Managing Large Engineering Projects

Roger Miller, M.Eng., D.Sc. FCAE

Jarislowsky Chair in Innovation and Project Management

Ecole Polytechnique de Montréal

September 2003

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Understanding the Front-End :three basic research orientations

- **A transformation of social arrangements**
  - ***From single sponsorship to***
  - ***Sharing of risks amongst multiple sponsors***
- **Project by project: the IMEC program:**
  - ***Project level attend to identify the best practices to improve project performance***
  - ***Diffusion of best practices and training of engineers***
- **The governance approach: many projects over time**
  - ***learning from the British PFI initiative***
  - ***Standardization from 451 projects***

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1 A Transformation of social Arrangements

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1 Transformation of social arrangements for developing and building large projects

1. **In the 1980's and early 1990's a major shift occurred in the social arrangements for shaping and delivering large projects**
   1. ***From risk taking by a single large sponsor using***
      1. **Rational planning of front end and detail planning**
      2. **Bidding from suppliers and contractors**
      3. **Value creation through "superior design" and "lower prices"**

2. **To a governance mode involving**
   1. ***Multiple sponsors***
   2. ***Sharing of risks amongst partners***
   3. ***Generative relationships with suppliers and contractors***

3. **This observation led us to study how things were done in the 19th and 2oth centuries.**

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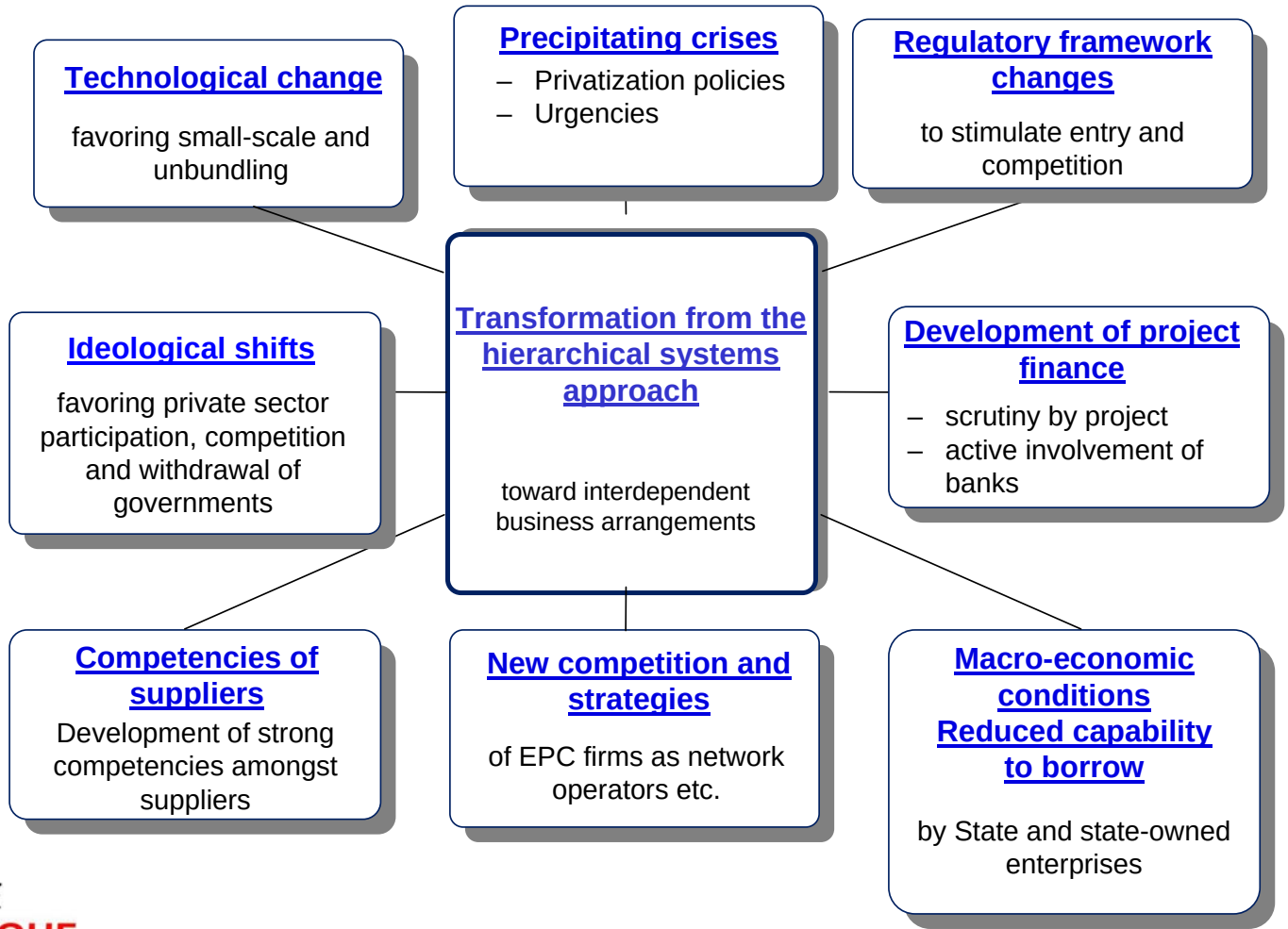
Forces Leading to Transformation of Project Arrangements in the 1980-1990's



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Characteristics of the three main types of institutional arrangements

	Entrepreneurial	Rational system	Governance
Institutions	Minimal regulation Exclusive rights or concession frameworks	Regulated monopoly (price or rate) Environmental regulation	BOT/concession Rules to foster competition and private ownership, environmental regulation
Economic context and trends	Space for expansion Cost-reducing and performance-enhancing innovations	Predictable cost reduction for output Room for system expansion	Urgent need for infrastructure (Third World) and and room for new projects (West)
Technology	emergent	established dominant design	emergent and established technologies
Main actors	entrepreneurs and Banks	Large operators of networks/ Regulators	Developers, EPC, etc
Risk allocation	Risks assumed by entrepreneurs and banking partners	Risks internalized by large system	Risks allocated to participants
Project practices	Internal design Public stock issues Multiple construction contracts	Internal financing, planning, and design Multiple fixed-price contracts, bidding Detailed specifications	Partnerships/alliances Project financing Turnkey contracts Broad specifications
Ways to attain effectiveness and efficiency	Effectiveness: owner-performed design, control over construction Efficiency: competitive bidding	Effectiveness: rational centralized planning Efficiency: scale and network economies and competitive bidding	Effectiveness: diversity of competencies and risk allocation Efficiency: owner/contractor partnership
Organization forms	Small, dynamic	Hierarchical	Networks
Dominant ideology	Pragmatic	Modernism (rational planning, bureaucracy)	Deregulation, privatization, ecology

Failures within institutional arrangements

Entrepreneurial	Rational systems	Governance
Duplicated investment and destructive competition	Network operators are symbols of national pride, tools of vested interests	Vulnerability to government opportunism
Small projects fail to capture economies of scale	Bureaucratization: specialization and formalism lead to slow decisions and high overhead costs	Complexity of front-end negotiation processes, which increase transaction costs
Fragmented systems and markets not capturing network economies	Arrogance, inability to deal with ecological groups and local opposition	Rigidity of contractual structures
Tendency to form monopolies in order to increase prices	Tendency to build expensive and unneeded projects	Incapacity of contractual structures alone to protect from failure and opportunism
Underinvestment in underpopulated areas	Over-reliance on internal planning and definition of projects precludes joint problem-solving and cost reduction with contractors and equipment suppliers	Predilection for simple and conservative solutions that reduce technical risks but produce technically sub-optimal projects
Rate discrimination between places where there is competition and places where firms enjoy monopoly, as well as between large and small clients	Incapacity to focus on small or marginal projects	Underinvestment in projects due to increased selection hurdles
Financial speculation	The "capture" of regulators who are unable to impose efficient investment	High cost of capital for private projects
Issues of probity, corruption,		

YET Projects Built with the Governance Model do not Perform Better

- **Sponsors, bankers, and EPC firms mention numerous hesitations.**
  - ***public and legislative risks are shifted to private firms***
  - ***the private sector can "economize" no more than 20-25%***
  - ***ownership of projects can sink EPC firms***
- **Statistical tests indicate that the new model performs no better. There is no significant difference in project performance between the rational and the governance model.**

	Projects with low performance	Projects with acceptable performance	
Rational Model	6	19	25 **41.7%**
New Model	16	19	38 **58.3%**
	22 **36.7%**	38 **63.3%**	60 **100%**

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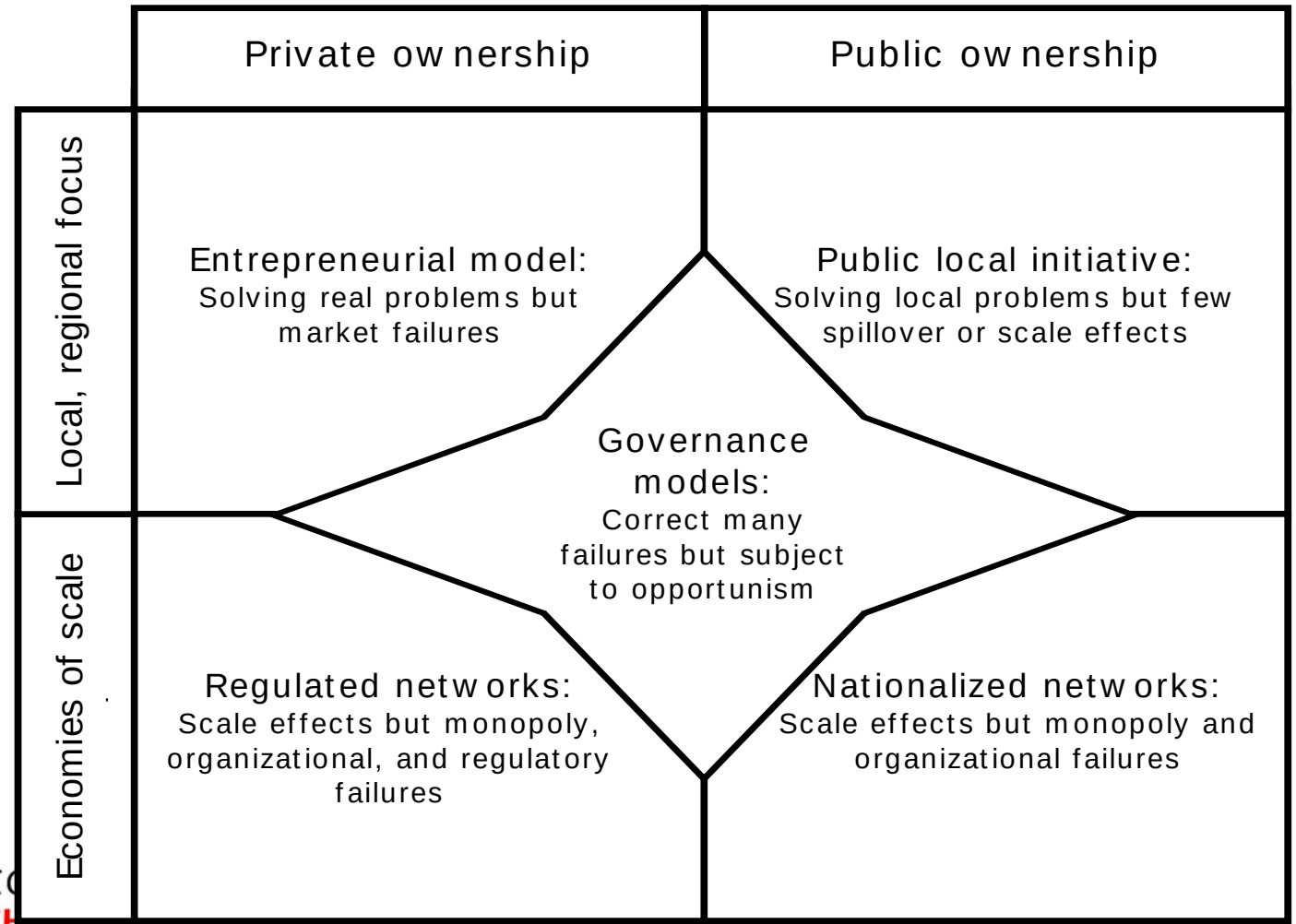
There is no optimal model just workable solutions



