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## Evolving Strategy: Risk Management and the Shaping of Large Engineering Projects

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## Introduction and Overview

Large engineering projects (LEPs) are high-stakes games characterized by substantial irreversible commitments, skewed reward structures when they are successful, and high probabilities of failure. Their dynamics also change over time. The journey from initial conception to ramp-up and revenue generation takes 10 years on average. While the "front end" of a project – project definition, concept selection, and planning – typically involves less than one third of the total elapsed time and expense, it has a disproportionate impact on outcomes, as most shaping actions occur during this phase. During the ramp-up period, the reality of market estimates and the true worth of the project are revealed. Sponsors may find that actual conditions are very different from expectations, but only a few adaptations are possible. Once built, most projects have little flexibility in use beyond the original intended purpose. Managing risks is thus a real issue.

The purpose of this chapter is to sketch out the various components of risk and outline ranges of strategies for coping with risks and turbulence based on an assessment of 60 projects as part of the IMEC study. Further more, we propose the elements of a governance system to master their evolutionary dynamics. The main finding is that successful projects are not selected but shaped. Rather than choosing a specific project concept from a number of alternatives at the outset based on projections of the full sets of benefits, costs and risks over the project's lifetime, successful sponsors start with project ideas that have the potential to become viable. These sponsors then embark on shaping efforts to influence risk drivers

[1] This chapter is based primarily on Miller and Lessard (2001) and the underlying IMEC study. However, it also reflects the insights that the two authors have gained from their separate journeys over the last six years. Miller has gone on to define and lead the MINE study, a large-scale project focusing on innovation games based at HEC. Lessard has continued his work on large-scale projects in the oil-and-gas sector as faculty director of the BP Projects Academy and the Major Projects Research Program at MIT.

ranging from project-related issues to broader governance. The seeds of success or failure of individual projects are thus planted early and nurtured over the course of the shaping period as choices are made. Successful sponsors, however, do not escalate commitments, and they abandon quickly when they recognize that projects have little possibility of becoming viable.

Two other key concepts related to risk that emerge from the study are governability – the creation of relationships that allow a project to be reconstituted and proceed even after major changes in project drivers and the resulting payoffs to the various parties involved – and turbulence – the tendency for risks to compound dramatically once things begin going off track.

In our view, projects are dynamic, iterative, and often chaotic systems, and project-management architectures must reflect this. While they tend to resemble a spiral more than the classic waterfall, even this metaphor may be too orderly. Projects are better viewed as evolutionary and path-dependent systems composed of episodes displaying different dynamics.

These findings apply equally, albeit in somewhat different ways, to the three distinct classes of risk (in terms of their causes) encountered in most projects: those emanating from the dynamics of the project itself (technical and operational risks), those associated with the markets with which the project interacts (market risks), and those related to the political, social, and economic setting of the project (institutional/social risks).

In this chapter, we first discuss the IMEC project and the sample of projects that underlie it. We then describe the nature of risks encountered in projects and assess the various strategies that successful projects employ to cope with these risks. Using these descriptions, we highlight the extent to which project management in the face of risk is a sequence of shaping episodes, and then we draw conclusions.

## The IMEC Study and Large Engineering Projects

The IMEC (International Program in the Management of Engineering and Construction) study grew out of the noted difficulties in project delivery that became public (Miller and Lessard 2001). As long as

governments and businesses were content to rely on traditional financing, governance, and methods, there was no need for innovative approaches. However, as public financing became tight and many projects become more financially, politically, and socially complex, methods that had served their purpose in the past were no longer sufficient.

IMEC was thus set up to understand the changes that were occurring. To our knowledge, there had been no recent attempts to study, evaluate, and present a systematic analysis of the new approaches to large projects except the initiatives of the U.K. Treasury Board (HM Treasury 2006) , B. Flyvbjerg and his colleagues on mega projects and risks. (Flyvbjerg et al 2005) and the book by Thomas Hughes, *Rescuing Prometheus* (Hughes 1998). To counter the objection that each project is unique and that generalizations are therefore impossible, we decided to undertake grounded research to understand what leads to success or failure, using a sample of 60 LEPs. The goal was to identify the practices that, in the experience of executives involved in projects, really made a difference. The IMEC study was distinctive in several ways. First, it was an international field study. The study sums up the collective experience from Europe, North and South America, and Asia. In general, seven to eight participants – sponsors, bankers, contractors, regulators, lawyers, analysts, and others – were interviewed for each of the 60 projects. Second, it involved systemic and strategic perspectives. Particular emphasis was placed on front-end development decisions, but execution and initial ramp-up to operation were also studied. Calling upon a range of disciplines, the IMEC study focused on themes such as coping with uncertainty through risk analysis, institution shaping, and strategies. Finally, projects were selected from a range of domains. The 60 projects included 15 hydroelectric dams, 17 thermal and nuclear power plants, 6 urban transport facilities, 10 civil infrastructure investments, 4 oil platforms, and 8 technology initiatives.

Projects differ substantially in terms of the intensity of the social/institutional, technical, and market-related risks that they pose to sponsors (see figure 1 for the IMEC sample). For instance, oil platforms are technically difficult, but they typically face few institutional risks because they are built far from public attention and bring high direct benefits to their sponsors and affected parties. Hydroelectric-power projects tend to be moderately difficult insofar as engineering is concerned, but very difficult in

terms of social acceptability. Nuclear-power projects pose high technical risks but still higher social and institutional risks. Road and tunnel systems present very high levels of risk, as rock formations usually hide big surprises and markets are difficult to predict when user fees are applied. Market risks faced by roads, bridges, and tunnels are especially high when private sponsors build them under concessionary schemes. Urban transport projects that meet real needs pose average market and social/institutional risks. However, they pose technical risks, as they often involve underground geological work that affects costs. Research-and-development projects present scientific challenges but face fewer social acceptability and market difficulties, as they can be broken into smaller testable investments.

[FIGURE 1 ABOUT HERE]

## The Nature of Risks in Projects

Risk is the possibility that events, their resulting impacts, and their dynamic interactions will turn out differently than anticipated. Risk is typically viewed as something that can be described in statistical terms, while uncertainty is viewed as something that applies to situations in which potential outcomes and causal forces are not fully understood. In this chapter, both risks and uncertainties will be referred as risks. Risks are multi-dimensional and thus need to be unbundled for a clear understanding of causes, outcomes, and drivers.

In the IMEC study, managers were asked to identify and rank the risks they faced in the early front-end period of each project (Miller and Lessard, 2001). Market-related risks dominated in terms of mentions (41.7%), followed by technical risks (37.8%), and institutional and sovereign risks (20.5%). Figure 2 illustrates the frequency of mentions of the risks that managers identified as important in their projects.

[FIGURE 2 ABOUT HERE]

**Market-related Risks**

The ability to forecast demand varies widely, thus creating high levels of risk. The output of oil projects is a fungible commodity sold in highly integrated world markets: probabilistic forecasts are possible. In contrast, many road projects face a specific set of customers; however, users of highways, tunnels, bridges, airports, and ports often have alternatives, and forecasting behaviour is extremely difficult. Failures to reach traffic volume seriously threaten business models.

The market for financial inputs depends on prior risk management.[2] Unless all risks have been addressed by sponsors, financial markets are hard to convince. Many projects that offer an adequate prospective return are unable to go forward because of the parties' inability to work out acceptable risk-sharing arrangements. Supply risks are similar to market risks: both involve price and access uncertainties. Supply may be secured through contracts, open purchases, or ownership.

