

BCVR Methodology: A Holistic Approach for Industrial Performance Management

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IIEC Conference, February 7-8, 2018, Tehran, Iran



- ❖ Introduction
- ❖ Industrial performance
- ❖ BCVR (Benefit, Cost, Value & Risk) methodology
- ❖ Experimental application
- ❖ Conclusions & perspectives



«YOU CAN'T MANAGE WHAT YOU CAN'T MEASURE»

Paradigm shift (over the 20th century):

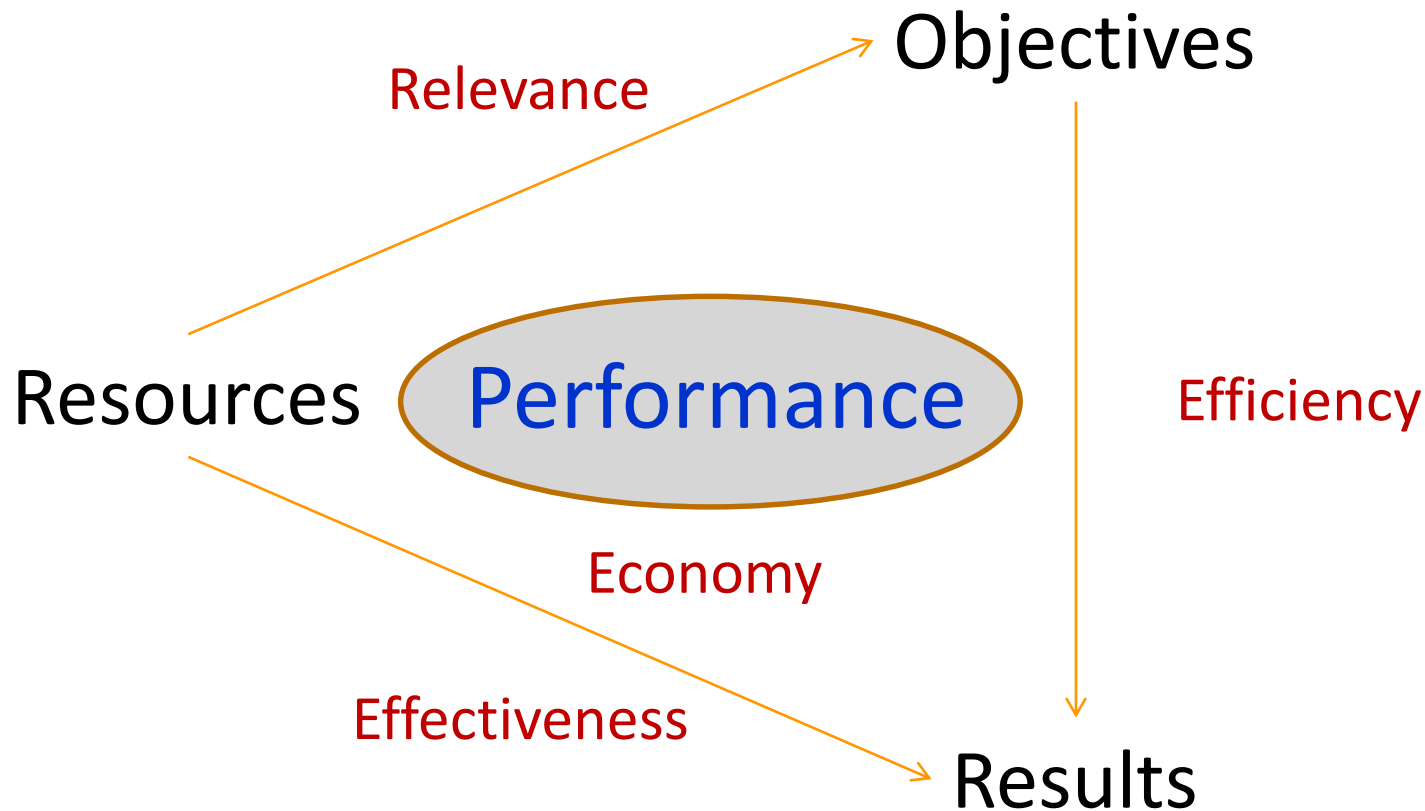
- Cost measurement → Cost management,
and then
- Perf. measurement → Perf. management

Performance

- Is about the **degree of satisfaction** of a goal/objective/requirement/need
- Is a relative concept:
 - Depends on the objective
 - Varies over time
- Is a multi-criteria concept
- Financial vs. non-financial criteria

- **Performance** (European Court of Auditors)
 - Efficiency
 - Effectiveness
 - Economy
- **Industrial Performance** (QCD paradigm)
 - Quality
 - Cost
 - Delay



