Cairo University
Faculty of Engineering
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PROJECT MANAGEMENT COURSE

PROJECT DELIVERY SYSTEMS

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Outline

- The Long List of Project Delivery Methods
- Illustrative Examples of Typical Project Delivery Structures
- Project Delivering Systems (PDS)
- The Complexity of PDS Selection Process
- PDS Selection Methods
- Project Indicators Applied in the PDS Selection
- Risk Allocation in PPP projects
- Risk Mitigation
- Concluding Remarks

The Long List of Project Delivery Methods

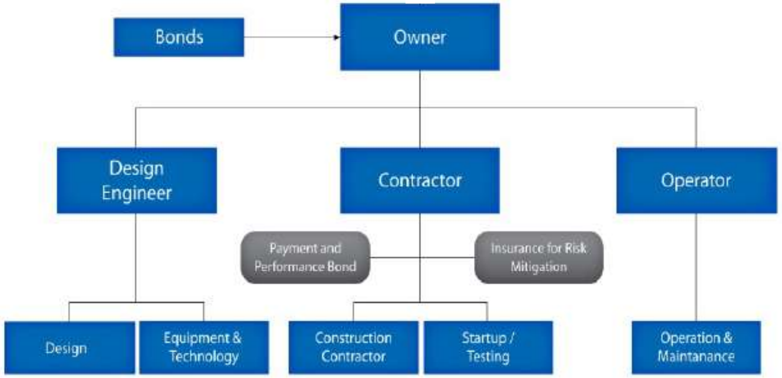
Strategy	Methodology
Traditional	• design-bid-build • multiple prime contracting
Collaborating	• agency construction management • construction management at risk • design-and-build • engineering-procurement-construction • Turn key
Integrative	• alliancing • partnering • integrated project delivery
Partnership	• build-operate-transfer • build-own-operate • build-own-operate-transfer • concession • design-build-finance-and-operate • private finance initiative • public private partnership

Source: KPMG International, Project Delivery Strategy: Getting It Right, 2010.

Illustrative Examples of Typical Project Delivery Structures

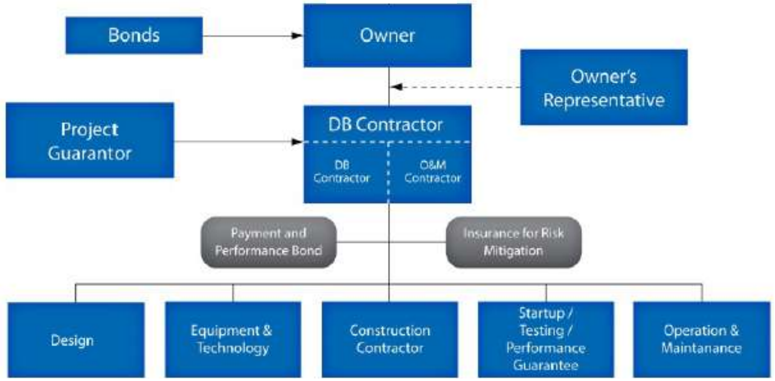
- Traditional Design-BID Build (DBB) Project Structure
- Design-Build-Operate (DBO) Project Structure
- Build-Own-Operate-Transfer Boot Project Structure
- CM@Risk Project Structure
- The JV Option

Traditional Design-BID Build (DBB) Project Structure



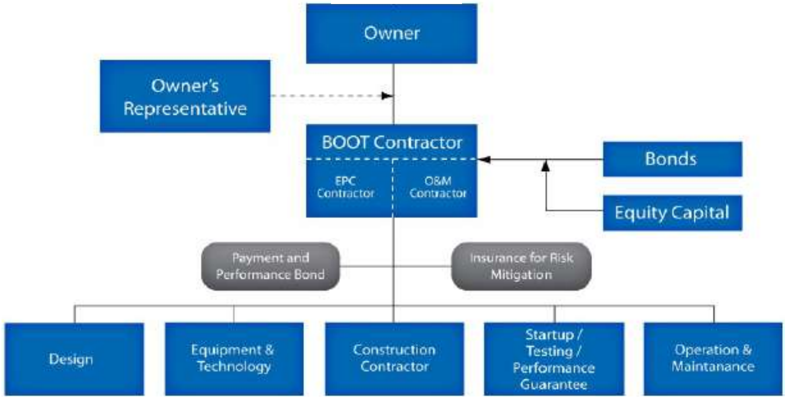
- “Low-bid” lump sum fee
- Simplest – understood by all municipal parties
- Construction contractor – independent oversight
- Owner must select the lowest responsive, responsible bidder
- Segments design, construction and operation
  - Reduces collaboration, promotes adversarial relationships
- Owner must own core competence in delivery of this asset type
- Owner desires extensive involvement in design
- Challenges:
  - Finger-pointing between designers and contractors
  - Projects falling behind schedule
  - Inability to accurately predict costs–Change orders
  - Litigated construction outcomes
  - Commissioning risk and fixes are owner’s responsibility