The IMEC Program

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2 IMEC Project

- **Main Research question: What are the factors influencing the success or failure of large complex engineering projects ?**
- **Sponsors: Cofiroute, EDF, Hydro-Québec, Ontario-Hydro, PMI, CAE,SNC Lavalin, PM2000, CRSNG, CRSH and Secor Group**
- **International study: 60 projects for which we met 450 sponsors, bankers, constructors, regulators, lawyers, analysts, etc.**
- **A systemic perspective focussing on strategic decisions during the front-end period**
- **A « grounded theorizing » approach: the conceptual framework emerges from the reality of studied projects, as opposed to pre-existing theoretical constructs**

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2.1 Large Engineering Projects as Social Experiments.

Product of negotiated compromise:

- Customized to meet client requirements 70.9%
- Integrated parts of networks 64.4%

Contested externalities :

- Facing extensive community opposition 40.3%
- Facing international pressure groups 31.9%

Crafted over many years :

- Average front-end period (search) 79 months
- Average EPC period (sprint) 49 months

Exposed to political risk:

- Political considerations influenced initiation 43.8%
- Viewed as a vehicle for economic development 51.1%
- Facing bureaucracy with strong expertise 69.8%

Facing coherent regulatory frameworks :

- Facing highly developed regulatory frameworks 61.8%
- Having to deal with multiple uncoordinated agencies 38.3%

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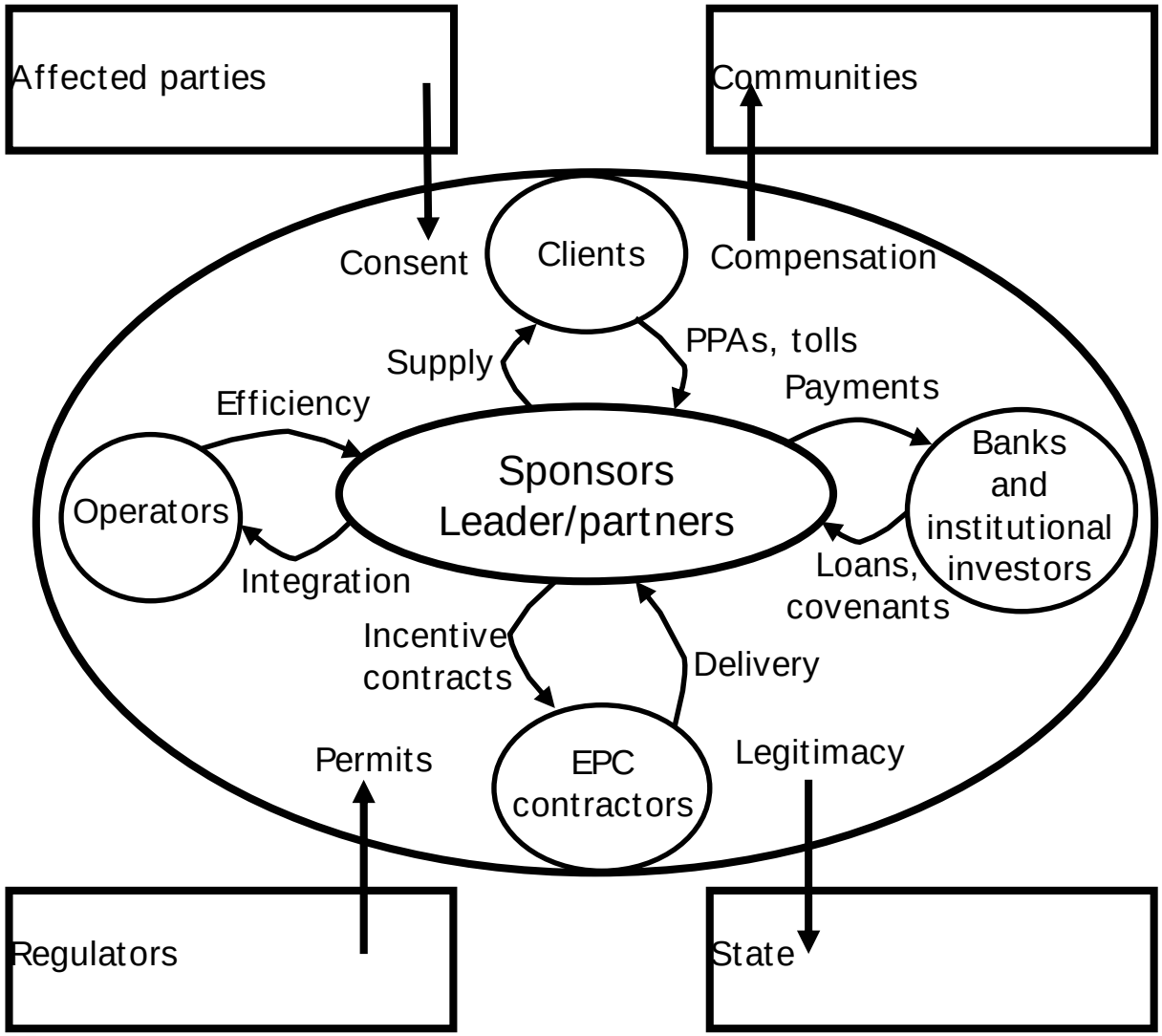
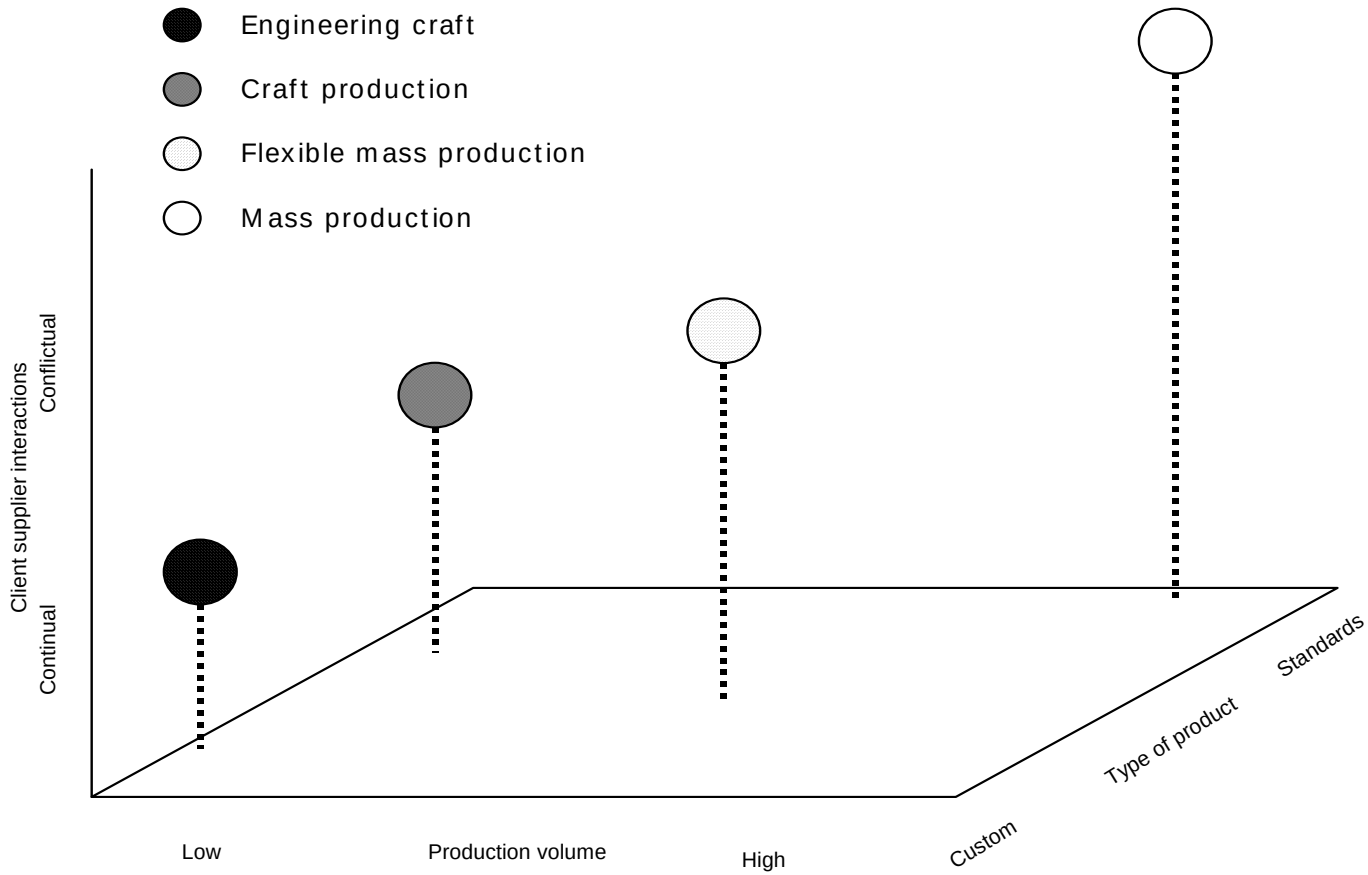
Players involved



Large Engineering Projects: unique, custom,and highly interactive Slow clock-speed