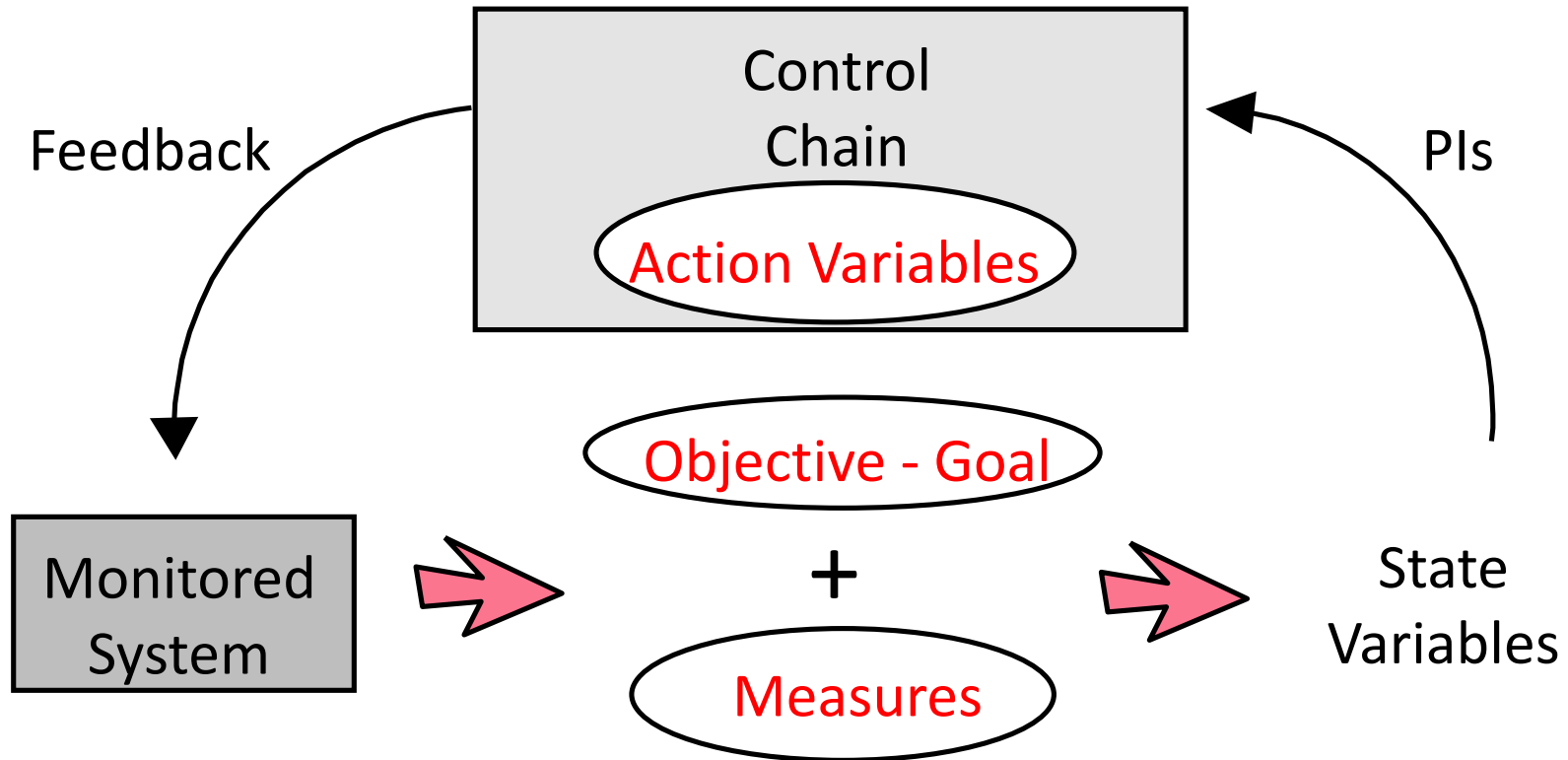


(From Bescot, 1995 and Jacot, 1996)

- **Performance Evaluation:** is about how an objective has been (or is) achieved/fulfilled
requires
- **Performance Indicators (PIs):** Evaluation of performance elements / measures
aggregated into a
- **Global Performance:** A measure of the achievement of the global objective(s)

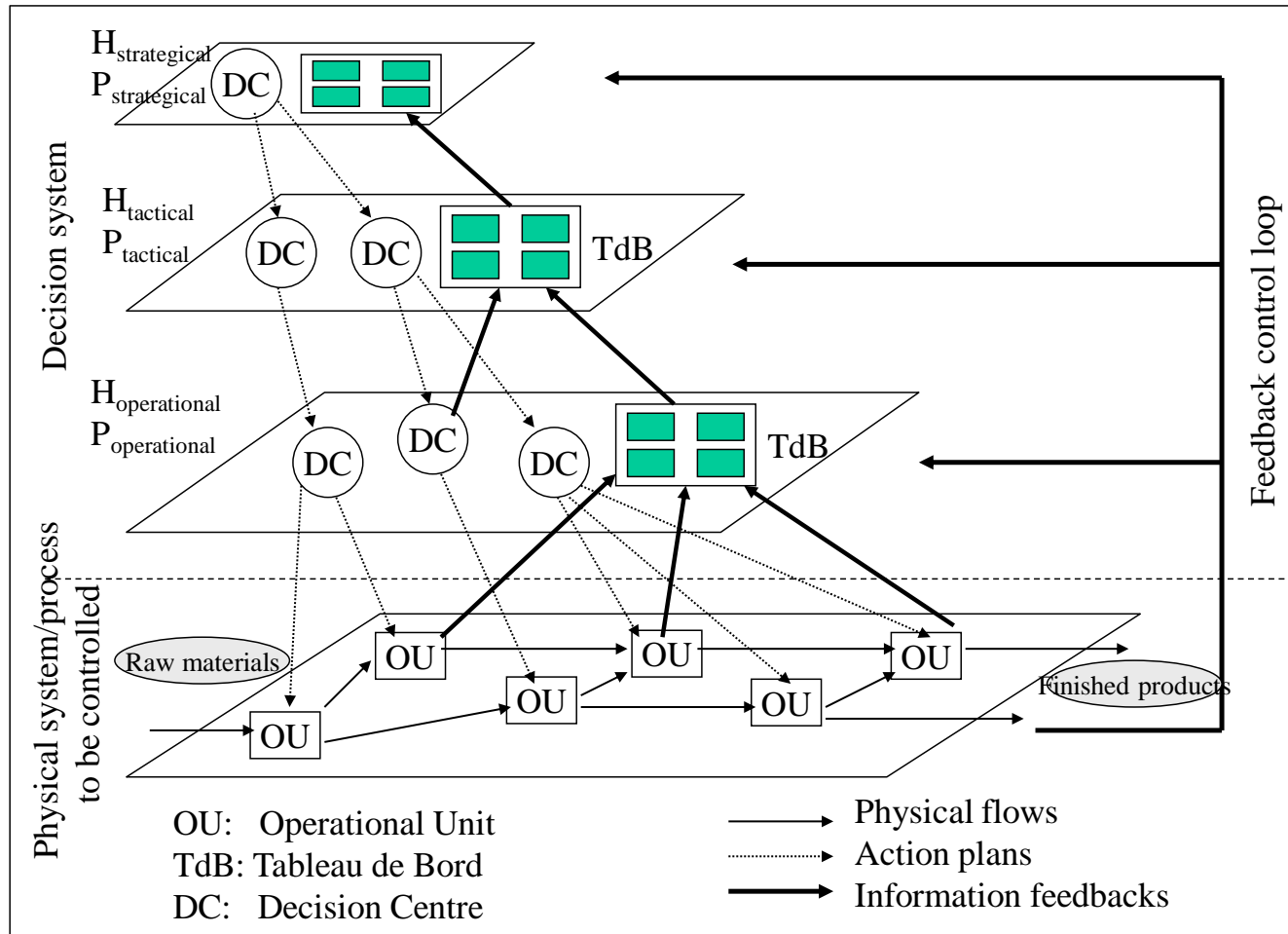
Two Types of Performance Indicators:

- **Result Indicators** (*a posteriori* evaluation)
After the fact (measures, statements...)
(nb of parts made, nb of scraps, availability rate, prod cost...)
- **Process Indicators** (*on-line* evaluation)
During the fact (trends, thresholds...)
Are part of the decision-making process
(increase rate of scraps per hour, reach 5% below limit threshold...)



Controlability: (objective, measure, (action) variable)

(Berrah & Vernadat, 2002)



- Fundamental questions:
 - How to define the PI's (to be RACER)? Where?
 - How many? Performance dashboard or PMS?
 - How to aggregate performance elements in PMS?
 - How to handle the multicriteria dimension of performance?
 - When should PI's be questioned/revised?

(RACER: Relevant, Accepted, Credible, Easy, Robust)