Design-Build-Operate (DBO) Project Structure



- Provides a single point of contract accountability
- Can provide for design innovation if a performance-based approach is taken
- Potential to reduce delivery schedule by 10 percent to 30 percent
- Potential to reduce capital cost by 5 percent to 20 percent
- Potential to reduce life-cycle project costs by 10 percent to 30 percent
- Provides more certainty about total project cost at an earlier stage
- Significantly reduces disputes between designer and construction contractor
- Allows owner to transfer performance and cost risks to D/B/O contractor

Build-Own-Operate-Transfer Boot Project Structure

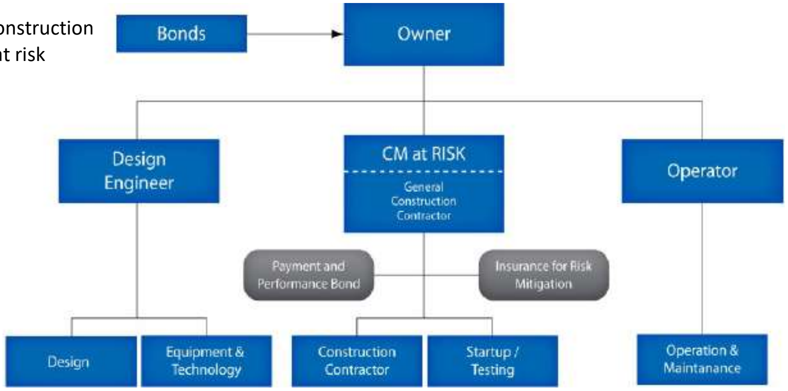


- Build/Own/Operate/Transfer (BOOT) can deliver all cost advantages of a Design/Build/Operate
- Greatest opportunity for design innovation through technical and financial competition
- Product water purchase under defined terms and conditions
- Includes schedule, product quality and cost performance guarantees and acceptance testing

CM@Risk Project Structure

- Retains high level of owner involvement
- Maintains traditional owner-design relationship
- Facilitates conventional permitting
- Reduces delivery schedule
- Construction management expertise provided during design period
- Some risk mitigation potential
- Open book costs
- Guaranteed maximum cost