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High Stakes Games

- Indivisibility of investment in front-end and EPC:
  - *long, costly search, ramp-up periods*
  - *few options to modularize*
  - *full investment to test market*
- Irreversibility of choices and exposures:
  - *at ramp-up, sponsors and bankers are fully exposed*
  - *specific assets cannot be moved*
  - *full exposure to downside risk*
- Rent production, distribution, and appropriation interact:
  - *rent appropriation depends on rent distribution which affects project configuration*
  - *upside gains are constrained by regulations or public fairness*

..Large, irreversible commitments :

- **Average cost $985 million**
- **Built ahead of demand 35.6%**

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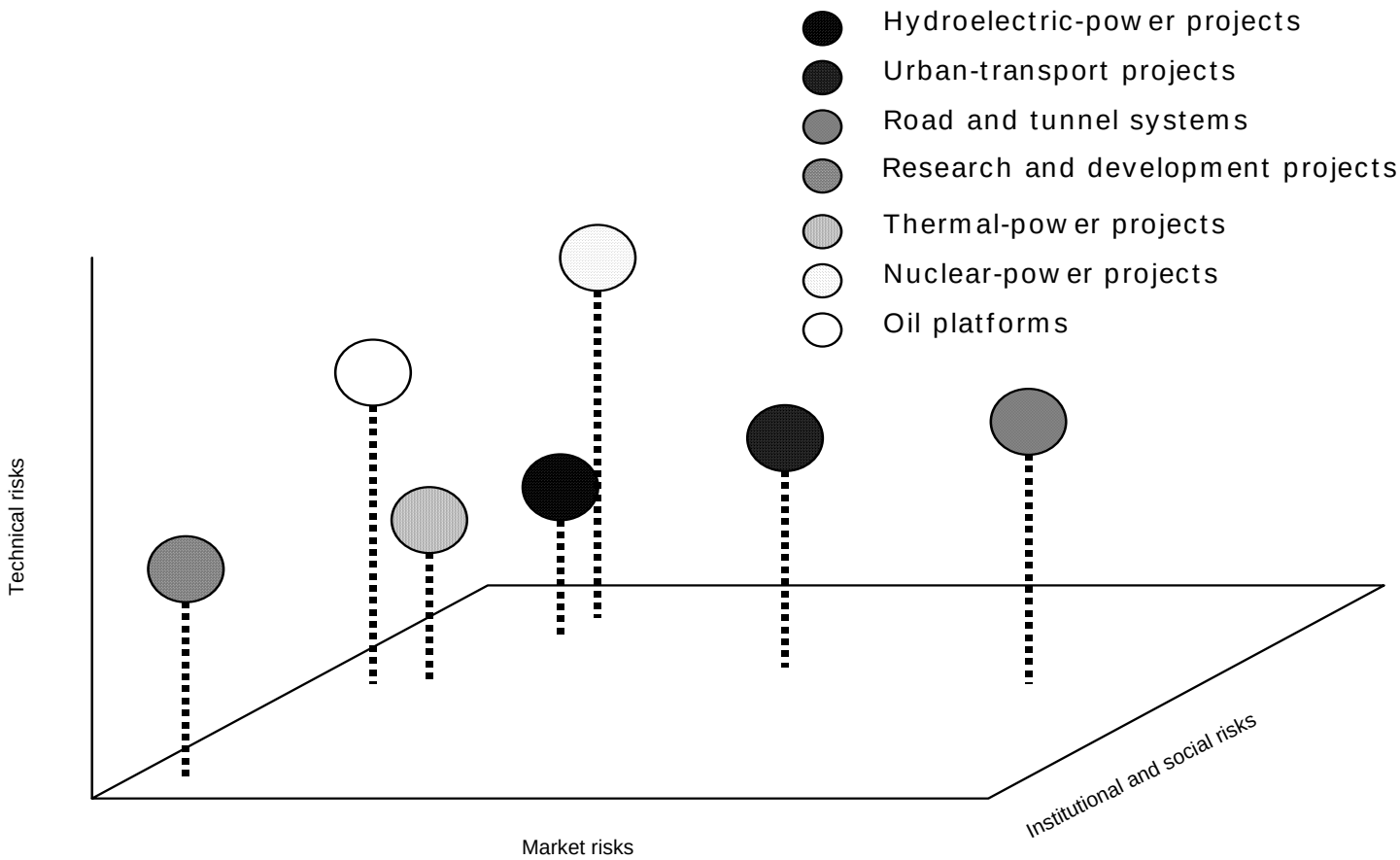
2.2 Risks differ depending on the type of projects



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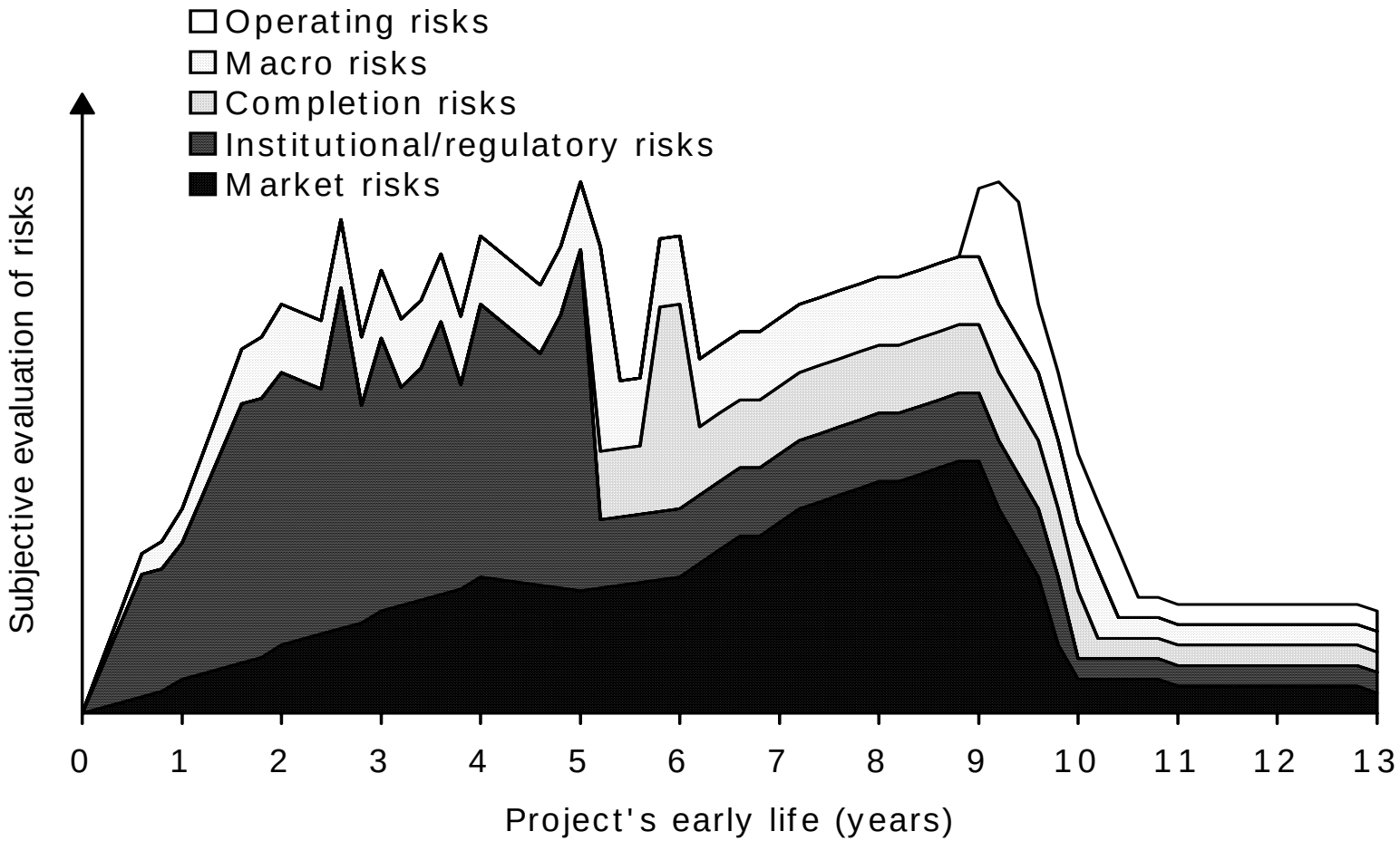
Evolving risks: an illustration



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Emergence of Turbulence often leads to the disintegration of projects

Type	Example
Exogenous events	
Sociopolitical and macroeconomic	Financial crises (country or world) Major legislation (unexpected) Abrupt changes in input prices (oil, gas, etc.)
Unexpected natural events and discoveries	Bad weather, unforeseen geology Discovery of valuable natural resources
Direct opposition to project	Court challenges by pressure groups Organized community opposition International opposition
Sovereign behavior	Rule changes by regulator Refusal to grant permits Expropriation battles Granting of competing concessions

Turbulence often leads to the disintegration of projects…

Endogenous events

Coalition unraveling	Withdrawal or bankruptcy of major partners Opportunistic moves Difficulties experienced by one partner
Uncontrollable interactions	Unexpected consequences of strategies Social deadlocks
	Accidents, strikes Complementary work not ready Contractor bankruptcy Problems with new technology, site, etc.
Ramp-up	Forecasts proven wrong Expropriation

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Performance: Efficiency and effectiveness of projects in the IMEC sample

	%
Efficiency indicators	
➢ meets cost targets	81.9
➢ meets schedule targets	71.9
Effectiveness indicators	
➢ meets most stated objectives	45.0
➢ below target but satisfactory and without crises	18.3
➢ restructured after experiencing crises	16.6
Abandoned after high levels of development expenditure	*6.6*
➢ taken over by public authority after sponsor's bankruptcy	10.0
➢ abandoned white elephant	3.3

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2.3 Factors explaining success or failure of large engineering projects

- **Presence of institutions**
- **Sponsors' competencies**
- **Risk management**
- **Shaping the configuration**
- **Instilling governability**
- **Shaping institutions**

(2.3.1) The presence of an institutional framework enabling the control of risks

- **The institutional framework to control risk:**
  - ***By defining rules of interactions***
  - ***By anchoring the project in its social environment***
  - ***By stabilizing long term revenues***
  - ***By establishing the project's legitimacy***
  - ***By enabling flexibility when turbulence arises***
- **The new institutional framework established in the 80's has not increased the probabilities of success**
  - ***The previous framework established risk sharing in such a way that 75% of projects succeeded***
  - ***The new institutional framework has supported success in only 60% of cases***
  - ***Project developed by entrepreneurs: 50% success rate***

(2.3.2)Shaping by competent Sponsors'