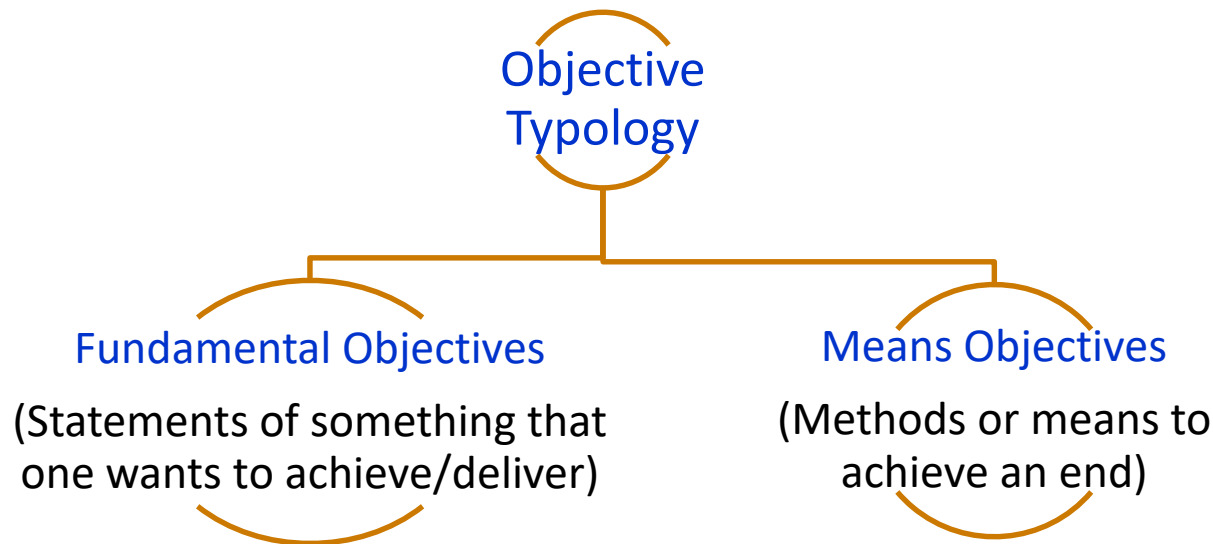
- Global vs. elementary objectives
- Global vs. elementary performance
- Performance measurement & aggregation

Objective analysis is fundamental

Elementary objective \leftrightarrow Performance indicator

Global objective \leftrightarrow Global performance

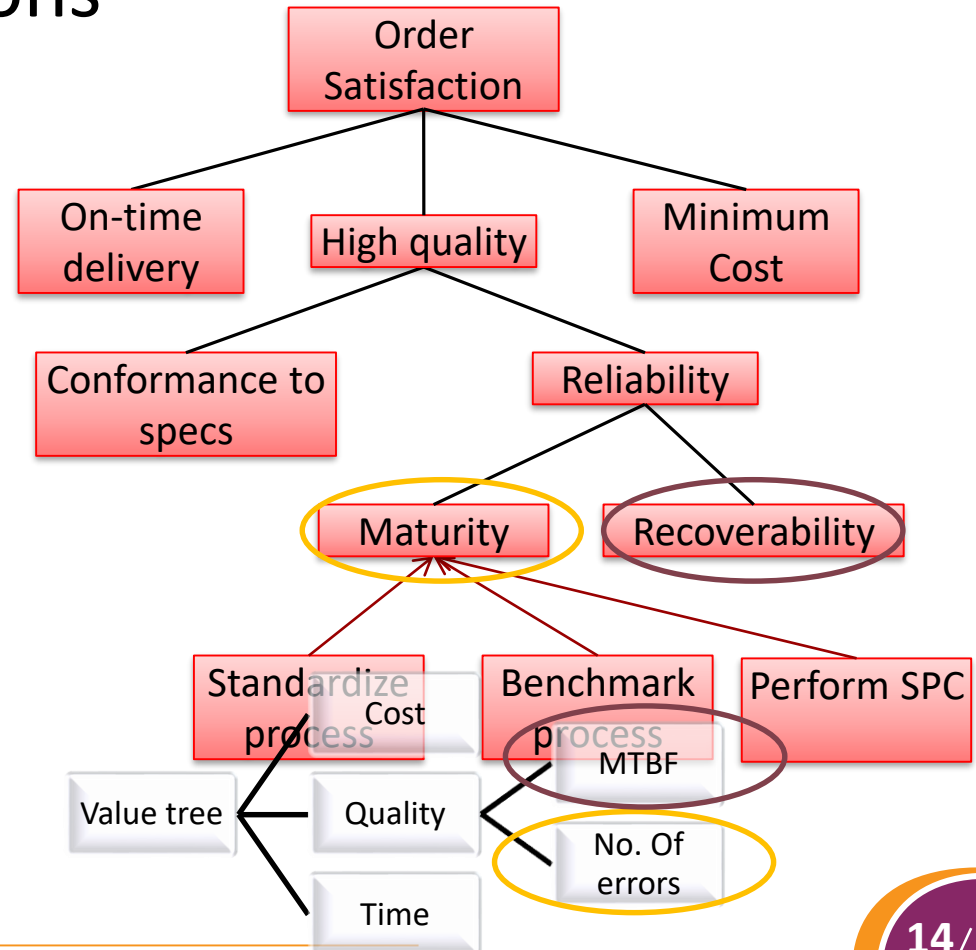
- Value-Focused Thinking (VFT) Method for objective identification and break down:



(Keeney, 1996)

Objectives: SMART statements reflecting stakeholders expectations

- 1. Identify overall fundamental objective
- 2. Identify fundamental sub-objectives (Q: *What do you mean by that?*)
- 3. Derive performance measures/criteria
- 4. Identify means objectives (Q: *How can this be achieved?*)



- **Elementary performance** expression is the result of the **comparison** between a measure and an elementary objective
- **Global performance** expression is the result of the **aggregation** of elementary expressions of sub-objectives

