches to formalize strategic option-like thinking in design will then become critical for firms seeking high performance.

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