CMAR = construction manager at risk



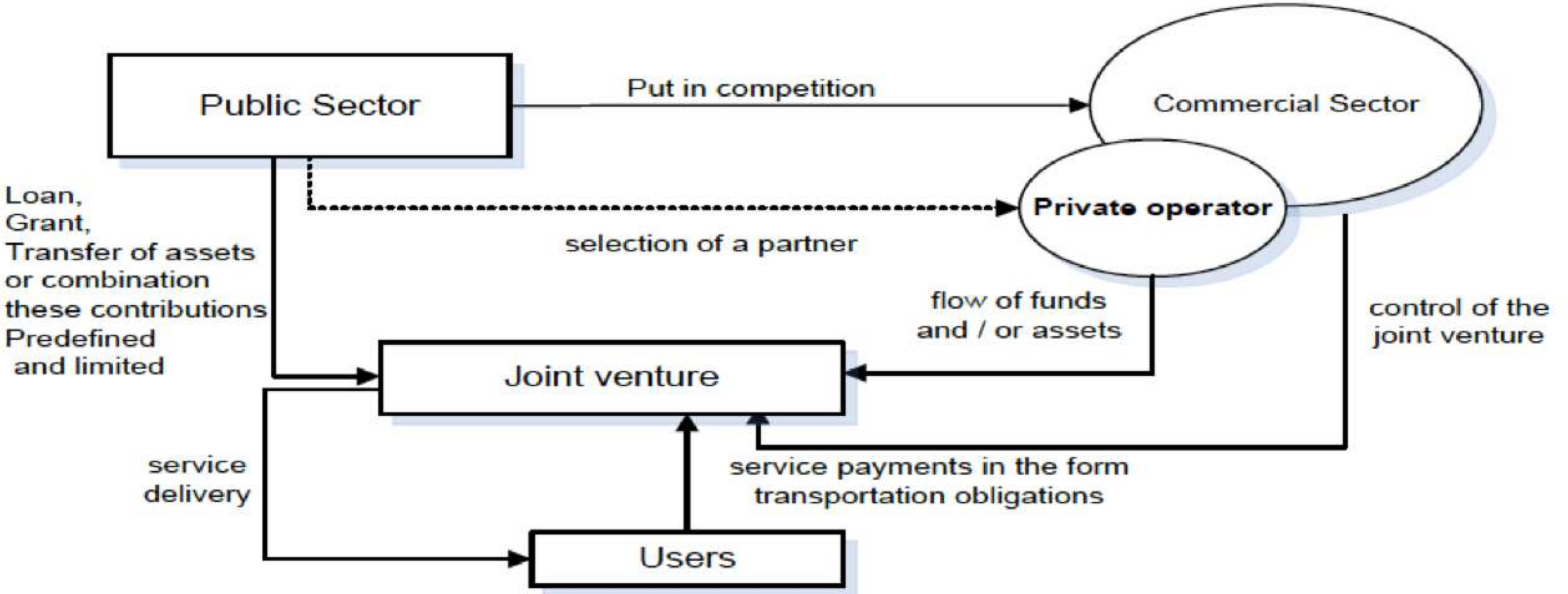
The JV option

- The owner may contribute to the long-term equity capital of the Special Project Vehicle (SPV) in exchange of shares. In such a case, the SPV is established as a joint venture company between the public and private sectors and the owner acquires equal rights and equivalent interests to the assets within the SPV as other private sector shareholders.

- The main reasons for such direct involvement may include:
  - To hold interest in strategic assets;
  - To address political sensitivity and fulfil social obligations;
  - To ensure commercial viability of the project;
  - To provide greater confidence to lenders; and
  - To have better insight to protect public interest.

The JV Project Structure

PFI as a joint venture public-private: - The case of Channel Tunnel Rail Linkn



Source: Chohra et al, Desalination in Algeria paper

Project Delivery System (PDS)

- PDS describes how the project participants are organized to interact, transform owners objectives into finished facilities and services
- PDS defines the process by which the finance, design, construction, operation and maintenance activities of the project are executed
- PDS is one of the main “Critical Success Factors”, affects: project schedule, cost, quality and contract management
- PDS selection models try to predict project future performance under different PD methods

The Complexity of PDS Selection Process

1. The PDS selection involves the consideration of numerous PDS alternatives (e.g. DBB, DB, CM@Risk, BOT, BOOT,…). These PDSs vary in several aspects. A PDS that can achieve certain project objectives better than others may also perform worse on some other objectives. No single PDS is appropriate for all types of projects under all circumstances.

2. The PDS selection requires the consideration of different groups of factors such as client's objectives, project characteristics and external environment . The variety of these factors and their interrelationships (e.g. a conflicting relationship between time and cost) further complicates the PDS selection problem.

3. The decision often involves great uncertainty because it is made at the early stage of a project, a time when only limited information is available.

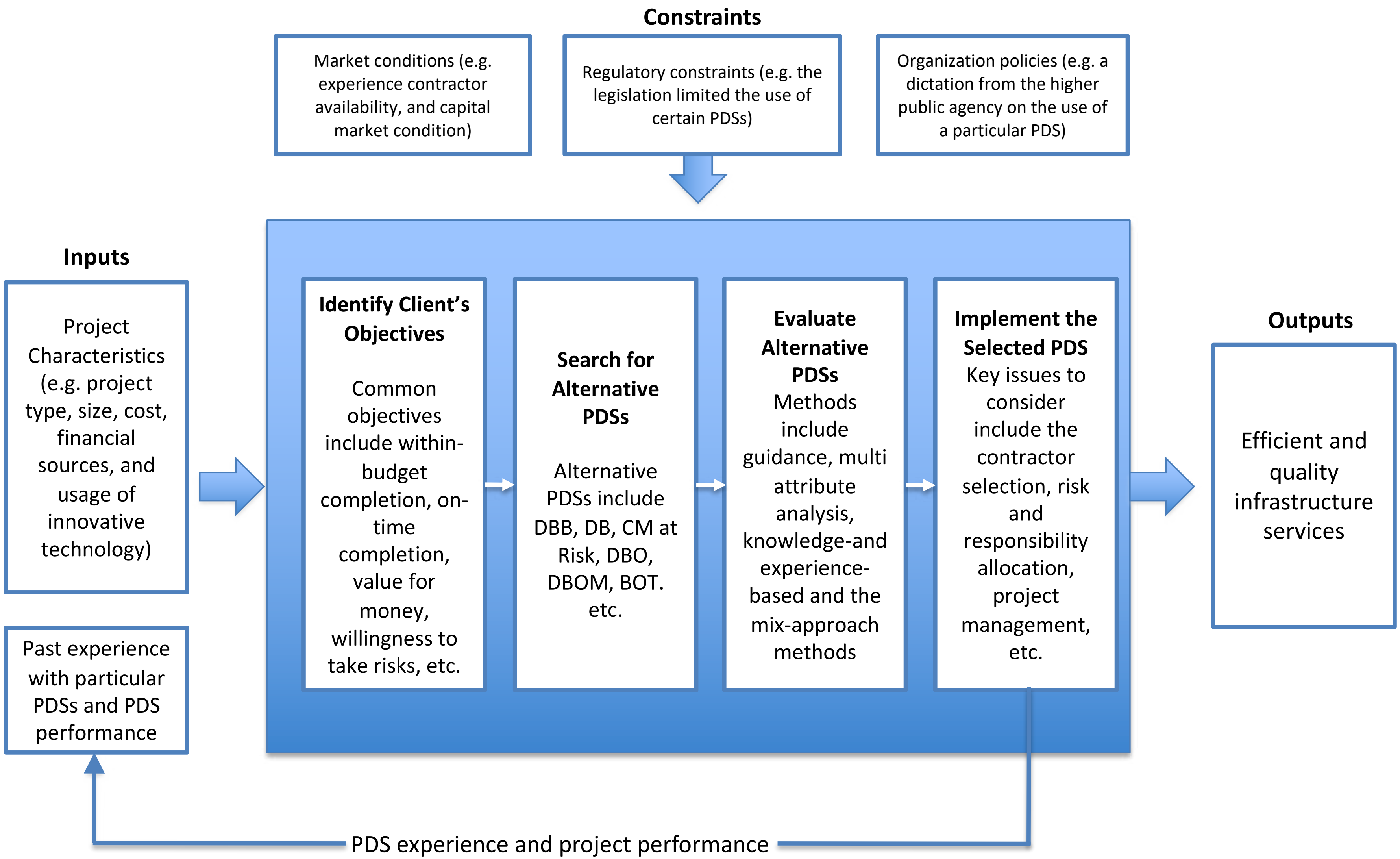
4. The decision is made in a multi-project environment, where complex interdependencies exist. The understanding and consideration of project interdependencies id essential.