- **Sponsors' competencies increase the probability of success:**
  - ***Network operators and agents showed together higher competencies to ad-hoc alliances***
    - **Deep pockets: up to 33% of the project cost has to be invested prior to a final decision**
    - **Capacity to invest over many years to support negitation of all agreements**
    - **Political negotiation competencies**
- **What are the required competencies ?**
  - ***Ownership competencies: arbitrage for major decisions to ensure the flow of revenues***
  - ***Competencies for evaluating complex systems***
  - ***Rapid decisions to stop non viable projects***
  - ***Relational competencies***
  - ***Coalition building competencies***
  - ***Survival competencies: a portfolio large enough to survive temporary turbulence***

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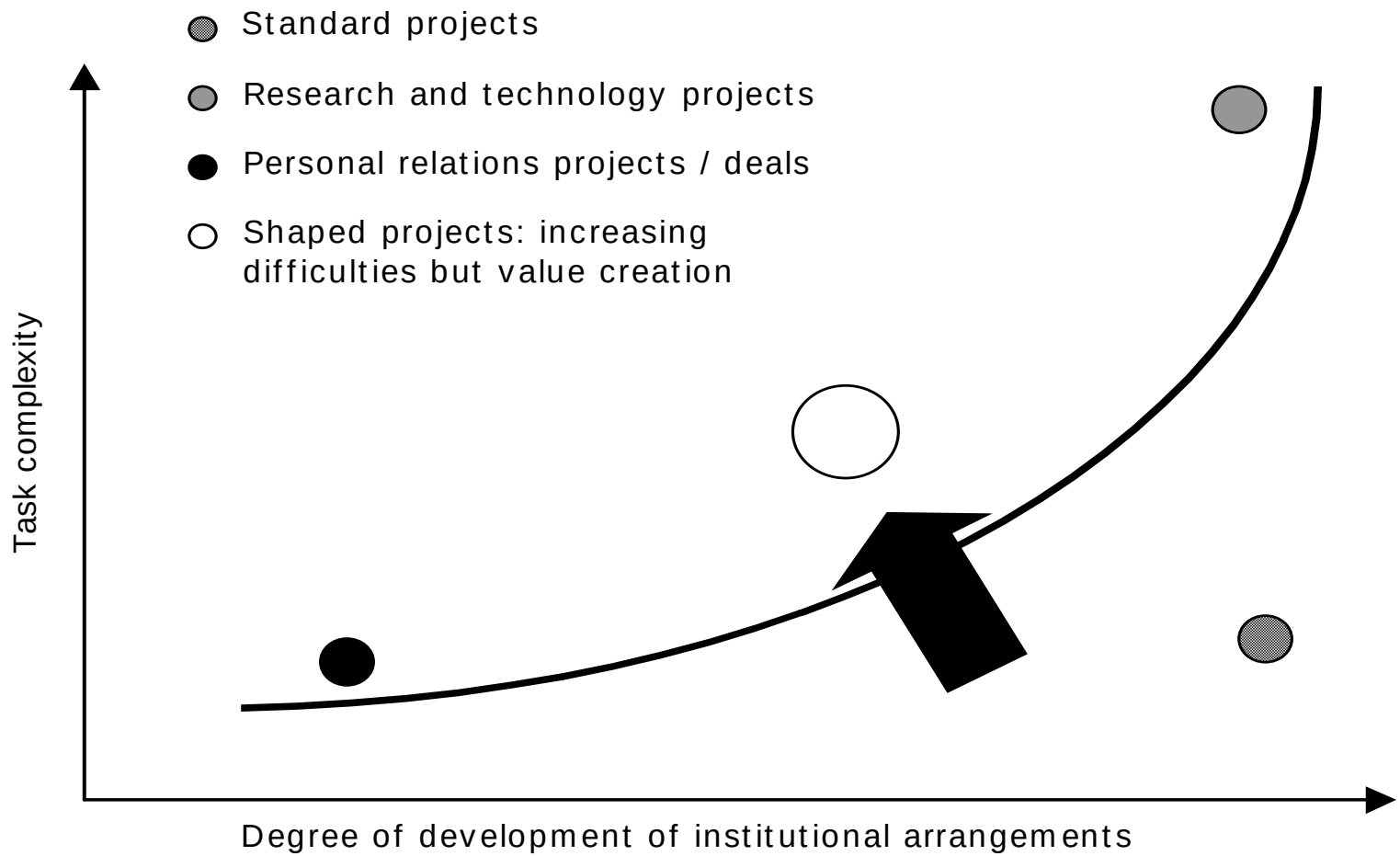
.Managing Large Engineering Projects.

- **Rational Planning and Project Management**
  - ***Specification in detail***
  - ***Advanced programming***
  - ***Accountability***

- **The Theater of Passions**
  - ***Intuition***
  - ***Entrepreneurship***

- **Shaping in evolutionary terms**
  - ***Rationalizing models***
  - ***Strategizing***

The competent sponsor looks for difficult but manageable projects



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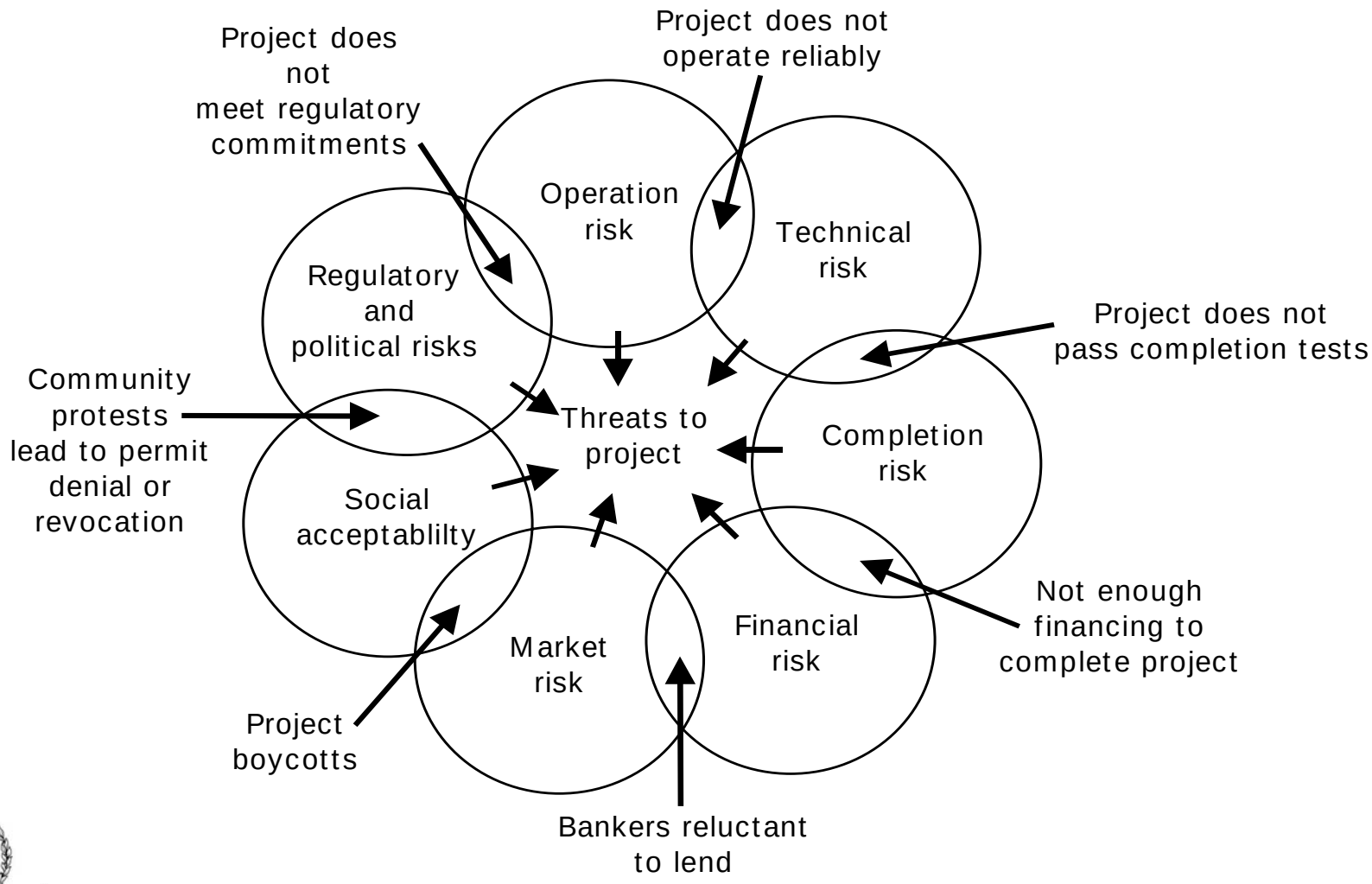
(2.3.3) Risk Management

- **Risk: possibility that an event or its impacts occur in a different way than what was anticipated**
  - ***Risk is usually defined in statistical terms: the probability of the event can be calculated***
  - ***Low uncertainty: absence of complete data but sufficient for structuring simulation and decision models***
  - ***High uncertainty: lack of data or understanding such that the decision context is ambiguous and indeterminate***
  - ***In high uncertainty contexts, future results depend upon endogenous and exogenous factors which strategic action enable to solve partly indeterminacy***