**Completion Risks**

Projects face technical risks that reflect their engineering difficulties and degrees of innovation: some of these risks are inherent in the designs employed. Construction risks refer to the difficulties that sponsors, prime contractors, and contractors may face in the actual building of the project. Execution risks refer to issues that arise from errors or conflicts in the task breakdown, schedule, and so on.[3] Operational risks refer to the possibility that the project will not function as expected – for example, that the availability, capacity, or operating efficiency will turn out to lower than anticipated.

[2] The term "financial risk" is often used overly broadly to refer to risks with financial consequences – essentially everything. For us, the term applies only to events that have some underlying financial cause.

[3] Schedule risk also is often used to identify a risk that has an impact on schedule. Here, we refer to schedule risks only when they are a cause and not just a consequence. Of course, in episodes of turbulence (see below) a schedule impact may become a cause of further unraveling, and hence the distinction becomes less clear.

**Institutional Risks**

The ability of projects to access key resources or to appropriate the returns from operations in order to repay debts and recoup and profit from investments depends on the laws, regulations, and norms that govern the appropriability of returns, property rights, and contracts. Some countries are governed under constitutional frameworks and the rule of law, while others are led by powerful political parties or clans. Institutional risks refer to unexpected changes in these rules and norms that somehow alter the project payoffs. They are typically seen as greatest in emerging economies – countries whose laws and regulations are incomplete and in a state of flux – although the risks associated with community opposition to projects (the NIMBY phenomenon) or changes in environmental regulations may be as great or greater in highly developed countries.

Regulations concerning pricing, entry, unbundling, and other elements are presently undergoing major changes in many countries, thus opening opportunities. Social-acceptability risks refer to the likelihood that sponsors will meet opposition from local groups, economic-development agencies, and influential pressure groups. Sovereign risks, in turn, involve the likelihood that a government will decide to renegotiate contracts, concessions, or property rights.

Many of these risks emerge only over time. Emerging opportunities or risks may call for changes in project configurations. Benefits may outweigh costs but the reverse can also be true. Projects that appeared sound at one point in time all of a sudden become ungovernable. Events burst out and interact to create turbulence. Figure 3 illustrates the evolution of risks that emerge and challenge sponsors. Many risks are linked to the life cycle of the project: regulatory risks, for instance, diminish very soon after permits are obtained, while technical risks drop as engineering experiments are performed.

[FIGURE 3 ABOUT HERE]

**Turbulence**

While strictly speaking not an additional category of risk, one aspect of risk that we observed in many projects was turbulence. Turbulence refers to the way that consequences of events are compounded in unforeseen ways, even if the initial event lies within a range of possibilities that was known in advance, but often more seriously in the case of events that are truly "surprises." In the face of such difficulties, some parties have a tendency to leave projects or minimize their losses, perhaps at the expense of other participants. Moves and countermoves lead to a vortex that causes project demise. Without a set of institutional and governance devices to contain degradation, otherwise viable projects sink into deadlocks. In the case of a major civil transportation project, the discovery of geological conditions that were different from those planned for but well within the range of possibilities and did not represent that large a change in overall project economics, for example, allowed opponents to raise multiple issues that ultimately caused the collapse of the entire project.

**Opportunity Failures and Oversights**

Opportunity failures refer to the risk of missing a good opportunity to improve value or to reduce costs due to error, inadvertence, or even design. While an opportunity failure may be seen as a risk event resulting from a completion or social/institutional cause, the accumulation of such oversights in a project may itself become a cause of a governance crisis. Failures to capture opportunities do not threaten a project's continuity when the public or private sponsors remain unaware of what could have been achieved. When, however, there is a consensus that too many opportunities have been lost, the sponsor or other key players may lose legitimacy in the eyes of others, and the fabric of agreements required to sustain the project breaks down.

Oversight risks are particularly salient when projects are constructed using the traditional mode of contracting, in which the sponsors define expectations in detail and call for bids for execution: since these

arrangements typically have no mechanisms for responding to opportunities and changes in circumstances, they thus generate oversights. In contrast, new modes of governance that rely on partnerships or relational contracts may allow the incorporation of changes and trigger innovative solutions that reduce the likelihood of such oversights.

## Approaches to Managing Risk in Large Engineering Projects

Theoretical perspectives on structuring and coping with risks range from narrow, technical analysis to systemic political and institutional approaches. In the course of the IMEC study, we have observed that sponsors strategize to influence outcomes by using six main risk-management techniques: decisioneering to assess and mitigate risks; building robust strategic systems; instilling governability; shaping institutions; hedging and diversifying risks through portfolios; and embracing risks.

Figure 4 illustrates the applicability of these strategies to types of risks classified along two axes: the extent to which the risks are controllable and the degree to which they are specific to the project or inherent to the economic system and thus affecting large numbers of actors. When risks are specific to the project and controllable – that is, endogenous – the usual prescription is to mitigate with risk-management approaches. However, if one party has comparative advantage in such mitigation, due to possessing more information regarding the risk or control over the outcomes, the prescription is to shift these risks to that party through contract. When risks are poorly defined but at least partially under the control of affected parties, governments, or regulators, transforming them through institutional influence is the way for sponsors to gain some control. When risks apply broadly but are not under the control of any of the parties, the preferred approach is to transfer them through hedging transactions when markets exist or though insurance when it is priced efficiently. Sponsors must be prepared to embrace the remaining risk, and typically enhance their ability to do so by diversifying exposure through forming portfolios of projects, or equivalently, syndicating out parts of some projects to balance their overall exposure.

[FIGURE 4 ABOUT HERE]

**Classic Decisioneering Approaches to Assessing and Controlling Risks**

Decisioneering approaches view projects as initiatives that can be planned in advance and under conditions of calculable risks. Careful analyses of trade-offs between costs and risks, it is argued, can yield good approximations for the appropriate timing of investment in projects. Accelerating a project will increase development costs to the point that there is a danger of sinking it. Proceeding with prudence increases the danger of missing the opportunity that the project aims to capture.

This perspective, typical of much of the project-management literature (Cleland and Ireland 2006) assumes an environment in which the range of issues facing a project is more or less constant and current quantitative trends can be easily extrapolated into the future. Decisioneering approaches can be grouped into two basic streams. The first are quantitative sensitivity analyses that investigate the impact that possible deviations in some variables, such as anticipated costs, may have on financial performance. The second are probabilistic approaches -- using scenario analysis, decision trees, or influence diagrams --, that provide more sophisticated alternatives to sensitivity analysis and, in some cases, link the assessment of risk to choices and actions. Sensitivity analysis and similar approaches are helpful for making go–no-go decisions by eliminating the projects with high anticipated performance variability. However, because they focus on aggregate variables, they are less useful for the concrete and detailed shaping of a strategic system through specific choices and actions.

**Building Robust Strategic Systems**

Sponsors of projects deal with anticipated risks, constraints, and issues by creating strategic systems with scope. Large-scale projects potentially face several classes of risks: sponsorship/development, market, social acceptability, regulatory and political, financial, execution, and operation. A large portion of the risks are addressed with project-specific strategies, to reduce the odds of negative events or the maximal negative impact that such events may have on the project. We identified five classes of strategies (summarized in table 1): information/selection, co-optation, allocation, design, and action.