Ibbs and Chih Review 2011

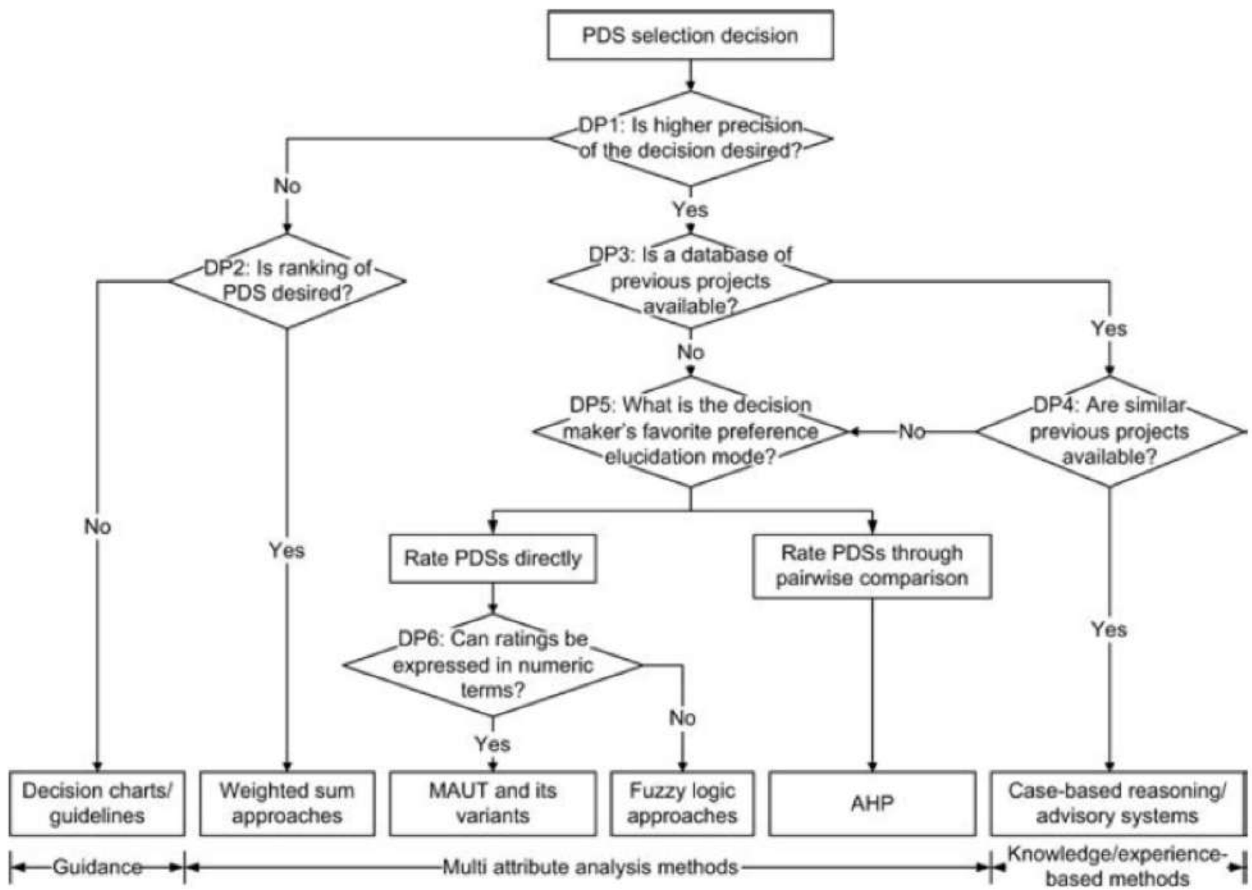
PDS selection methods

Category	Methods
Guidance	Individual PDSs
	Comparison of alternative PDSs
	Formalized framework and guidelines
	Decision charts
Multi-attribute Analysis	Weighted sum approach
	Multi-attribute utility/value theory (MAUT/MAVT)
	Analytical hierarchical process (AHP)
	Fuzzy logic approaches
Knowledge/experience based methods	Case-based reasoning approach (CBR)
	Decision support system
Mix-method approaches	AHP/value engineering (VE/multicriteria multiscreening AHP/mean utility values MAUT/project database A qualitative assessment/a weighted score approach