A multidimensional perspective on risks



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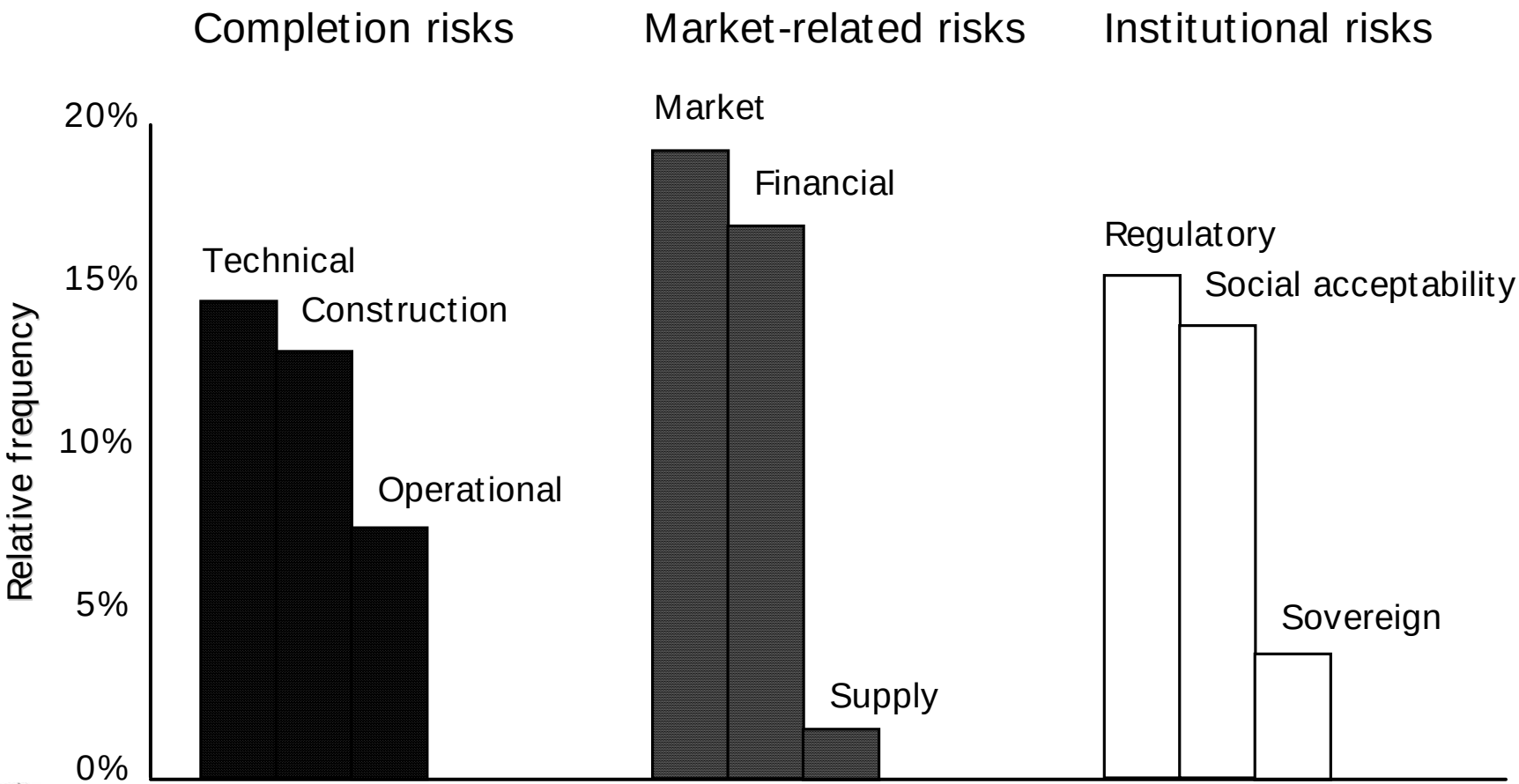
Risks observed in the IMEC projects (+500 mentions)



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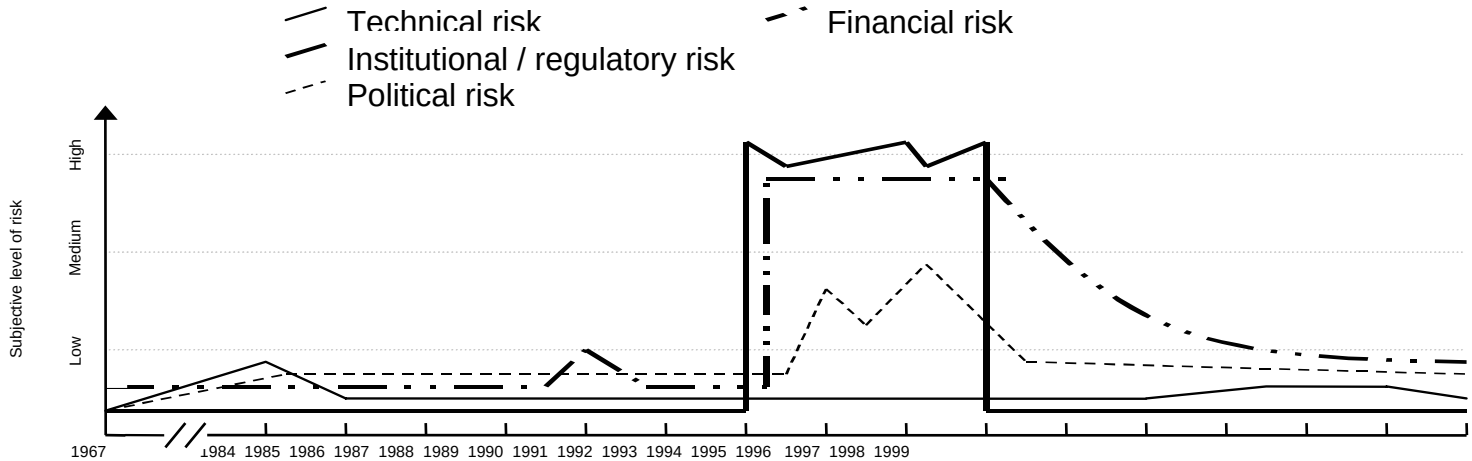
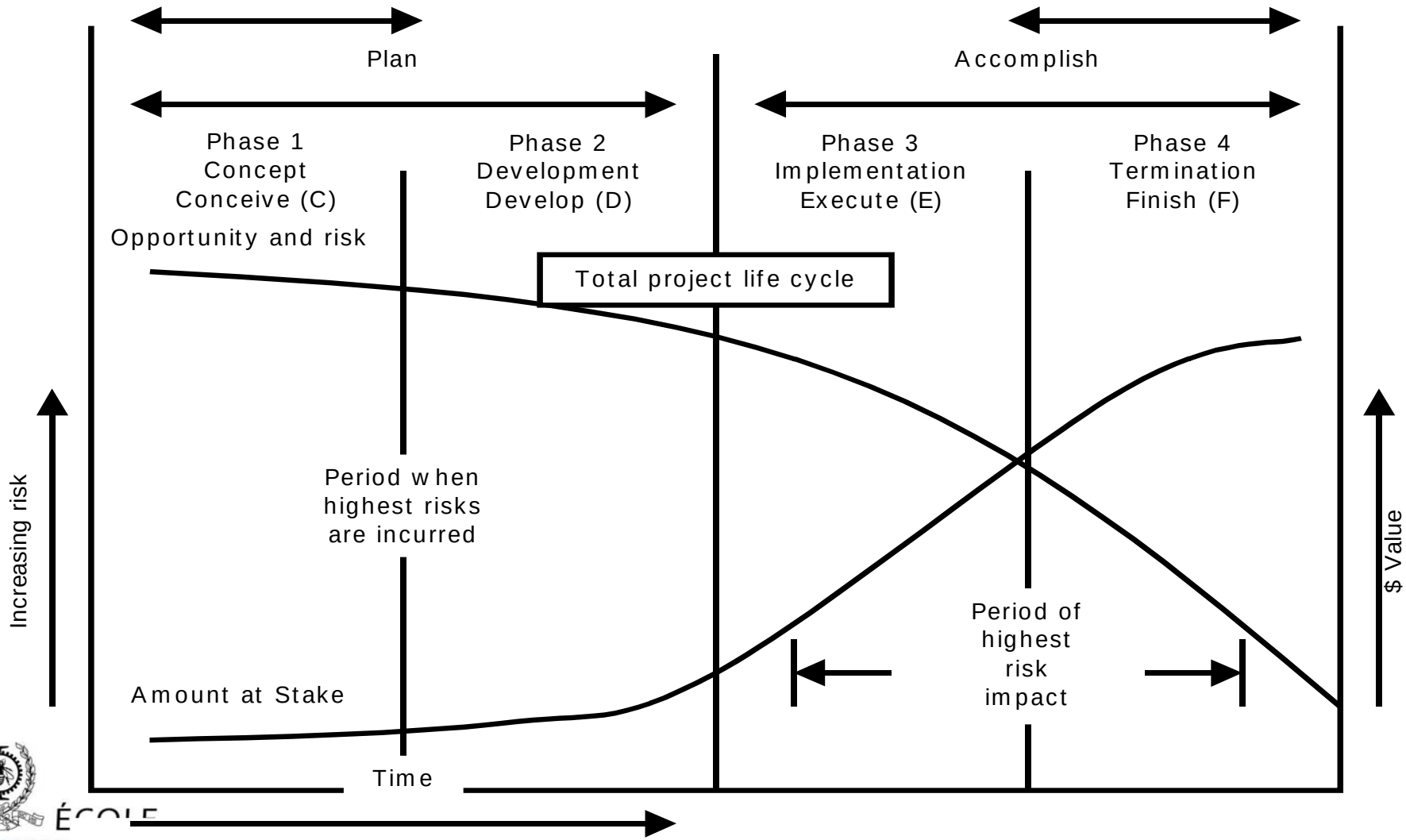
Risks emerge during projects



1967: Concession awarded
1984: Exploratory technical studies
1987: Economic and technical viability of project tested
1988: Basic design finished
Detailed design started
1989: Construction bidding for civil works
Contract awarded
1991: Development of new strategy: search for industrial partners
1992: Preliminary protocol between joint-venture (JV) partners
1993: Enactment of decree permitting joint ventures with industrial partners
Memorandum of understanding signed between JV partners
1994: Formal JV contract
1995: Concession transferred to the JV
Cost of civil works reduced from $350 million to $240 million
Construction restarted
1996: Equipment purchased on barter trade e.g. turbines
1999: Target completion date