$$f : O \times M \rightarrow P$$

$$(o, m) \rightarrow p = f(o, m)$$

➤ Ratio measure

$$\rightarrow p = \frac{m}{o}$$

➤ Distance measure

$$\rightarrow p = |o - m|$$

➤ Format and properties of p

↳ Performance measure ➤ Any domain

➤ Degree of achievement of the objective

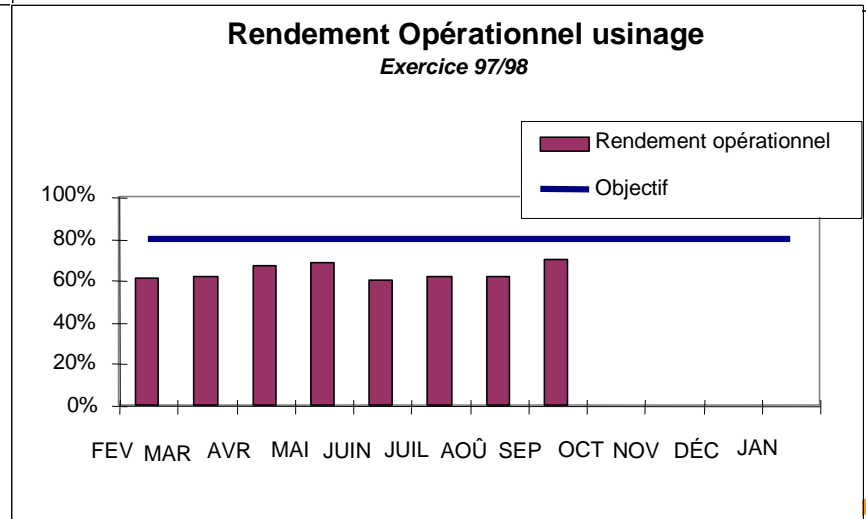
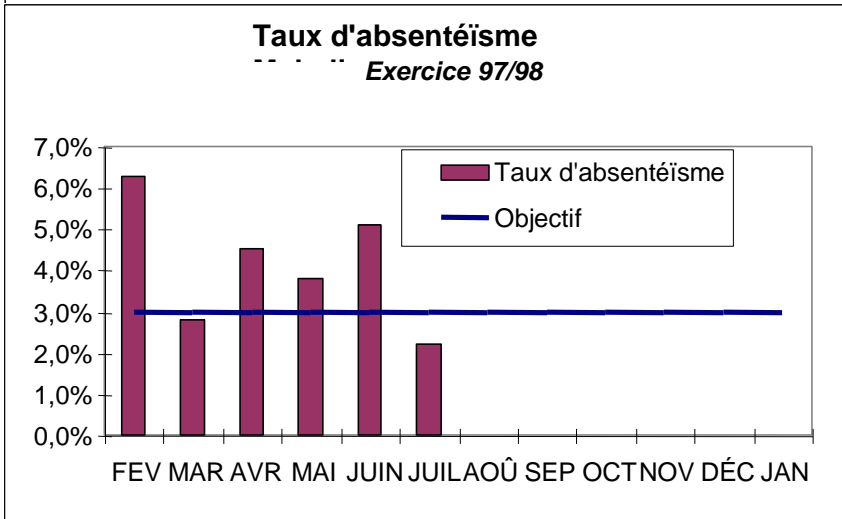
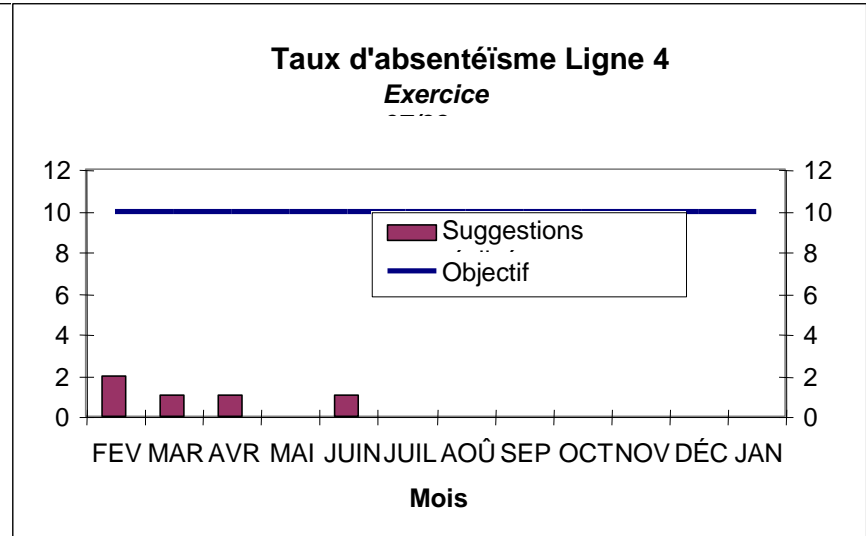
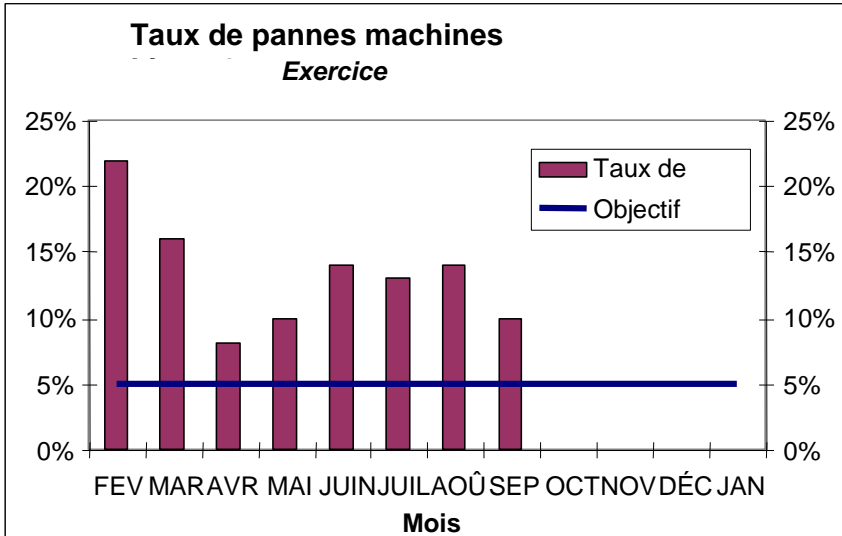
↳ Performance evaluation ➤ $[0,1]$ (Berrah, 2001)

➤ Satisfaction of the decision-maker

Examples of PIs

<p>Cost / Volume</p>	$\text{Productivity} = \frac{\text{number of parts made}}{\text{number of hours spent}}$ $\text{Efficiency} = \frac{\text{quantity made} \times \text{allocated time}}{\text{elapsed time}}$ $\text{Costs_Purchase} = \frac{\text{amount of purchase}}{\text{annual sales}}$
<p>Quality</p>	$\text{Return_Ratio} = \frac{\text{number of returned deliveries}}{\text{total number of deliveries}}$ $\text{Re works} = \frac{\text{number of hours of rework}}{\text{number of hours worked}}$ $\text{Scrap rate} = \frac{\text{number of scrap parts}}{\text{number of parts made}}$
<p>Delay</p>	<p><i>Delivery date/customer due date</i></p> $\text{Production throughput} = \text{production start date} - \text{end date}$ $\text{Customer service} = \frac{\text{orders delivered in time}}{\text{delivered orders}}$

Tableaux de bord or PMS exemple



$$Ag : P_1 \times P_2 \times \dots \times P_n \rightarrow P$$

$$(p_1, p_2, \dots, p_n) \rightarrow p_{ag} = Ag(p_1, p_2, \dots, p_n)$$

↳ **Commensurability** ➤ $P_1 = P_2 = \dots = P_n = [0, 1]$
(MACBETH technique)

↳ **Aggregation operators** ➤ **Weighted Means**

➤ Relative criteria importance

➤ Interactions between criteria **Choquet Integral:
2-additive**

(Berrah & Clivillé, 2002)

2-additive Choquet Integral:

$$p_{ag} = Ag(p_1, \dots, p_i, \dots, p_n) = \sum_{i=1}^n \phi_i p_i - \frac{1}{2} \sum_{i,j=1, j>i}^n I_{ij} |p_i - p_j|$$

$$\left(\phi_i - \frac{1}{2} \sum_{j=1, j>i}^n |I_{ij}| \right) \geq 0 \quad \forall i \in [1, n] \quad \text{et} \quad I_{ij} \in [-1, 1]$$

↳ ϕ_i **Shapley index**: weight of i^{th} criterion, which takes into account its importance in the coalitions in which it intervenes

↳ I_{ij} **Mutual interaction coefficient** between the i^{th} and j^{th} criteria: mean of mutual interactions between the two criteria, wrt all criteria