[TABLE 1 ABOUT HERE]

*Information/selection strategies* refer to the approaches that managers use to gather information about the project and its environment, as well as to shape and approve the project concept, and to identify and decide on the best strategies. We identified three classes of information/selection strategies: studies, private search, and relational probing. "Studies" refer to "impersonal" and "objective" information-gathering approaches such as comparative costs estimates, forecasts, tests, and simulations. In this class, selection emphasizes theoretical models and bureaucratic procedures. The "private search" class involves the use of a network of personal contacts to obtain "privileged" information; it often requires a history of previous joint work and trust. Selection takes the form of early commitment to and relentless but flexible pursuit of a single opportunity. "Relational probing" refers to lengthy face-to-face interactions with potential participants, such as banks, regulators, clients, suppliers, engineering and construction firms, operators, and affected parties, during which the information emerges and concept is directly tested. Like personal searches, relational probing strategies proactively uncover flaws or risks and focus on meeting potential opponents and critics of the project, rather than friends. Selection relies on iterative discussion and negotiation to expose unworkable alternatives and stimulate the emergence of a better project concept. The information/selection approach used will influence the extent to which risks are identified and the quality of the solutions and strategies that will be produced.

*Co-optation strategies* secure a basic set of "core competencies," such as technical and construction skills, which will increase the odds for success in critical areas of project execution and ensure access to "resources" such as markets, financing, and even public support. The first step in co-optation is deciding which resources can be provided by the owner's business units or subsidiaries. Some projects, however, require bringing independent participants on board through "partnership" links – as co-owners, joint-venture partners, or equity investors. Alternatively, resources can be co-opted through contracts and formal agreements such as project financing and tax treaties. Then again, access to some

resources may be achieved through informal “engagement” links with communities and other stakeholders in order to obtain their support.

*Allocation strategies* refer to the detailed ways in which rights, responsibilities, rewards, and risks are apportioned between participants through pricing, transfer, penalty, incentive, and other contractual clauses. Parties to a contract delimit their respective responsibility areas – what each of them has to provide to the other party, when, and under what conditions. For instance, a joint venture between an electric utility and an independent firm contains agreements that stipulate that the utility provides a site for the gasification plant and guarantees the supply and quality of coal, demineralised water, and auxiliary power. The utility has the obligation to accept all the synthetic gas that meets the quality requirements and owns all the by-products that result from the gasification process. Failure to supply the required quantities reliably triggers the payment of penalties.

Price-determination formulas are another frequently used allocation strategy. Cost-reimbursement contracts allocate risks to the owner; fixed-price contracts transfer the cost-overrun risk to the contractor. In cost-incentive and performance-based price-determination schemes, the owners and contractors share the risks and rewards. In many power plant projects the price of the turnkey contract increases if the contractors delivered the plant early or if performance tests revealed that real plant capacity was larger than specified capacity. Other risk-allocation strategies limit the negative consequences for one of the parties to a contract. For instance, utilities often include clauses that allow them to cancel contracts with independent developers if regulators do not allow them to fully recover the contract costs from their customers. Economic-dispatch formulas can be designed to pass the additional costs resulting from operating a power plant at sub-optimal capacity on to the electric utility that purchases the power and dispatches the plant.

*Design strategies* involve the use of technical, organizational, scheduling, and financial choices to reduce the likelihood and impact of risks. One spectacular example of a technical solution used mainly for political risks is the building of power plants on barges that can be towed away from the host country in case of difficulties. Other examples are technical solutions that reduce the supply risk by providing fuel

flexibility, repowering old plants to avoid regulatory risk, and economic development initiatives to gain the support of local communities.

*Action strategies* include confronting opponents using legal or informational means; persuading other participants and stakeholders such as banks, rating agencies, regulators, politicians, publics, and opponents; making gestures that legitimate the project in the eyes of the regulators or the communities; developing alternatives to be used if the preferred course of action is blocked by an adverse event; and taking pre-emptive steps to signal commitments. For instance, faced with the prospect of social opposition, the owners of the ITA power plant project in Brazil established a public relations centre in the community and organized town-hall meetings at which the project was explained. Opposition weakened and the population became an ally of the project. Traditionally, engineering firms design projects under a cost-reimbursement contract, and construction is contracted using fixed-price or unit-price contracts. More recently, engineering-procurement-construction and turnkey contracts group these activities together to better align incentives between engineering and construction. BOT-like schemes, which make a single firm or consortium responsible not only for developing, designing, and building the project but also for operating it for a long period of time, propose an even more radical way of aligning incentives. Finally, participant selection procedures may range from invited negotiations to open and public calls for bids.

**Instilling Governability**

In the last 20 years, the environments in which LEPs, such as power plants, highways, bridges, tunnels, and airports, are developed have become increasingly characterized by turbulence resulting from shifts in institutional frameworks, political and economic discontinuities, a rise in environmental and social activism, and, to a lesser extent, technological changes and innovations. Such changes clearly limit the validity of traditional risk-management approaches.

Diligent sponsors do not sit idle, waiting for the probabilities to yield a “win” or a “loss,” but work hard to influence outcomes and turn the selected initial option into a success. They shepherd their choices in light of changing conditions and often succeed against odds. Governability is enabled by

instilling a series of properties in projects: cohesion, reserves, flexibility, and generativity (Miller and Floricel 2005). These four properties are often contradictory, so a balance must be sought. For instance, strong inter-organizational bonds increase cohesion but limit flexibility. Hierarchical links create inefficiencies, while long-term contracts bring rigidities. Short-term contracts do not provide sufficient stabilization of the future to induce adequate investment. Increasing flexibility through design and incentives may reduce the efficiency of the project.

*Cohesion* is the property that results in participants' staying with the project and solving the problems caused by turbulence, instead of exiting as crises erupt. The main sources of cohesion are the bonds between project participants resulting from co-optation strategies and informal links created during project execution or early operation. Still other bonds are the result of collateral ties between the organizations participating in a project.

Inadequate cohesion leads to disintegration. Cohesion emerged quite unexpectedly as the basic governability property; one cannot govern a project that is disintegrating; flexibility is clearly not enough. To support reserves can be built into the institutional arrangements surrounding a project. In fact, ownership is the dominant factor in building reserves. Co-optation and sharing, used to deal with anticipated risks, also build in the ability to respond to turbulence. Reserves are frequently incorporated into execution budgets and schedules; contingency allowances in budgeted costs are a common practice for dealing with cost and schedule variability. Finally, reserves can be designed into projects through redundancies and slack resources.

*Flexibility* is the property that enables a project to be restructured as choices, actions, and commitments, which initially stabilized the future, change when unexpected events occur. Flexibility can be achieved by using strategies that do not produce long-term constraints, offer other avenues for action, or reduce the costs of restructuring and pursuing alternatives. These costs can be reduced through co-optation and design strategies that emphasize modularity, in which no element of the project is critical by itself. Contractual structures associated with co-optation and allocation strategies are among of the main sources of lack of flexibility. The same long-term contracts that reduce market and fuel-supply risks in

independent projects may block efforts to respond to new market realities. Contracts often create rigidity at the interface between owner and contractor; as contractors stick to specifications, changes required by the owner will be very expensive.

*Generativity* is the ability to develop creative responses to situations that appear difficult. Response generation presupposes correct sensing and interpretation, as well as the time and attention needed to produce constructive rather than destructive debates. Co-optation strategies, especially those that bring in participants with different competencies, may help. Having many points of view and access to different networks also means that adverse developments will probably be detected earlier and different perspectives will be brought into the discussion. For instance, unlike projects financed on the balance sheet, project financing brings banks, investment advisors, rating agencies, and consulting engineers to the heart of project debates. Creative individuals bring in new perspectives from outside the circle of managers who normally participate in the project. With their different experiences, they can sense danger and propose innovative solutions. On the other hand, numerous participants and contractual interfaces hamper creativity, especially when parties focus on contracts instead of problem solving.