A naïve approach

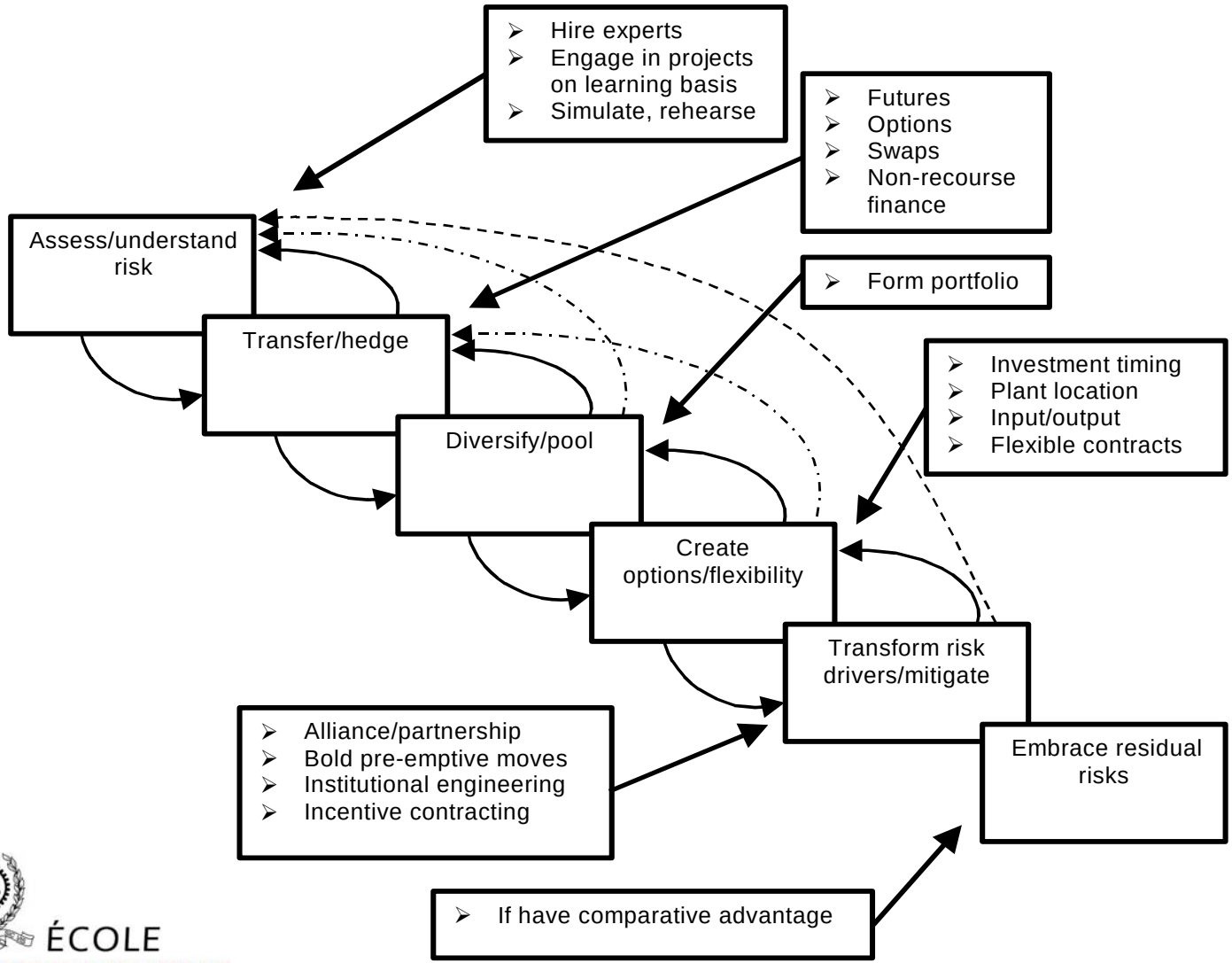


Source: Project Management Institute.

Risk management

- **(i) Analytical approach**
  - ***Decision engineering***
  - ***Impact assessment***
  - ***Subjective probabilities***
  - ***Simulations***
  - ***Hypotheses***
    - **Probabilistic**
    - **Stable structure**
    - **Models**
  - ***Limits***
    - **Probabilities are treated as exogenous data**
    - **Choice of optimal strategy to maximize given parameters (utility, vulnerability, etc.)**
- **(iiShaping approach**
  - ***Complex spectrum ranging from analysis to endogenous and exogenous influences***
  - ***Insists on the necessity to be prepared to face unknown futures***
  - ***Insists on the transformation of risk factors***
  - ***Takes time into account***

Shaping strategy to mitigate risks: a dynamic description



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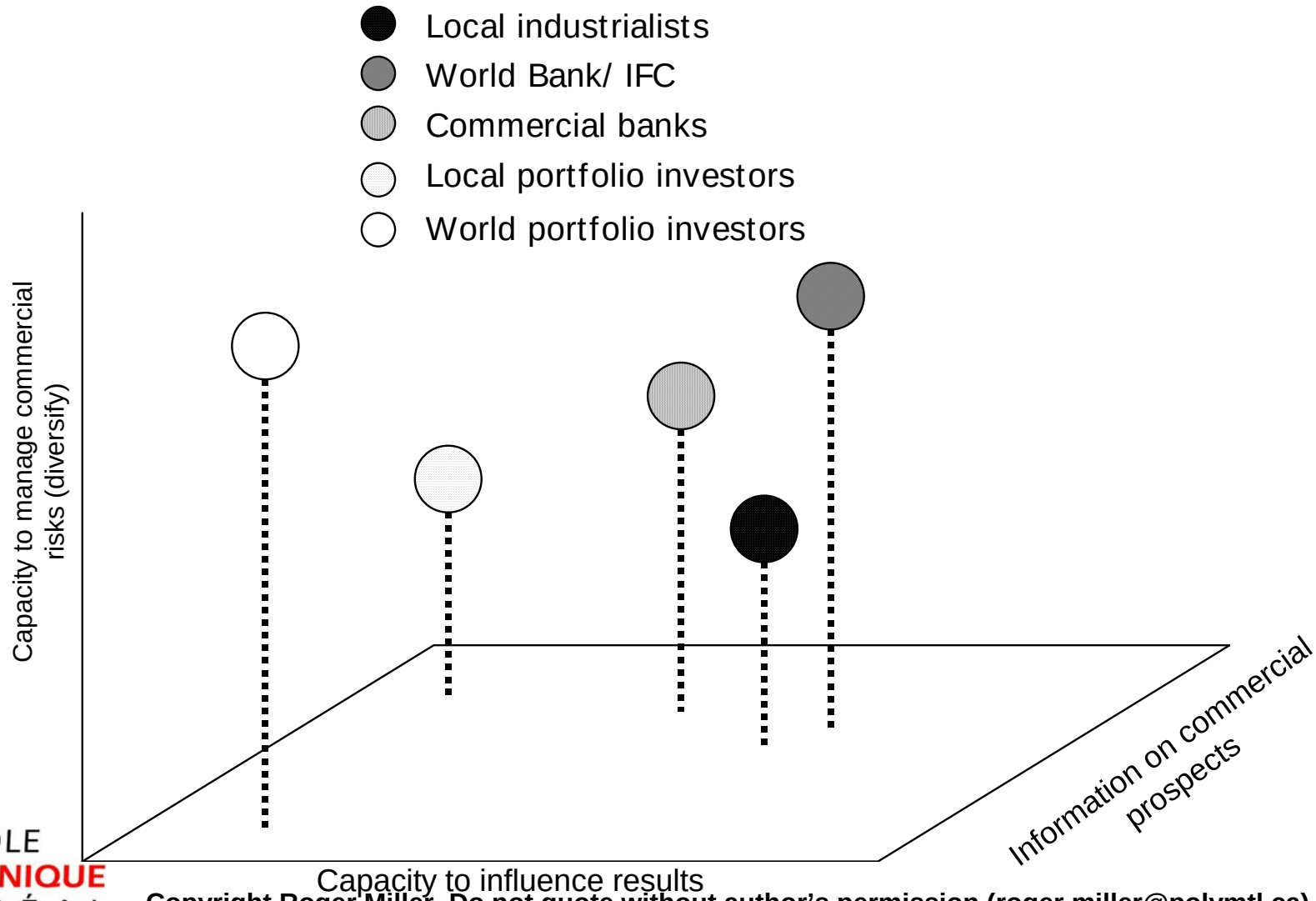
Comparative advantages in risk mitigation



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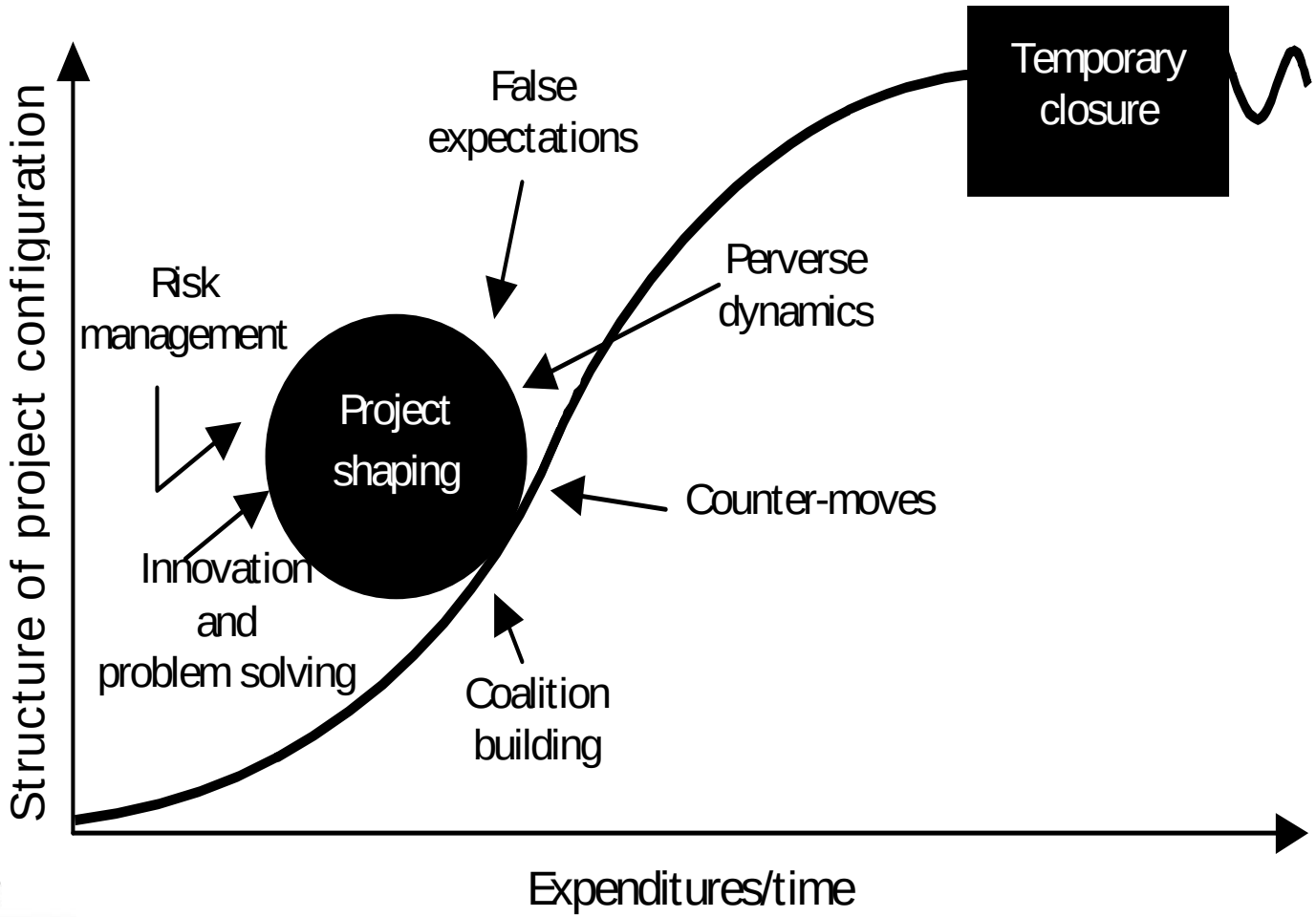
2.3.4 Project Shaping by Episode