If $p_i \neq p_j$, with respect to the mean

p_{ag} is unchanged if $I_{ij} = 0$ independence between criteria

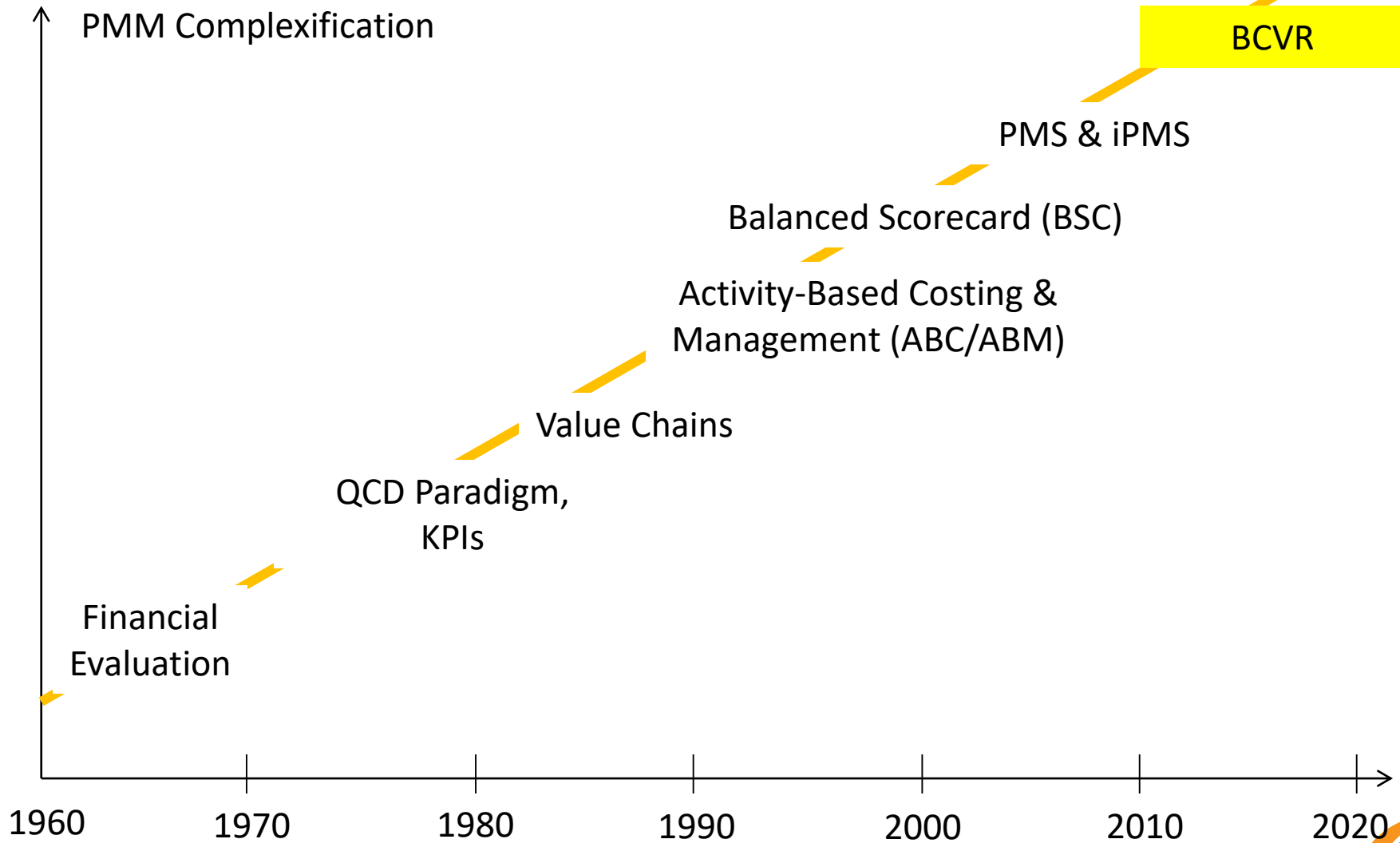
p_{ag} increases if $I_{ij} < 0$ synergy among criteria
(*weighted mean*)

p_{ag} decreases if $I_{ij} > 0$ contradiction between the criteria

Performance Aggregation Example

	C1	C2	C3	C4	P_{ag}	R1	R2	R3	R_{ag}
PP1	0.6	0.9	0.89	0.33	0.56	1.0	0.22	0.1	0.36
PP2	0.5	0.6	0.78	0.17	0.39	0.29	0.11	0.2	0.18
PP3	0.2	-0.2	0.44	1.0	0.12	1.0	0.14	0.44	0.42
v_i	0.34	0.24	0.28	0.14		0.47	0.18	0.35	
I_{ij}	I_{12}	I_{13}	I_{14}	I_{23}		I_{12}	0.052		
	0.049	0.131	0.049	0.098		I_{13}	0.052		
	I_{24}			I_{34}		I_{23}	0.10		
	0.016			0.081					

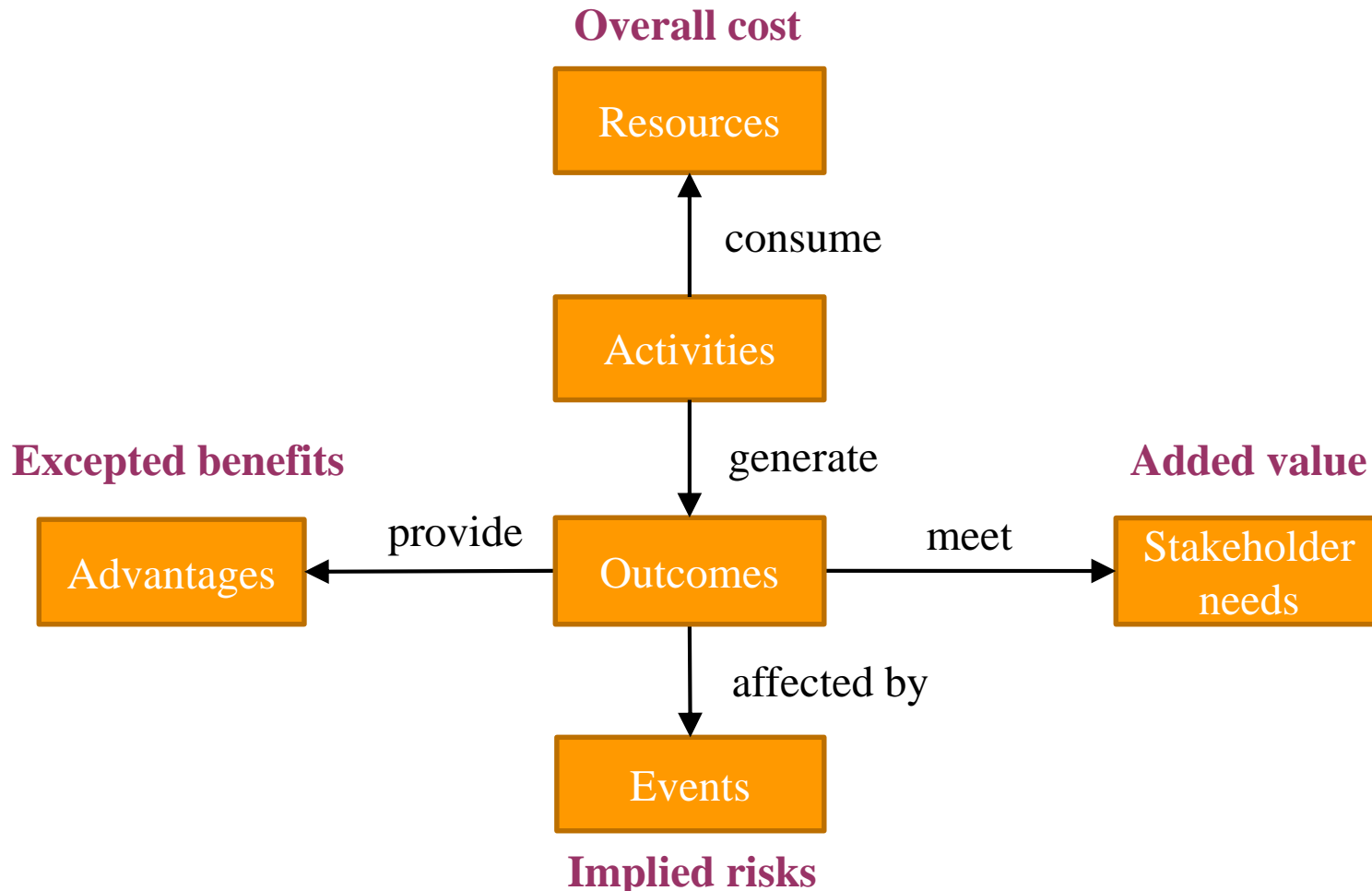
Performance Measurement & Management (PMM) Evolution