General Framework of the PDS Selection Process and Link to Project Implementation



Conceptual framework for choosing a suitable PDS selection method



Ibbs and Chih, Facilities, 2011

Decision points

DP1. Determine if the higher precision of the decision is desired.

DP2 . Determine if the ranking of PDSs is still desired even when a highly precise decision is not required. If it is, the decision maker should choose the weighted sum approach. Otherwise, the guidance-type methods are considered to be appropriate.

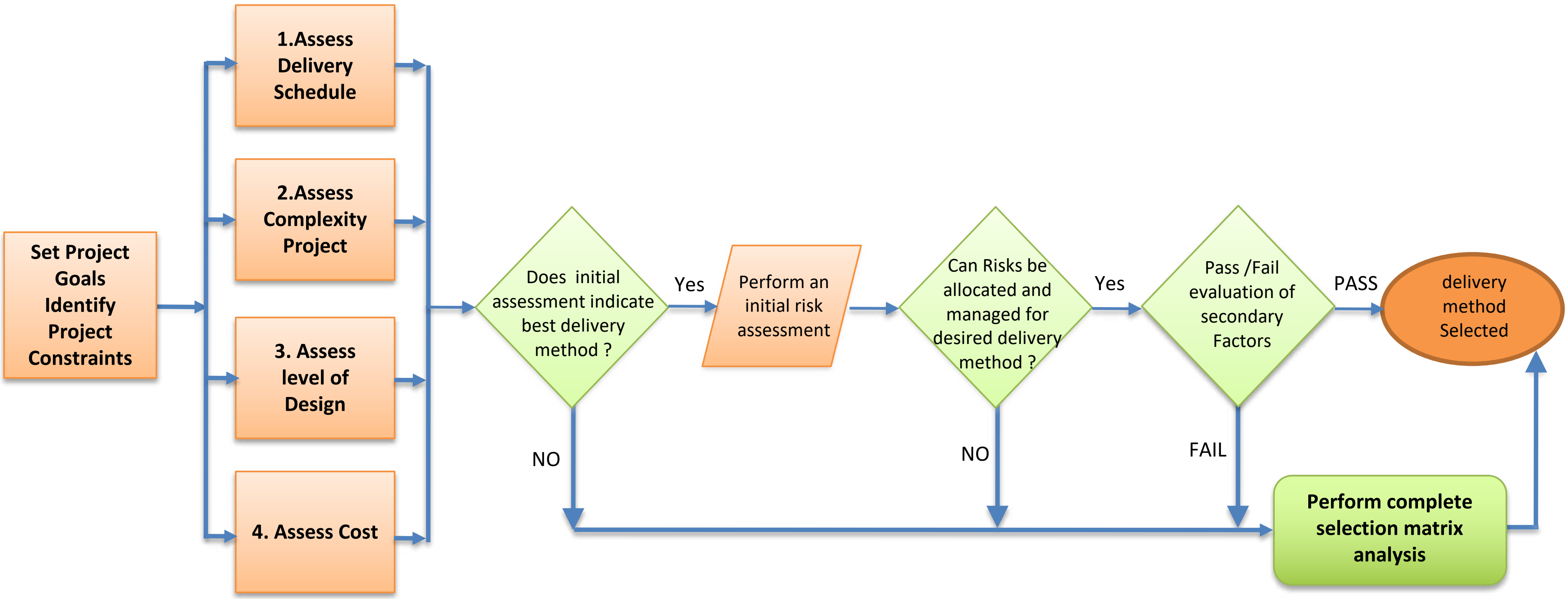
DP3 . Determine if a database of previous projects is available. This DP concerns the information required for a PDS selection method.

DP4. Determine if previous similar projects are available in the database. This DP investigates the quality and quantity of information in the database.

DP5. Determine the decision maker’s preferred elucidation mode. If the decision maker is more comfortable with a pairwise comparison, AHP is recommended. If he or she prefers to rate PDSs directly, it is not.