Rationalizing Models

Financial	Non-recourse project financing Public placement of bonds Credit grading by rating agencies Risk-analysis seminars
Ownership	Alliances of partners PPA/BOT/concession Repowering Entrepreneurial projects/IPPs
Contract	Turnkey contracting Round-table decisions Design–finance–build–contract Frame supply agreement
Organizational	Participatory engineering Continuous commissioning Partnering with contractors/suppliers Co-engineering in design with suppliers
Legitimacy	Co-definition with regulator Public–private partnerships Mutual-gains approach State agreements

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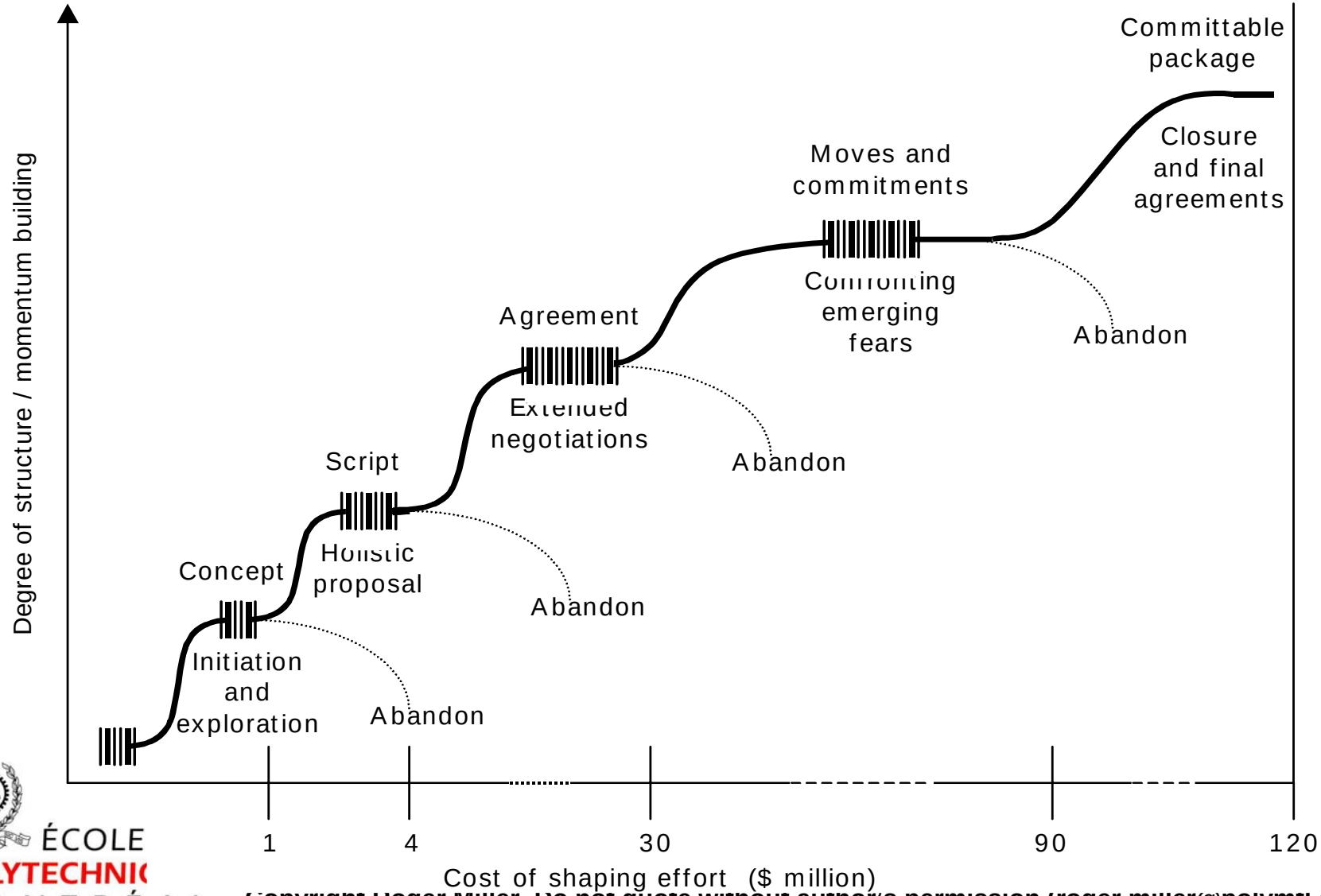
Succeeding episodes in building agreements



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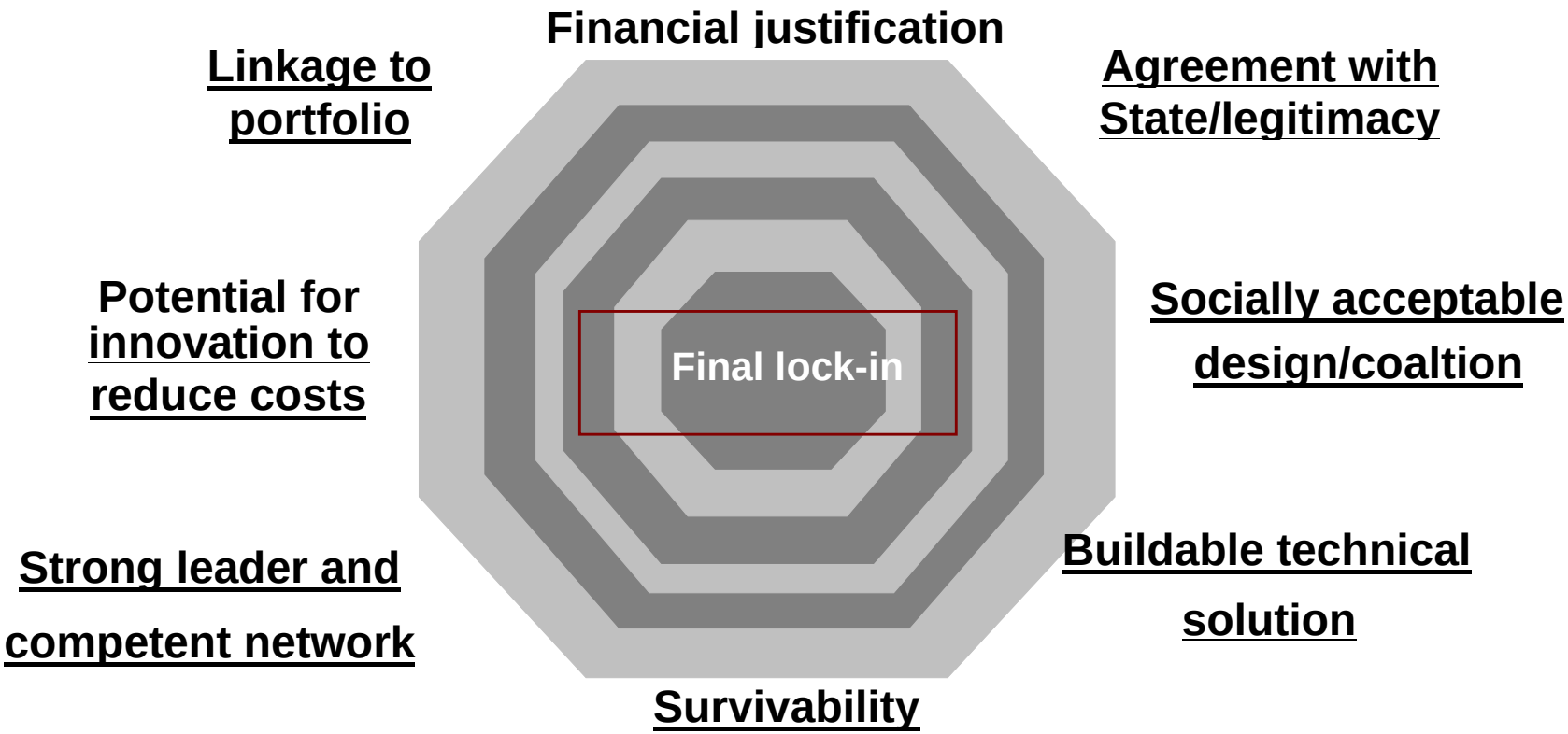
Episodes of succeeding shaping efforts

Episode	Coalition building	Dominant risk	Configuration and conceptual closure	Leadership/ sponsorship
Initiation and exploration	Narrow coalition led by a champion	Is there a sponsor able to carry risks and finance development effort? Is project holistically feasible: economically, politically, socially, technically?	Sketchy definition of initial hypothesis: multidimensional concept, memorandum of understanding	Entrepreneur, developer, or government group promotes initial hypothesis
Development of holistic proposal	Initial coalition plus developers ready to sponsor project	Do early estimates still leave the project holistically feasible?	Proposal containing “horseback” estimates	Leadership shared between client and developers or bidders
Extended negotiation	Core coalition includes leader, developers, bankers, and government agencies	Working details to ensure viability, identify risks, assign responsibilities, and provide guarantees	Volume of contracts detailing all dimensions of project configurations	Leadership shared between client and chosen developer
Confronting emerging fears	Sponsorship coalition extends to gain consent from social and environmental groups.	Is the feasible project able to carry real social/environmental costs that arise?	Viable concepts expanded to include social benefits, compensation, environmental plan, and symbolic aspects	Leadership is the sponsorship coalition with affected parties as autonomous decision makers
Closure on a committable package	Sponsorship coalition may include government agencies	Formal agreements lock projects into decisions allowing execution	Complex project documents detailing formal agreement	Leadership is passed to developers/owners interacting with engineering contractor and suppliers

Coherent and Robust Project Configuration: Committable Package



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2.3.5 Devices used by sponsors to instill governability

Relationships between leaders and owners

-alliance of equity owners
-diversity of competencies
-leadership of major investor
-business linkages (prior)
-partners' agreement

Relationships with affected parties

-negotiation/compensation
-sustained engagement

Relationships with clients/markets

-power-purchase agreements
-tolls/public support
-revenue guarantees
-client is owner

Relationship with the state

-founding contract
-agreement with state
-involvement of multilateral agencies
-state participation

Relationships with banks and institutional investors

-strong equity position
-financial architecture/covenants
-selection of responsible leaders
-government guarantees
-adaptability protocols