**Shaping Institutional Forces**

The prevailing framework of laws and regulations serves to reduce uncertainty and opportunism. Coherent and well-developed institutional arrangements are, without a doubt, the most important determinants of project performance. Projects shaped in incomplete and shifting arrangements have a hard time taking off: they require deals that may not stand for long. In contrast, well-developed laws, regulations, and practices contribute significantly to enhancing project performance.

However, complex projects present challenges and sometimes call for transformation of laws and regulations. The main function of institutional arrangements is to help anchor projects in their economic and political contexts and ensure that investments will be repaid and social utility be provided. Unless they are solidly anchored, projects will be at the mercy of shifting interests, caprices, and opportunistic moves. Sponsors will seek institutional arrangements to buttress LEPs.

*Stabilization of the long-term future to enable investments.* Legal and regulatory frameworks, such as sector regulations and concession frameworks, help to reduce risks by minimizing opportunities for clients, communities, or governments to attempt to capture revenues after the investment is sunk. The goal is to create the prospect of secure streams of funds in the long term to cope with the various uncertainties that can affect the project. To secure streams of revenues, the approach throughout most of the twentieth century has been to assign sponsorship and ownership to network operators. Recently, power-purchase agreements in which the regulator or the state forces network operators to sign long-term supply contracts with independent producers, have been used as a tool for providing revenue flows. Concessions by the state to sponsors also provide a framework for future revenues but are less secure.

*Flexibility to face turbulence.* During the front-end development of projects, when agreements are negotiated and commitments made, managers develop specific strategies to cope with foreseeable risks; they cannot, however, develop specific ways to cope with "surprise" events. Turbulence is likely to arise given the long time span required for development. Flexibility is provided by elements of institutional arrangements that enable projects to undergo rescheduling, restructuring, or bankruptcy. The flexibility provided by institutional arrangements helps many projects survive unforeseen events.

*Enhancing the legitimacy of projects, participating organizations, and agreements.* Many projects face opposition from interest groups. Laws, regulations, and practices that create well-structured assessment frameworks enable sponsors and interest groups to air their views through public hearings, and even to oppose decisions through appeal procedures. Public-bidding frameworks structure the orderly selection of "fit" sponsors and provide legitimacy. Practices such as inviting representatives of the public into planning and design meetings and proactively consulting conservationist groups and environmental regulators help to find credible solutions and reduce the likelihood of protest.

Frameworks for structuring voice, decision making, and public trade-offs make it possible to choose public transportation systems, erect power plants, and, in some countries, build nuclear facilities. To manage social-acceptability risks in siting of power plants in Japan, for instance, the Three Power Source Laws System was put in place by the Japanese Ministry of International Trade and Industry. This

framework structures public consultations and hearings across the country; the population is consulted on choice of eventual sites for projects and their technical features.

Sponsors attempting to anchor projects often find that laws and regulations are incomplete. Many projects serve to unlock new models of project delivery (for example, the first BOTs [build-operate-transfer projects] were developed in the 1980s). One third of the projects analysed by IMEC required at least one change in laws and rules. Concession rights, property rights, economic regulations, or foreign-investment rules needed to be modified. More than one-fourth required or accompanied changes in property rights: land rights, water rights, monopoly on or improvements to BOT and concession frameworks. Changes to laws and regulations in capital markets were also frequent. A few projects called for new environmental frameworks.

**Portfolios, Insurance, and Hedging**

The principle of diversification is applied in projects in many different ways. In the IMEC studies, three applications were observed. First, sponsors of risky projects likely to face turbulence from disturbances caused by economic crises or government behaviours build a diversified portfolio across sectors and jurisdictions to balance risks and cash flows. Positive variations in a few compensate for negative outcomes in others. While sponsors may be able to influence some behaviours, these risks – particularly those of overall macroeconomic conditions or general policy changes – by and large are beyond the control of project participants. Diversification generally is the sole option. Second, sponsors may hedge against possible losses due to currency fluctuations or commodity exposures by employing financial derivatives or other structures to shift these exposures to “the market at large,” which by definition possesses the maximum diversification potential and hence should demand the lowest premium for bearing such risks. Third, sponsors may protect themselves against political risks by investing in many countries, finding partners in each country, or buying insurance against expropriation. They may also

engage in shaping or influencing behaviours by incorporating legitimate stakeholders and/or by being sure that they deliver value to those in control.[4]

**Embracing Residual Risks**

Of course, not all risks can be mitigated, shaped to sponsors' advantage, or transferred to others through contracts or markets transactions. Successful project sponsors and other strategic players understand which risks must be taken in order to seek "the prize" associated with the project. Through experience, they have developed a clear sense of their comparative advantage in bearing various risks, reflecting their financial strength (their capital base, diversification, access to capital markets, and financial sophistication), their understanding of particular risk domains, and their influence over the relevant events or consequences of those events. Figure 5 illustrates the comparative advantage of different actors associated with major public-private projects in dealing with various types of risk.

[FIGURE 5 ABOUT HERE]

**Matching responses to risks**

Efficient risk management requires matching risks and responses, all within a dynamic iterative system. This is typically done though an iterative "layering process," as depicted in figure 6. For any given risk that is identified, there is a pecking order of responses – for example, mitigating or shaping for risks that are controllable to some extent – applying the principle of comparative advantage to determine who best should bear them given the ability to control coupled with the financial capacity to bear the risk: hedging in the case of risk that can easily be transacted in financial markets, and pooling or diversification for risks that cannot be shaped or traded.

[4] For an excellent recent study of how sponsors deal with political risk in major projects, see Wells and Ahmed (2007).

[FIGURE 6 ABOUT HERE

In the IMEC study, we observed that when the strategies used by sponsors in the shaping of their projects and facing risks are broad, projects perform well. In fact, the scope of the strategic system is statistically and significantly linked to the performance of projects: the chi-square correlation coefficient between the scope of the strategic system and project performance is 8.3 with a confidence level 0f 0.015.

**Governing Projects as Evolutionary Systems**

The strategic system set by the sponsors to shape concepts and cope with risks is built up through time. In this section, we will outline a governance framework to manage projects while recognizing that they are essentially evolutionary and messy. The actual decision-making processes observed in the projects studied in IMEC were indeed messy, and often chaotic. Projects are often launched by promoters who need to charm potential participants and feel compelled to build convincing but less-than-reality-grounded stories. Expenditures are allocated to soft issues such as opinion research, public affairs, and announcements that lay bare issues of politics and power. Decisions are never final but are remade, recast, and reshaped. Confrontations often bring deadlocks.

This messiness, as opposed to clear-cut decision-making, has led many observers to argue that LEPs are basically unmanageable, and that success is a matter of luck and improvisation. In reality, projects are better viewed as evolutionary systems where messy decision processes can be structured by a governance framework that combines discipline with creative responses.

**The Performance of Projects**

Traditional perspectives on project management measure performance in terms of meeting projected costs, deadlines, and functionality. However, project sponsors buy benefits not artefacts: they evaluate projects by the value and satisfaction they create. Should one adopt an evolutionary perspective, performance becomes the output of processes over which control varies from strong to minimal. Achieved results may be different from initial expectations for a number of reasons:

- The internal governance framework of the sponsoring organization may have led to initial estimates that were the off mark, wrong, or deceptive, as managers were unwilling to allocate the resources necessary to build solid estimates or tell the truth.