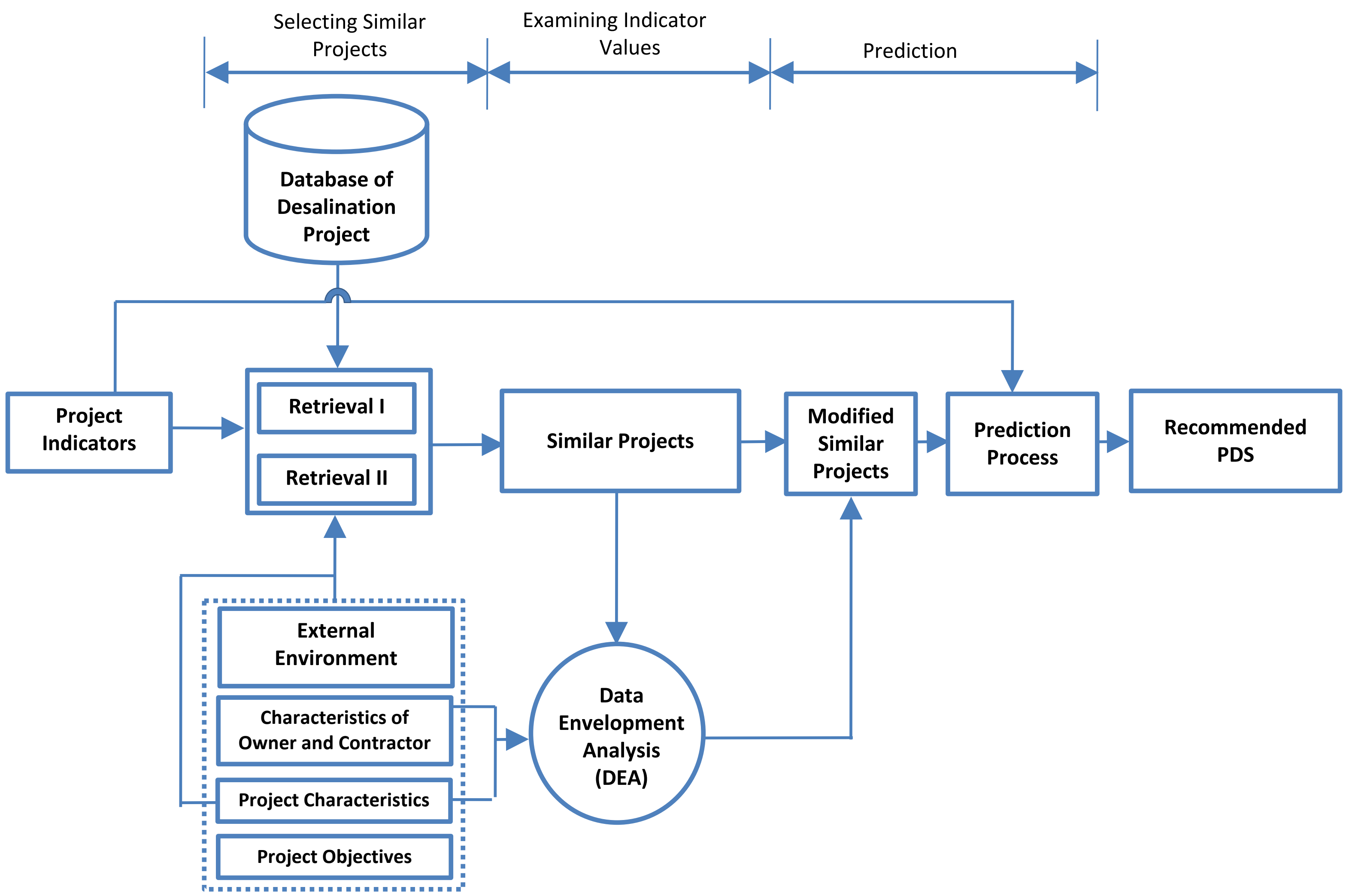
DP6. Determine if the ratings of PDSs can be expressed in numeric terms. If a decision maker prefers to express the preferences in linguistic terms, a fuzzy logic approach is suggested. If numeric expressions are possible, MAUT and its variants are more suitable.

Risk-Based PDS Selection flowchart



Guidebook for Selecting Project Delivery Methods
and Alternative Contracting Strategies, University of Colorado 2012

PDS Selection Using Data Envelopment Analysis 1



Chen et al, Expert Systems and Applications, 2011

PDS Selection Using Data Envelopment Analysis 2

Project indicators applied to the PDS selection

Project objectives
Delivery speed
Schedule delay
Cost growth
Cost certainty
Quality performance
project characteristics
Project type
Project scale
Complexity
Ability to define the project scope
Flexibility
Disputes
Characteristics of owner and contractor
Owner's willingness to be involved
Owner's willingness to take risks
Owner's available human resources
Contractor's capability
External environment
Market competitiveness
Regulatory feasibility
Technology availability