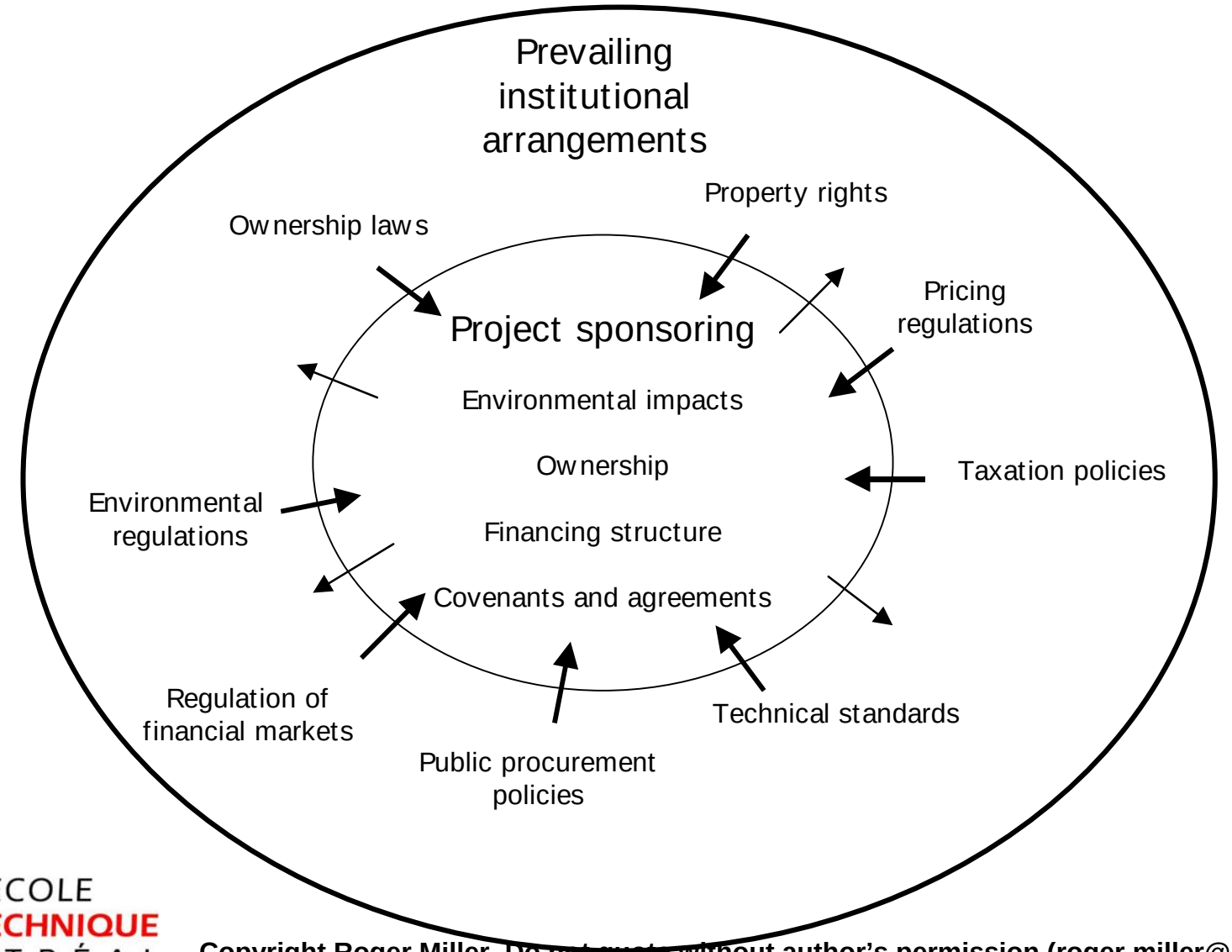
Relationships with contractors

-number of work packages
-consortium
-EPC firms involved in ownership
-degree of specification at cut-off
-owner's involvement
-incentives in engineering
-incentives in construction
-owner-contractor collaboration

Relationships between owner and operator

-owner(s) operate
-contract operator

(2.3.6) Influences on the institutional framework



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Penetration of the New Practices Varies by Sector

Sector	Novelty of arrangements Index
Technology	62
Nuclear	84
Thermal power	105
Oil	112
Hydro power	102
Urban transport	120
Roads/tunnels	134
Average	**110**

/. The Governance Approach

The British PFI experience reveals 3 distinct phases

- **Project by project approach (1992-1997)**
  - ***Projects are launched prior to the development of governance framework***
  - ***Public managers are left to develop project by project***
  - ***Minimum learning at the treasury board level***
  - ***Performance objectives often miss***
  - ***Numerous projects are blocked***
- **1997 Publication of the Bates review**
  - ***Analysis of PFI projects and identification of problems and bottlenecks***
  - ***Establishment of treasury task force with mandate to develop standards and tools***
  - ***Treasury task force eventually becomes partnership UK and PPPP programs***
- **1997-2003 The governance approach**
  - ***Development of standard contract, processes, methods and practices***
  - ***By 88% of projects are deliver on time (before time) and within budget***
  - ***Compare to lower results for non-PFI 30% for time delivery and 27% for budget***

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Elements of the governance framework

The British experience demonstrates clearly the beneficial role of a governance framework in managing large projects.

- **Sponsorship organizations (OGC, Partnership UK, PPPP, Project Review Group) established to build coherence among**
  - ***Strategies, policies and practices***
  - ***Centralize the accumulation of learning***
  - ***Diffuse best practices***
- **A public commitment to PFI to ensure participation of private sector**
  - ***Centralization of evaluation of business plan***
  - ***Emphasis on well defined sharing of risks***
- **A continuous effort to communicate with**
  - ***Private sector investors***
  - ***Pressure groups***
  - ***Professional experts in government***
- **Standardization of contracts launched in 1999**
  - ***Reduce time and cost of negotiation***
  - ***Promote common understanding of risks***
  - ***Foster public sector independence from legal advisor***
  - ***Manage rates***

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Elements of the governance framework

- **Development of a gateway process to**
  - ***Ensure quality and coherence among projects***
  - ***Structure projects according to 5 phases and 5 project evaluation reviews***
- **Strategic and experts advises from the outside**
  - ***External advices used to cost up to 11% from 1992-1997***
  - ***Methodology for selecting, accrediting and remunerating external advisors***

Development and diffusion of a set of tools to foster the expertise of public managers

- ***Process to build business case***
- ***Process to develop and select bids and partners***
- ***Process to develop a public comparator***
- ***Process to recruit external advisors***
- ***Process for an accounting system***

- **A clear vision of projects with PFI potential; certain types of projects are not suited to PFI**
  - ***IT and communication projects***
  - ***Low capital requirement projects***
- **Accumulation of learning through central bodies**
  - ***Central learning from decentralized projects***
  - ***Communities of practice***
  - ***Diffusion of best practices***

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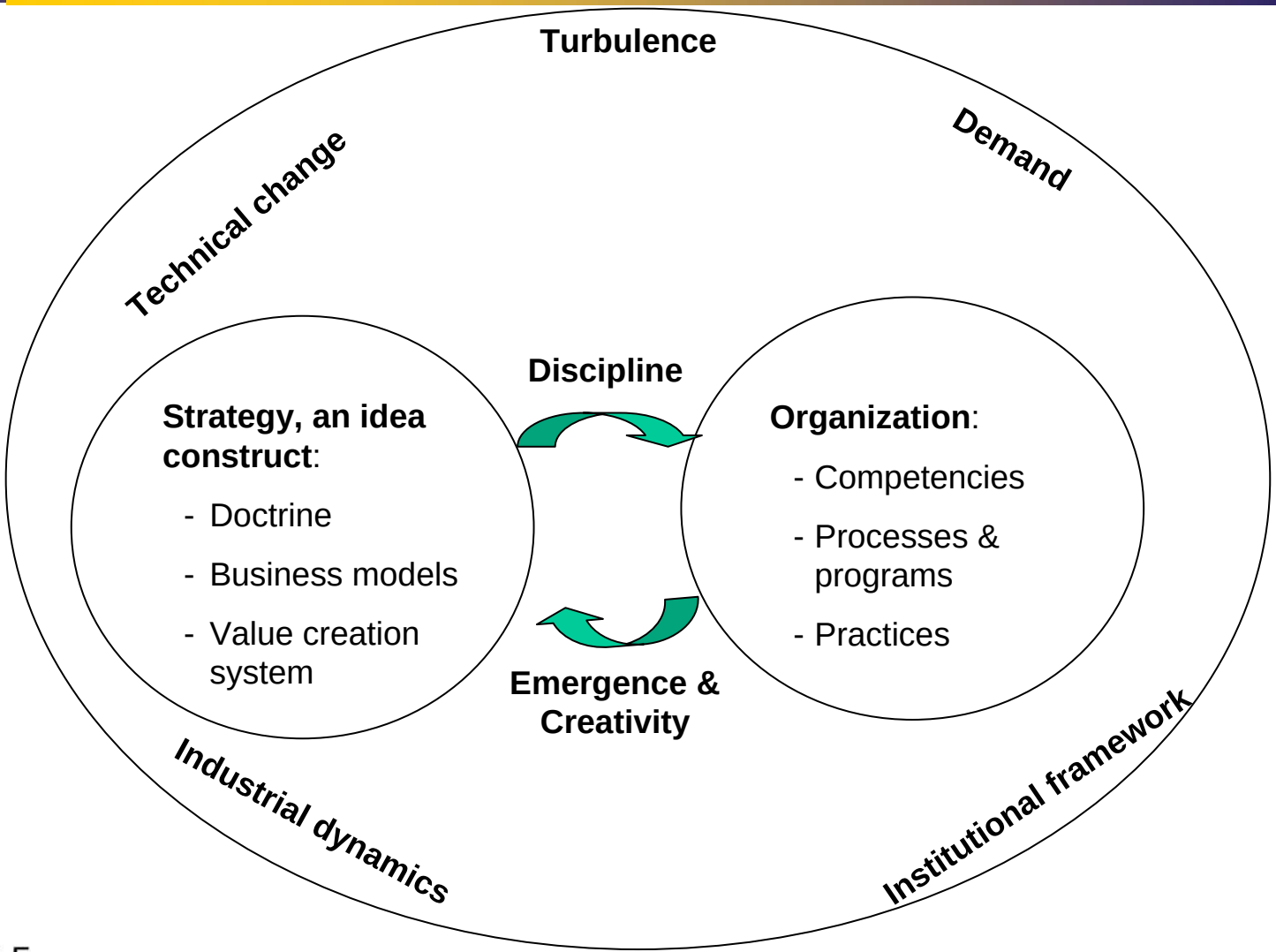
4.Conclusion: project dilemma and strategic principles

Project dilemma	Strategic principle
The forecasting dilemma	Planning for the journey rather than planning the journey
Strategic interdependency	Embracing interdependency and shared governance
Irreversible, indivisible exposure	Avoid locking in too early or too late
Dormant innovations	Unlocking latent solutions through trust-based relationships
Underinvestment in worthy projects	Tailoring public-private partnerships to internalize benefits
The dilemma of time	Stretching the front end and squeezing the back end
External effects	Seeking win-win solutions to accommodate stakeholders' interests

The strategic challenge: building discipline and innovation over time



Building on discipline and creativity, the firm builds its future and survive