- Capabilities of sponsors or consultants to shape projects or respond to crises may have been inadequate or have faltered. Exogenous or endogenous events may have required competencies that parties did not have.

- Exogenous unexpected events beyond the control of sponsors or partners may have generated turbulence that was difficult to master.

- Sponsors may have changed priorities mid-course, set new goals, or cut budgets, thus triggering endogenous turbulence.

- Bold moves to profit from emerging technical or market opportunities may have led to overruns but with increased benefits. Overall satisfaction may be high together with a perception of bad management.

Should one adopt an evolutionary perspective, the performance of projects becomes not a comparison with goals stated many years ago but the output of processes of shaping, countermoves and facing emerging risk. The project that has been built differs from the original concept because of unexpected events, imposed redesigns or voluntary changes in the concept.

### Progressive Issue Resolution through Shaping Episodes

Rather than evaluating projects at the outset based on projections of the full sets of benefits and costs over their lifetime, competent sponsors view and shape them in evolutionary perspectives. They start with initial concepts that have the possibility of becoming viable. They then embark on shaping efforts to refine, reconfigure, and eventually agree on acceptable concepts. Sponsors cut their losses quickly when a concept has little possibility of becoming viable.

Shaping episodes start with broad hypotheses about what nested problems and risks need to be addressed and what resources are necessary to achieve progress. The shaping process combines deliberate

actions with responses to emergent situations. A variety of intertwined issues have to be resolved one by one by sponsors alone or in cooperation with partners or co-specialized firms. Progress typically involves "buying in" some stakeholders and "buying off" others. In some cases, the expectations of stakeholders can be specified in advance. In many cases, though, it is not clear how to accommodate various interests; the leading sponsor uses the front-end period to identify mutual-gains trajectories.

Episodes start with momentum building, continue with the countering of opposing forces, and iterate until closure can be achieved. As shaping progresses, new options are opened and old ones are closed. At closure, clients and partners agree to commit thus losing degrees of freedom.

*Momentum building*. Momentum is built by imagining concepts, promoting legitimacy, and selling a project configuration such that partners, affected parties, and governments accept what is proposed. Risk seminars and decision conferences are used to shape the value proposition and identify risks. To ensure that investments are protected against opportunistic behaviours, risk-sharing agreements will be developed. To gain legitimacy, consent from affected parties and approval by governments will be sought.

*Meeting countering forces*. The countering forces that come into play over time can easily sidetrack weak sponsors into wrong choices or lead inexperienced ones to kill good ideas. In each shaping episode, the forces of criticisms and counteractions will be at work. Opponents will call for realism. Experts will challenge cost estimates and risk potentials. Sponsors will respond and take actions that may plant the seeds of later failure or success. In situations of antagonism or when desire to collaborate is mixed with the intention to oppose, parties learn opponents' values, communicate promises, and make veiled or overt threats to arrive eventually at meetings of minds.

Sponsors sometimes believe their own overly optimistic assumptions. Weak analyses, incomplete research, and the need to show progress lead to the rejection of valid criticisms. Excessive realism, in contrast, leads to scepticism and to the eventual rejection of good opportunities. What is basically a good concept is painted negatively and rejected. Unfavourable judgments drive away parties whose contribution is critical. Doubts, negative stories, and emergent problems set in motion self-fulfilling prophecies.

Sponsors often yield to the temptations of unreasonable commitments because they are unaware of particular risks. Blindness generally comes from the inability to form coalitions that confront distinct but relevant viewpoints. Regulatory agencies may refuse to grant permits or change rules during project shaping. Only projects whose leaders and sponsors have the resources, willingness, and competencies to counteract destructive forces survive.

*Closure*. Eventually, imperfectly coordinated but stabilized understandings move toward temporary agreements that are enforceable. Each shaping episode ends with a process of closure that suggests either abandoning the whole project or accepting a temporary agreement on a concept configuration.

Closure takes many forms; memorandum of understanding, business case, negotiated agreement, formal public commitment, sets of formal contracts, and so on. The dangers associated with closure are that choices can be made too early or too late, too rigidly or too flexibly. Missing the boat – rejecting a good opportunity – is just as real a possibility as selecting a bad option or pursuing the wrong project. Premature closure locks a project on a rigid configuration, narrow sets of agreements, or irreversible choices that limit degrees of freedom for the future.

When exogenous or endogenous forces are strong, the agreed upon closure may be reopened at the start of another shaping episode. For example, emerging technical opportunities may call for reopening IT projects or infrastructure projects. When this occurs, assessing costs against benefits is necessary. Similarly, changes in the business models may call for reconfiguration of the agreement. Figure 7 pictures the shaping effort as going up a hill through coalition building, problem solving, and risk management in the face of counter-dynamics such as cynicism, false expectations, and feedback effects.

[FIGURE 7 ABOUT HERE]

**Projects as Paths of interdependent Shaping Episodes**

Projects are rarely shaped in one over-arching episode. Instead, multiple and interdependent episodes are necessary to resolve issues and arrive at a closure that, though reopenable, can be agreed upon. Episodes

are not stages that logically flow from one to the other but distinct shaping dynamics that are autonomous yet path dependent. Figure 8 illustrates the path of early front-end shaping episodes for a bridge project that was examined in great detail. Five episodes characterized the progression from initial hypothesis to formal contracts and construction fund release. We will present these episodes in a generic manner:

[FIGURE 8 ABOUT HERE]

*Initiation and exploration*. The initiation episode is usually short (six months to a year) and closes when a credible party conveys to others that the project concept has relevance and should be sponsored. The credible party states openly that it is ready to allocate funds and lead debates on the ways and means of shaping and financing the idea. In the IMEC sample, project ideas were initiated by network operators (32%), entrepreneurial firms (20%), political leaders (20%), technical entrepreneurs (12%), and owners of rights (8%).

Resources of a few million dollars are used to shape the project concept during this episode. Exploratory searches are conducted internally or in collaboration with external parties. In the IMEC sample, the dominant modes of exploration were a team in symbiosis with external consultants (16%); open idea competition (20%), strategic-planning groups (30%), and entrepreneur design (28%). Conceptual closure is achieved when independent studies confirm the viability of the concept. The output is a series of documents sketching out ideas but with an emphasis on technical issues. The most common form is a position paper presented to legitimate authorities, such as ministers or boards of directors.

*Development of holistic proposals*. The leading sponsors start with “horseback” assumptions and proceed to develop holistic proposals covering financial and technical parameters, social acceptability, environmental challenges, and regulatory decisions and permits. The central concern is to maintain a perspective that avoids blindness to risks. Sponsors build fully developed scripts addressing pertinent risks and providing concrete solutions. Holistic proposals are presented as a business cases to investors or

public authorities. Preparing such proposals is expensive: from a few to many tens of millions of dollars. Entrepreneurial sponsors are often unable to fund such efforts.

*Extended negotiations.* Assuming that a version of the holistic proposal has been selected, the leader works with selected bidders to clear out assumptions concerning risks, revenues, costs, guarantees, engineering design, and other factors. Assumptions often need to be reworked. Many sketched relationships have to be made operational. Numerous issues skipped earlier are discovered and require solutions. Such issues may include definition of property rights to protect sponsors; development of guarantees to protect clients from completion risks faced by sponsors; negotiation of terms of guarantees and covenants to protect banks and investors; determination of the public contribution in the case of projects in which toll revenues are insufficient; determination of pricing structures and conditions of the concession; and identification of rules, regulations, and laws that will have to be modified to provide security to the project.