PDS Selection Using Data Envelopment Analysis 3

Table 2 Description of indicators of project objectives

Indicators	Description
Schedule delay	$=\frac{\text{Actual duration} - \text{Normal anticipated duration}}{\text{Normal anticipated duration}}$
Cost growth	$=\frac{\text{Actual contract price} - \text{Original contract price}}{\text{Original contract price}}$
Project quality	$=\frac{\text{Material quality} + \text{Workmanship quality} + \text{Design quality}}{3}$
Where:	
Material quality	$=\frac{\text{Amount of money paid for extra material fees for better quality than the normal}}{\text{Total material fee of the normal}}$
Workmanship quality	$=\frac{\text{Amount of money paid for extra workmanship fees for better quality than the normal}}{\text{Total workmanship fee of the normal}}$
Design quality	$=\frac{\text{Amount of money paid for extra design fees for better quality than the normal}}{\text{Total design fee of the normal}}$

PDS Selection Using Data Envelopment Analysis 4

Description of indicators of project characteristics

Indicators	Description
Project type	Industrial, infrastructure and building projects
Project scale	Project scale is measured with scale 1-9 to represent the amount of project cost 1 = much low than the average level 9 = much higher than the medium
Project complexity	= Number of extra working packages resulting from the need for extra complexity Number of total working packages of a project with basic complexity
Ability to define the project scope	= 1 – Variation caused by the indefinite project scope at contract signing Total variation
Flexibility	=Anticipated variations Original contract sum
Disputes	=Loss directly caused by disputes Original contract sum

PDS Selection Using Data Envelopment Analysis 5

Description of indicators of characteristics of owner and contractor

Indicators	Description
Owner's willingness to be involved	$= \dfrac{\text{Total time of direct involvement of owner in the project}}{\text{Total project time}}$
Owner's available personnel	$= \dfrac{\text{Working hours expected to be spent by owner}}{\text{Owners available working hours}}$
Owner's willingness to take risks	$= \dfrac{\text{Variations incurred to the client only}}{\text{Total variations}}$
Contractor's capability	This indicator is defined by scale 1-9. 1 means low level in specialty and management capabilities while scale 9 means high level in these capabilities.

Risk Allocation in PPP projects

Preferred Risk allocation in PP projects

AllocationZ	Risk factors	Level
Public sector	Nationalization/expropriation Strong political interference Change in tax regulation Changes in legal regulatory framework Site availability	Macro Macro Macro Macro Meso
Private sector	Geological conditions Weather Environment Poor financial market Availability of finance Financial attraction of project to investors High finance cost Design deficiency Construction cost overrun Construction time delay Material availability Poor quality workmanship Site safety and security Operation cost overrun Low operation productivity Maintenance cost higher than expected Maintenance more frequent than expected Organizational and communication risk	Macro Macro Macro Macro Meso Meso Meso Meso Meso Meso Meso Meso Meso Meso Meso Meso Meso Micro
Shared	Inflation Interest rate Force majeure Residual asset risk Scope variation Inadequate distribution of responsibilities Inadequate distribution of authority Differences in working method Lack of commitment between parties	Macro Macro Macro Meso Meso Micro Micro Micro Micro
Negotiated based on specific circumstances	Delay in approvals and permits Unproven engineering techniques Excessive contract variation	Meso Meso Meso

Lessons learned from previous PPP projects

Understanding Impacts of Time and Cost Related Construction Risks on Operational Performance of PPP Projects

The review revealed that:

- Site conditions and design complexity are among the most critical risk attribute influencing time performance in projects.
- Market dynamics is the most critical attribute influencing both construction cost and operational performance in PPP projects.
- Partner's dispute was found to be a good determinant of time and cost performance.
- Technical obsolescence has significant impacts on the operational performance of PPP projects.
- Design complexity, financial structure and government policy are the three main common factors affecting risks across time, cost and operational performance in PPP projects.

Doloi, Int Jl Strategic Property Management , 2012

Lessons Learned 1:
Risk factors: Project cost performance

Factors	Variables	Factor loading	Variance explained
Factor 1: Planning and design	5. Change in scope 4. Defects in design 1. Changes in output specification 2. Innovative design 11. Delay in operation	0.866 0.835 0.569 0.543 0.538	22.65%
Factor 2: Communications	23. Lack of cooperation of the government 30. Misinterpretation of contract 32. Failure/delay in obtaining permit/approval 29. Partner's disputes 9. Failure/delay in material delivery 26. Lack of communication between stakeholders	0.853 0.850 0.716 0.577 0.507 0.476	18.05%
Factor 3: Site conditions	38. Commercial rights due to development in vicinity 41. Site contamination 37. Adverse changes in tax 42. Force Majeure	0.871 0.858 0.614 0.520	14.05%
Factor 4: Market dynamics	36. Adverse changes in interest rates 35. Financial failure of private consortium 21. Unanticipated inflation 33. Unavailability of financing	0.883 0.856 0.716 0.674	11.60%
Factor 5: Construction risk	6. Constructability 28. Destructive industrial action 8. Unforeseen site condition 7. Failure/delay in site acquisition	0.870 0.840 0.774 0.753	8.85%
Factor 6: Policy, legislation & regulation	17. Unanticipated economic downturn 18. Increased competition 24. Misunderstanding the role of stakeholders 31. Adverse changes in law, policy or regulations	0.119 0.112 0.743 0.722	7.65%
		Total variance explained =	82.85%