- ABC/ABM (Cooper & Kaplan, 1990)
- Balanced Scorecard (BSC) (Kaplan & Norton, 1992)
- ECOGRAI (Bitton, 1990)
- QMPMS: Quantitative model for PMS (Bititci, 1995)
- IDPMS: Integrated Dynamic PMS (Ghalayini et al., 1997)
- IPMF: Integ. Perf. Meas. Framework (Medori, 2000)
- Performance Prism (Neely et al., 2002)
- ENAPS (Browne, 1999)

BCVR Methodology: Motivation

Our claim: The performance of an industrial system can be comprehensively measured and managed using four dimensions: benefit, cost, value and risk



❖ Benefit

A qualitative list of **potential advantages or gains** for a given stakeholder compared to an objective that is set beforehand with the realisation of an industrial project or system.

❖ Cost

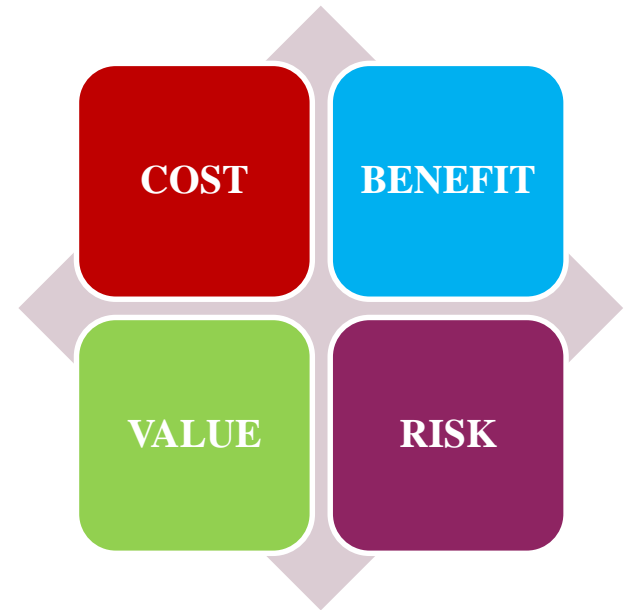
Total expenses (or TCO) for the design, production, distribution and acquisition to deliver the final result of a product or system.

❖ Value

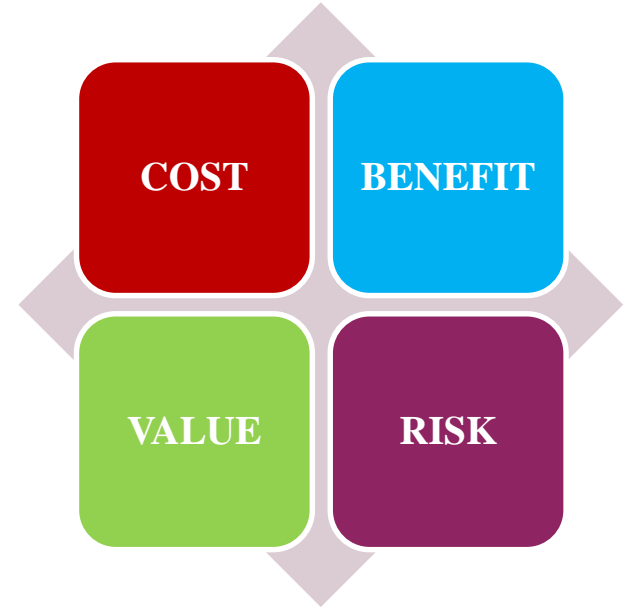
Degree of satisfaction of a set of stakeholder expectations or needs, expressed by the appreciation level of a number of performance indicators.

❖ Risk

Consequences of an event occurrence impacting the achievement of different stakeholders' objectives.



- ❖ Arithmetic weighted sum
- ❖ Average weighted sum
- ❖ 2-additive Choquet integral



$$p_{ag} = Ag(p_1, \dots, p_i, \dots, p_n) = \sum_{i=1}^n \phi_i p_i - \frac{1}{2} \sum_{i,j=1, j>i}^n I_{ij} |p_i - p_j|$$

$$\left(\phi_i - \frac{1}{2} \sum_{j=1, j>i}^n |I_{ij}| \right) \geq 0 \quad \forall i \in [1, n] \quad I_{ij} \in [-1, 1]$$

❖ Research objective

To develop a methodology (methodological framework and associated tools) for decision-makers in performance evaluation and decision making processes on the basis of four assessment dimensions: benefit, cost, value and risk.

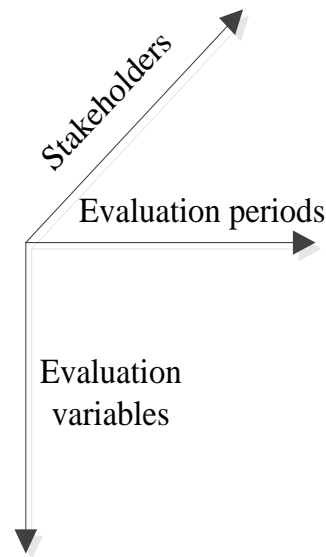
❖ Applications

- Perform opportunity evaluation for a new project/process/system
- Predict future performance of a project/process/system
- Control and monitor execution of an on-going project/process/system