When a government is the sponsor, negotiations of agreements have to meet additional criteria of transparency, probity, and accountability. Negotiations often extend over many years because different departments have distinct requirements and expectations. Many winners of competitions, having sketched beautiful holistic proposals, are dismayed when they have to restart negotiations after winning a bid and spend $15–20 million just to work out issues that they thought were resolved.

*Confronting emerging fears.* As information is made public, pressure groups are triggered. Facing social and environmental fears is a very expensive affair. Sponsors have to bind themselves through actions to gain consent. Promises to engage in future actions are insufficient. Concrete moves to meet expectations and solve social and environmental issues have to be made.

If parties are unable to forge agreements, they must wait for court or government decisions. The presence of public social- and environmental-assessment frameworks is extremely important here in helping to solve dilemmas. Delays are the inevitable consequence of such formal assessments, but the public framework builds legitimacy and forces parties either to make trade-offs or to kill the project.

*Closure on a committable package*. Commitment on a final package can take place when all major issues have been resolved. In many projects, sponsors have spent a few hundred million dollars to shape a holistic proposal, gain consent, solve social and environmental issues and build agreements. Once the slow front-end shaping process closes on a committable package, the sprint to engineering, procurement, and construction may then begins.

The costs of shaping projects and planning to meet risks can be high. For simple projects, around 2-3 % of the overall costs will be spent in planning activities. However, for socially complex projects up to 35% of the total costs will be spent in shaping the concept, ensuring good quality coordination between players and investing to master risks. Leadership tends to be different in each episode. During the initiation period, entrepreneurs or political officials tend to be leaders until a credible client accepts the project as a viable idea. In developing proposals and negotiations, two leaders, the owner and the sponsor/developer, interact. During construction, leadership is shared between the owner and contractors.

Sometimes, the re-opening of closure is so powerful that shaping has to return to early conceptualization. For example, during the construction of the Tucurui dam in Brazil, the extent of rain was such that prior estimates about the flow of water had to be revised and all designs redone while constructing. Similarly, progress in clinical research may lead doctors to openly question assumptions embedded in the design of a university hospitals.

**Governance Frameworks for Shaping Projects as Evolutionary Systems**

Various governance arrangements for developing projects have been tried. The rational model for project planning emerged in the twentieth century to replace the entrepreneurial approach. Belief in formal analysis was, and still is, the central pillar of the rational approach. Successful projects are portrayed as the product of advanced planning by experts who carefully weigh forecasts, alternatives, and contracts. Project failures are seen largely as resulting from planning errors. Although many studies showed that large projects did not always conform to the rational-system model, the ideal lives on.

The approach proposed here combines rational planning with evolutionary shaping as progress is made on facing issues, risks, and opportunities. Governance frameworks can be built at the projects level but also at the institutiobal level to provide the scaffolding around which the various issues of projects can be shaped.

Governance means setting up a structure - a set of decision-making processes and methods for accumulating of knowledge to ensure that creativity and discipline are brought to bear. In conjunction with analytical planning, debates, and discussions about risks, value creation, and opportunities to reopen projects are kept alive. They make sure that risks are not defined as cost contingencies but that risk-management systems are put in place to trigger the negative feedback loops necessary to counteract the positive loops. The reopening of closed agreements will be subjected to cost-benefits tests.

*The participant*. Building a structure to shape projects through their multiple episodes requires deciding what parties will be involved. The structure must identify the multiple perspectives from which the project may be viewed, and the multiple tests that it should be subjected to. If the project team is staffed only with internal technical experts, projects will be configured in technical terms. In contrast, if the project office includes external parties experienced contractors, lawyers representing opponents, and professional managers with a systemic perspective, risks and opportunities will be addressed. Sponsors that become blind to particular risks do so because they have not brought distributed and differentiated expertise and viewpoints. They fail to form coalitions that can identify the major issues, put in place mechanisms to address them, and not allow commitments to get out of step with the resolution of key risks.

Using a mountain-climbing metaphor, competent public or private sponsors do not rush to climb the mountains that they are best equipped to climb. Rather, they seek to select, equip, and train a climbing party. In fact, the game consists in identifying projects that stretch capabilities but that, because of their complexity and risk, offer substantial value and benefits to clients that in spite of the costs involved.

*Processes*. Governance processes set up decision-making frameworks to make sure all the right questions are being asked, to initiate research activities to develop answers, and to outline the hurdles that

the project must clear. Large multinational firms have often put in place complex frameworks composed of five or six decision gates in which most issues are addressed. Governmental frameworks are usually less complex with a few decision moments.

For example the system instituted by the Royal Ministry of Finance of Norway includes three gates at which the project concept is tested. Project concepts are developed technically by the relevant ministries but must answer the following questions: What is the value for clients and opponents? Is value created properly shared? What are markets estimates? How will the project be financed? Could it be built using other alternatives? What are the major risks and how will they be dealt with? Where are the forgotten costs, especially in risk mitigation? How do estimates compare with other projects in the world? Have competing options such as Public Private Partnerships been analysed? The initial concept is assessed internally. However, holistic proposals are evaluated in cooperation with external expert evaluators (Samset at all, 2006).

*Methods for accumulating knowledge*. Without comparative knowledge about costs, contracts, risks, and so on, it is very difficult to shape projects. Sponsors that get involved sporadically in large projects find themselves starting anew and building on high levels of ignorance. The accumulation of knowledge has to be organized on a systematic and continuous basis. Sponsors should internally and in cooperation with others build knowledge bases on construction cost estimates, risk-bearing costs, contractual forms, practices for introducing innovation, financial methods for business modelling, and learned best practices.

Powerful sponsors such as governments and large firms may even shape the environments in which projects will be developed. They may decide that ultimate users, engineering contractors or project management firms must build-up their capabilities to create value and share knowledge. Improved capabilities will make it possible to better answer questions and work co-operatively to develop superior solutions by engaging in generative thinking and search for innovative solutions.

## Conclusion: Creation and Exercise of Options

The succession of shaping episodes that form the front-end process to cope with risks can be reinterpreted in terms of the real-options framework that is currently revolutionizing academic treatments of project evaluation. In fact, as is often the case with cutting-edge practice, managers have been successful at creating value through the development and exercise of sequential options without explicitly framing the process in options terms. Academics have simply codified this practice in the form of a new conceptual framework.

The real-options framework is based on the same logic as that of financial options as developed by Black and Scholes (1974). It recognizes that the decisions that determine project cash flows are made sequentially over many episodes. The key insight of this approach is that uncertainty or volatility may actually increase the value of a project, as long as flexibility is preserved and resources are not irreversibly committed. As a result, the economic value of a project when it is still relatively unformed is often greater than the discounted present value of the expected future cash flows. Value is increased through the creation of options for subsequent sequential choices and exercising these options in a timely fashion. Thus, sponsors seek projects that have the potential for large payoffs under particular institutional and technical circumstances. Our study illustrates the rich varieties of mechanisms through which these options are shaped and exercised over the life of the project – the real management that is integral to real options.