Lessons Learned 2: Risk factors: project time performance

Factors	Variables	Factor loading	Variance explained
Factor 1: Market fluctuations	18. Increased competition 38. Commercial rights due to vicinity of development 36. Adverse changes in interest rates 17. Unanticipated economic downturn 37. Adverse changes in tax 21. Unanticipated inflation	0.913 0.887 0.877 0.863 0.843 0.833	21.65%
Factor 2: Stakeholder management	24. Misunderstanding the role of stakeholders 31. Adverse changes in law, policy or regulations 29. Partner' disputes 27. Public resistance 25. Change of stakeholder	0.824 0.812 0.628 0.569 0.536	17.55%
Factor 3: Quality control	32. Failure/delay in obtaining permit/approval 14. Failure/delay in commissioning test 10. Defects in construction 41. Site contamination 28. Destructive industrial action	0.773 0.736 0.557 0.531 0.470	12.35%
Factor 4: Scope variations	5. Change in Scope 7. Failure/delay in site acquisition 20. Adverse changes in law, policy or regulations 42. Force Majeure	0.889 0.751 0.632 0.453	9.55%
Factor 5: Design complexity	2. Innovative Design 33. Unavailability of financing 3. Design Complexity	0.905 0.641 0.579	8.53%
Factor 6: Design constructability	6. Constructability 4. Defects in Design 8. Unforeseen site condition	0.771 0.756 0.455	7.75%
Factor 7: Communication management	30. Misinterpretation of contract 26. Lack of communication between stakeholders 23. Lack of cooperation of the Government	0.823 0.695 0.573	7.05%
Total variance explained = 84.43%			

Lessons Learned 3:
Risk factors: operational performance

Factors	Variables	Factor loading	Variance explained
Factor 1: Market dynamics	36. Adverse changes in interest rates 38. Commercial rights due to vicinity of development 22. Withdrawal of government support 21. Unanticipated inflation 33. Unavailability of financing 7. Failure/delay in site acquisition	0.932 0.840 0.805 0.786 0.693 0.612	22.90%
Factor 2: Competitive operations	15. Demand below anticipation 17. Unanticipated economic downturn 19. Technical obsolescence 18. Increased competition 14. Failure/delay in commissioning test 30. Misinterpretation of contract	0.902 0.814 0.747 0.715 0.588 0.407	18.90%
Factor 3: Site conditions	41. Site contamination 31. Adverse changes in law, policy or regulations 39. Service and maintenance 40. Less residual value 13. Excessive maintenance and refurbishment	0.940 0.872 0.770 0.755 0.514	14.35%
Factor 8: Stakeholder's management	27. Public resistance 10. Defects in construction 28. Destructive industrial action 26. Lack of communication between stakeholders 29. Partner' disputes 31. Adverse changes in law, policy or regulations	0.791 0.667 0.464 0.653 0.601 0.529	12.65%
Factor 6: Post construction management	11. Delay in operation 24. Misunderstanding the role of stakeholders 12. Adverse impact of core services 25. Change of stakeholder	0.769 0.699 0.689 0.615	8.00%
Factor 7: Design complexity	4. Defects in design 3. Design complexity 2. Innovative design 1. Changes in output specification	0.875 0.834 0.665 0.657	7.90%
Total variance explained = 84.70%			

Risk Mitigation 1

Top Risks

- Changes in Schedule
- Changes in Cost
- Financial Risks
- Payment/Credit Risks
- Contractual Risks
- Technical/Design/Eng Risks
- Not Meeting Owner Expectations
- Not meeting Required Quality

Risk Evaluation Strategies

- Formal Brainstorming with Project Team
- Expert Input- Internal
- Expert Output- External
- Use of Checklists/ forms/ Risk Registers

Risk Mitigation 2

Risk Mitigation Strategies

- Contingency plan
- Develop Plan to manage Risks
- Regular Risk Meetings with Full Project Team
- Tracking Risk metrics Across project
- Special team to Monitor/ Mitigate Risk Throughout Project Life Cycle

Tools for Risk Assessment and Mitigation

- Statistical Modeling (such as Monte Carlo Simulation)
- Off-Shelf Software
- Internally-developed software

Concluding Remarks

- The short list of Project Delivery Methods includes Include DBO, BOT, BOOT, JV
- The short list of PDS method of selection includes Decision Charts, Multi-Attribute Utility Analysis and Analytical Hierarchal Process (AHP)
- Risk Analysis and Risk Mitigation Plans may be based on the wealth of lessons learned in previous projects.