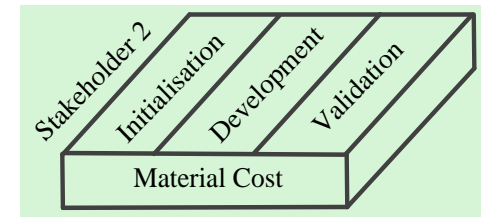
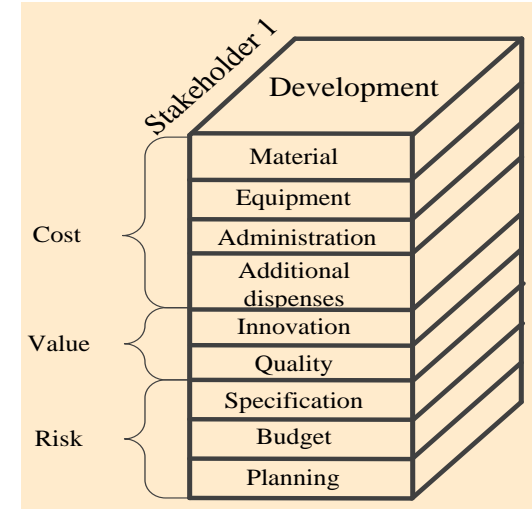
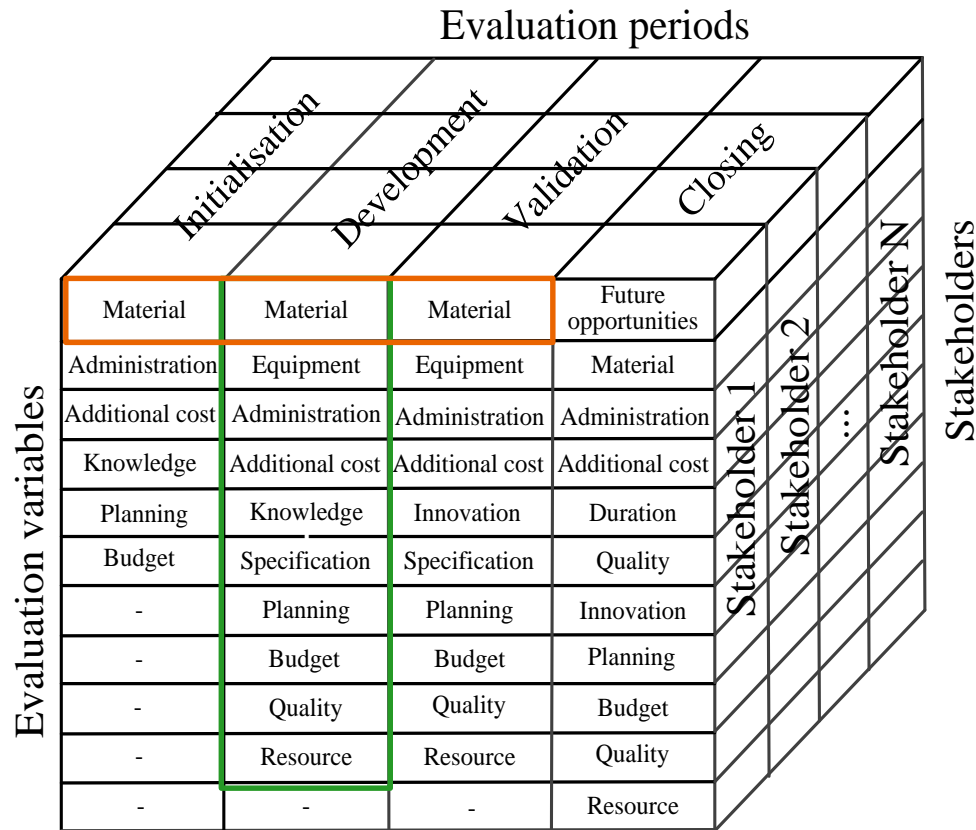
Industrial performance (P) must be comprehensively identified from three perspectives:

- **Stakeholders (S)**: a set of viewpoints from selected stakeholders
- **Evaluation periods (T)**: an instant, a life cycle phase or the whole project period
- **Evaluation variables (v)**: a set of components that are used as elementary performance measures

$$P = (S, T, v) \quad \text{with } v \in B, C, V, R \dots$$

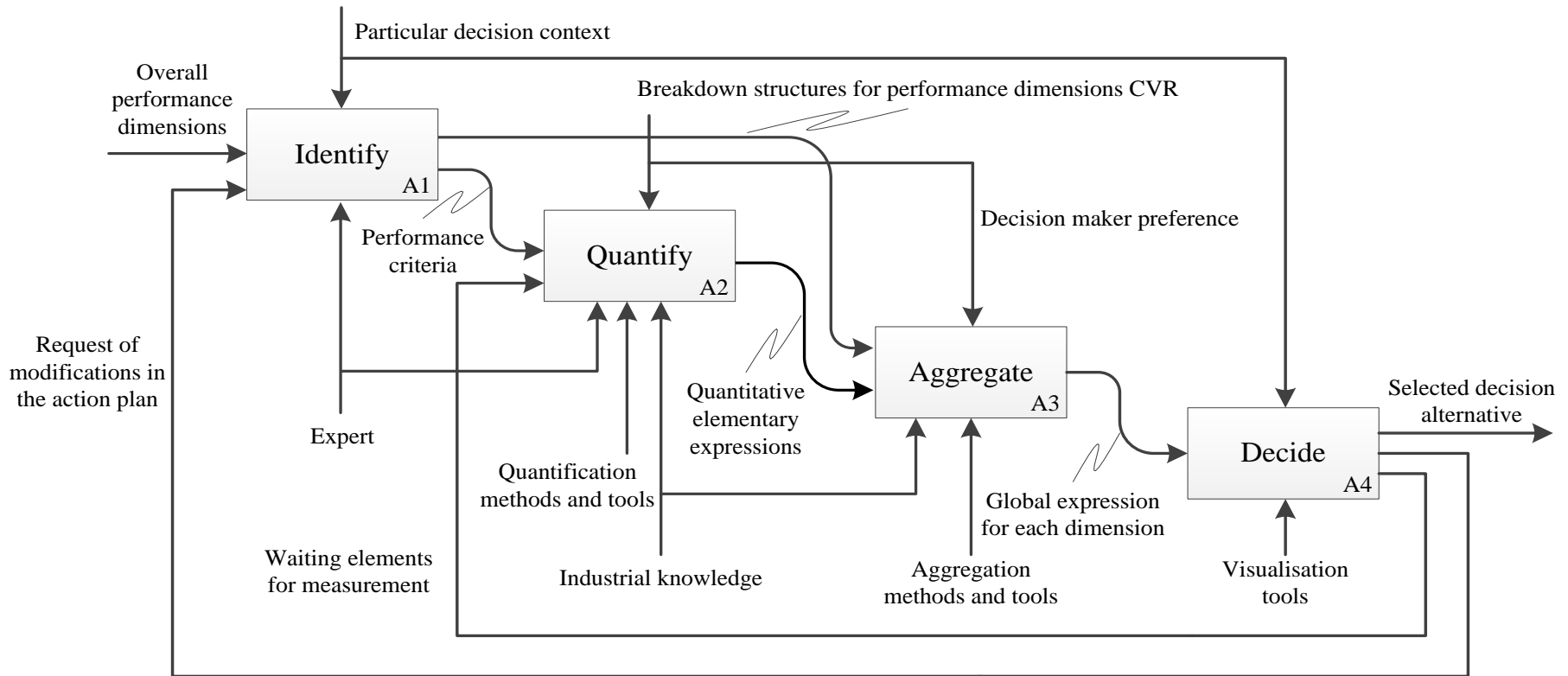


Performance expression - Illustration



- ❖ Copes with the **multidimensional** and **relative** characteristics of industrial performance
- ❖ Proposes a **flexible** structure that can be adapted to the particular decision context