**References**


Amram M. and Kulatilaka Real Options: Managing Strategic Investments in an Uncertain World Oxford University Press 2005

Black, Fischer, and Scholes, Myron. 1974. "From Theory to a New Financial Product." *Journal of Finance,* 29(2): 399–412

Cleland D. and Ireland L. Project Management: Strategic Design and Implementation, Fifth Edition Mc-Graw Hill New York 2006

Cooper, Robert G. 1997. *Winning at New Products: Accelerating the Process from Idea to Launch*. Reading, MA: Addison-Wesley.

Flyvbjerg B. Bruzelius N. Rothengatter Megaprojects and Risk: an Anatomy of Ambition Cambridge University Press Cambridge UK 2005

H. M. Treasury: PFI : strengthening long-term partnerships, HMSO March 2006 London

Hughes, Thomas. 1998. *Rescuing Prometheus*. New York: Pantheon.

Knight F., The Ethics of Competition, Quartely Journal of Economics 37 579-624

Metcalf, J Stanley. Innovation, competition and Enterprise: Foundations for Economic Evolution in Learning Economies Discussion Paper No. 71 CRIC University of Manchester 2005

Miller R. and Castonguay . La Gouvernance des Projets d'Infrastructure, CIRANO 2006 Montreal

Miller, R. and Floricel, S., "Project Risks." In André Manseau and Rod Shields (eds.), Building Tomorrow: Innovation in Construction and Engineering. London: Ashgate, 2005.

Miller, R. and Lessard, D. The Strategic Management of Large Engineering Projects: Shaping Risks, Institutions and Governance. Cambridge: MIT Press, 2001.

Morris, Peter. W. G. 1994. The Management of Projects, London: Thomas Telford.

Samset K., Berg P. and Klakegg O. J. , Front-end Governance of Major Public Projects, Concept Research Program, Technical University of Norway, May 2006.

Wells, Louis. T., and Admed, R. 2007. Making Foreign Investment Safe: Property Rights and National Sovereignty. New York: Oxford University Press.

Table 1: Devices used in building strategic systems

| | |
|---|---|
| Information search | Research and studies<br>Expert judgments<br>Debates, scenarios, risk seminars<br>Multidisciplinary strategy teams |
| Network building and co-optation | Early involvement of financiers, operators, and others<br>Public–private partnerships<br>Alliance of owners sharing equity<br>Partnerships with suppliers/contractors<br>Coalitions with affected parties |
| Structures of incentives, and contracts | Risks/decision rights allocation<br>Type and number of contracts<br>Incentives/penalties<br>Frame agreements<br>Methods of contractor selection |
| Project/design configuration | Select geographical location/site<br>Complementary investments and linkages<br>Contract flexibility, ability to restructure<br>Flexible/modular technical solutions<br>Flexible contracts/contractual options |
| Influence and bold actions | Educate regulator, rating agencies, and others<br>Side payments: compensation, add-ons<br>Pre-emptive action, signals<br>Climate of optimism<br>Windows of opportunity<br>Signal probity (e.g., bidding)<br>Seek and improve on legal requirements<br>Change laws and regulations |

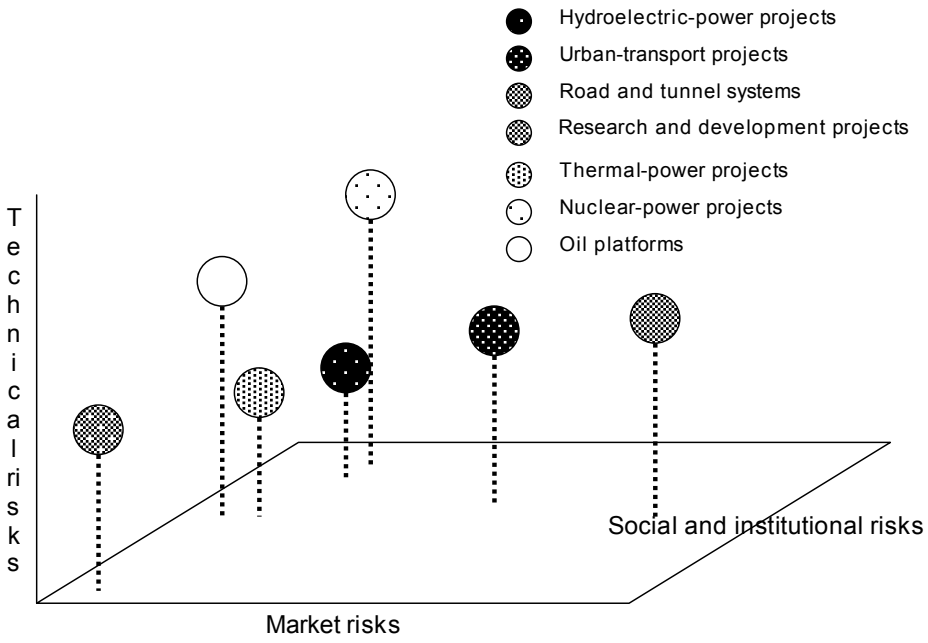


Figure 1. A taxonomy of LEPs in the IMEC sample.

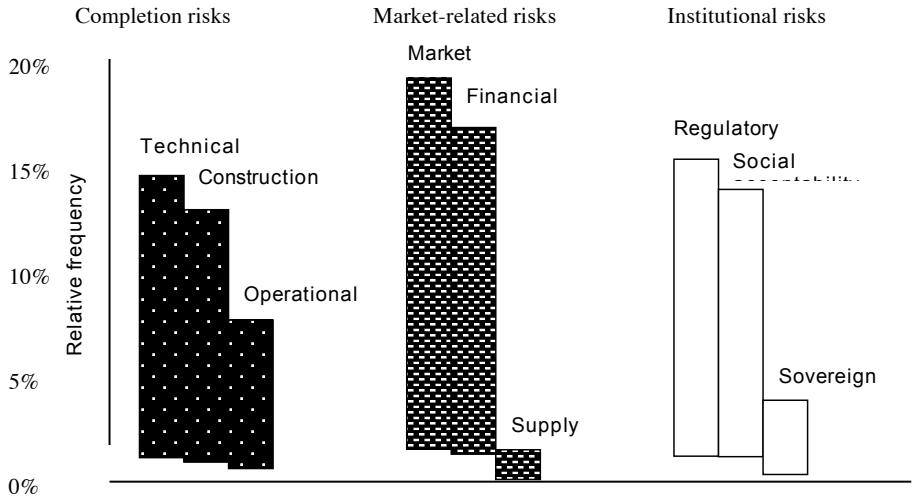


Figure 2. Major risks in LEPs, IMEC study

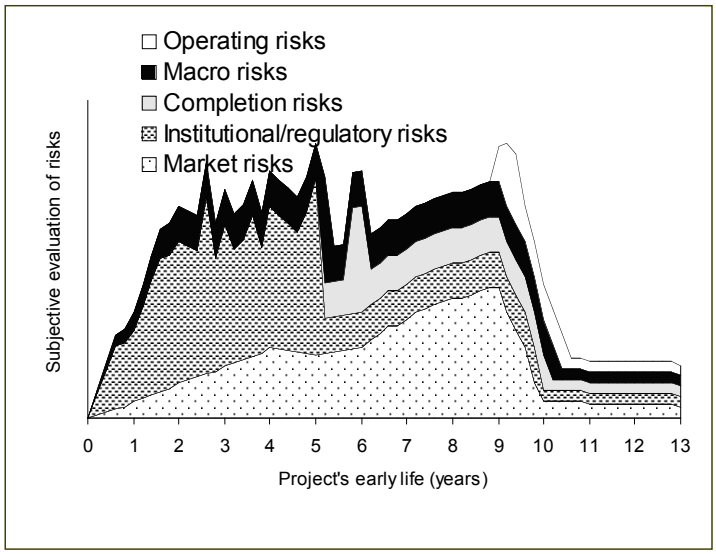


Figure 3. The evolution of risks over a project's life

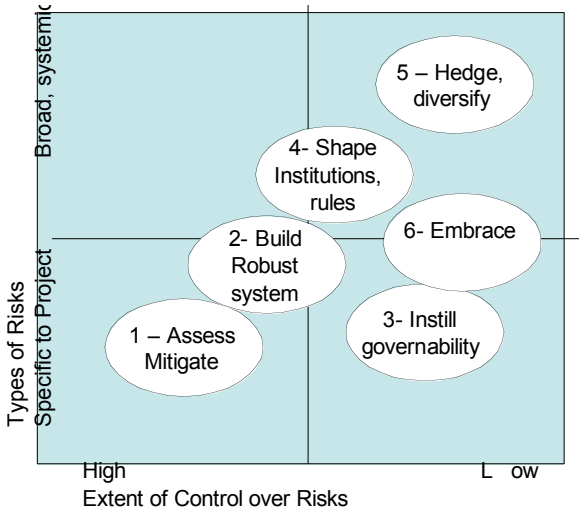


Figure 4. Strategies to cope with risk

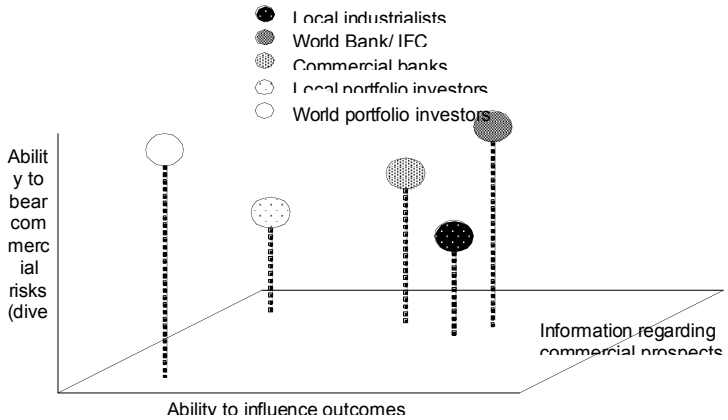


Figure 5. Comparative advantage in risk taking

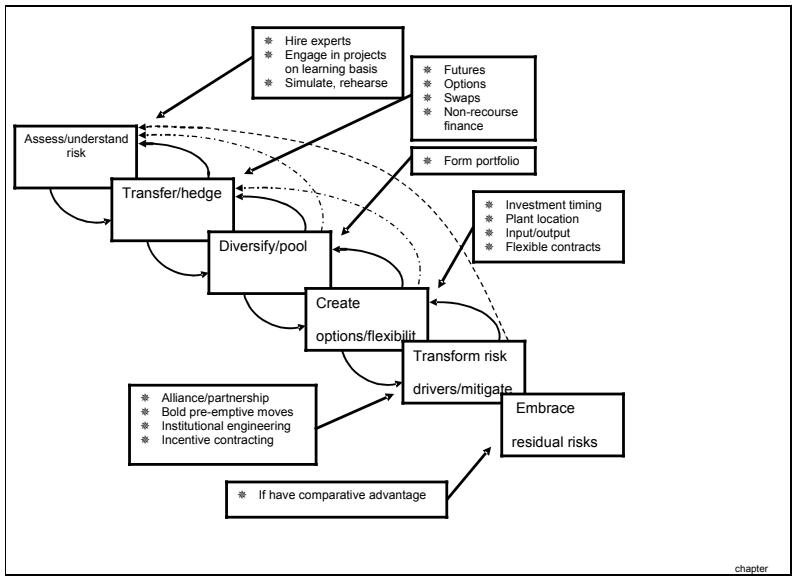


Figure 6. The layering process

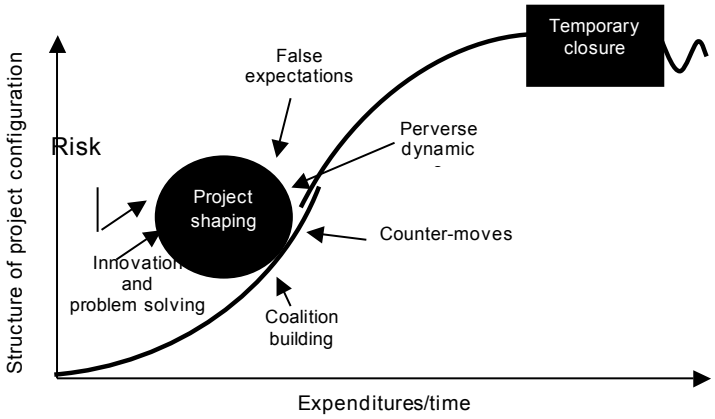


**Figure 7. Stages in Project Shaping**

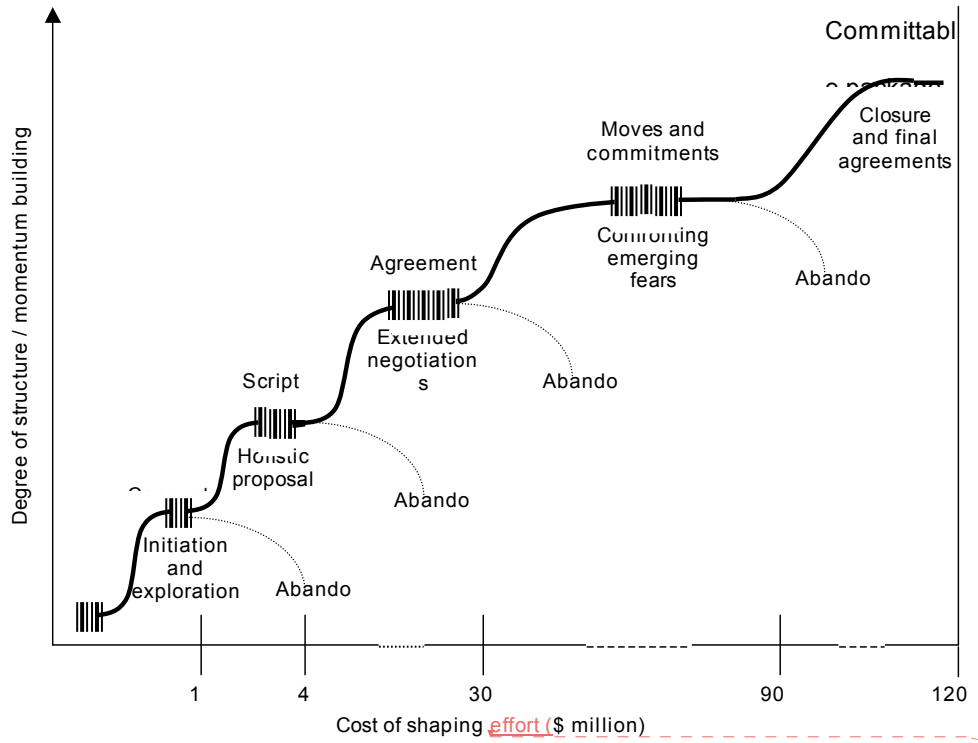


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**Figure 8.A project as a series of shaping episodes**