Performance evaluation process



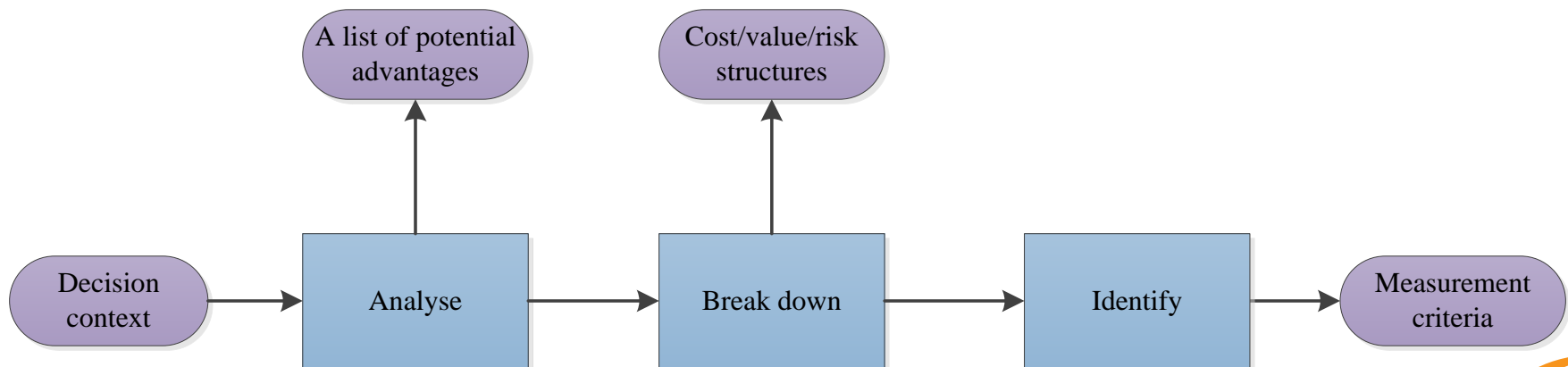
The methodology is **a set of tools and methods** which provides guidelines to decision makers in performance evaluation for the purpose of objective achievement

❖ Objective

To establish all **necessary elements** (*stakeholder objectives, life cycles phases, breakdown structures and evaluations criteria*) for performance measurement and management

❖ Deliverables

- A list of potential advantages as project benefits
- Individual **breakdown structures** for cost, value and risk
- A set of evaluation criteria for each evaluation variable

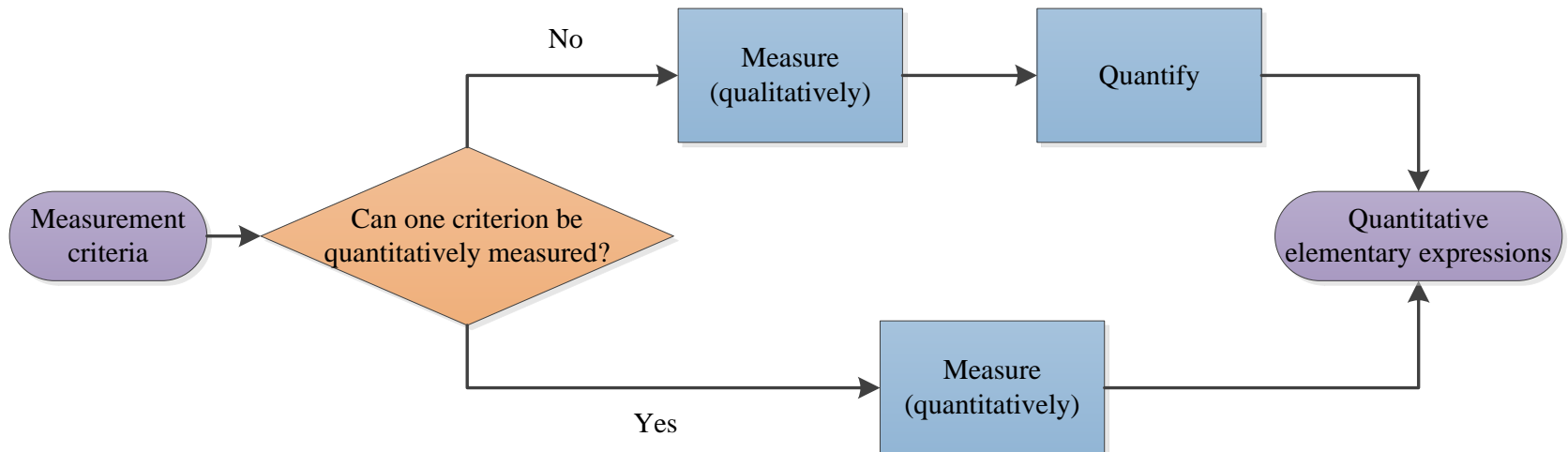


❖ Objective

To measure performance items to generate elementary performance measures for accurate performance evaluation

❖ Deliverables

Quantitative expressions for all identified performance criteria

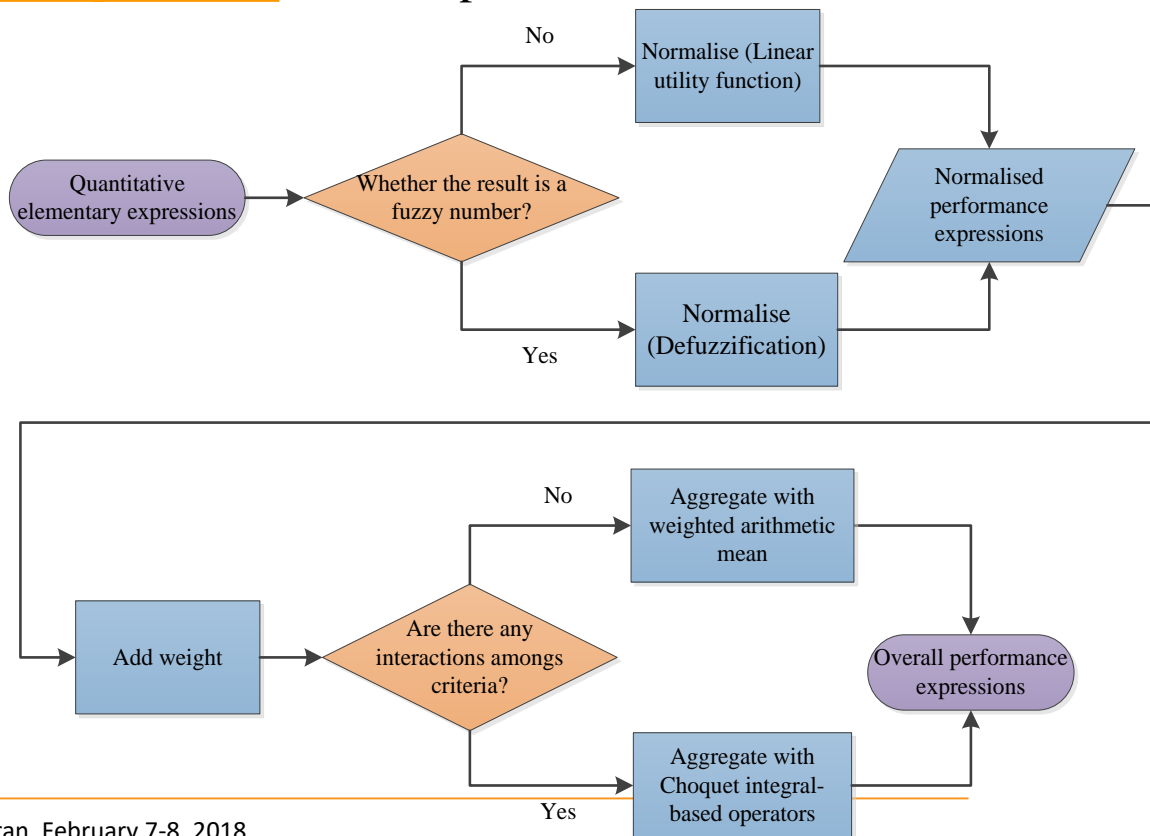


❖ Objective

To combine the elementary performance elements by means of a single representative value to ease performance evaluation (preferably in $[0, 1]$)

❖ Deliverables

Normalised expressions for each performance dimension CVR

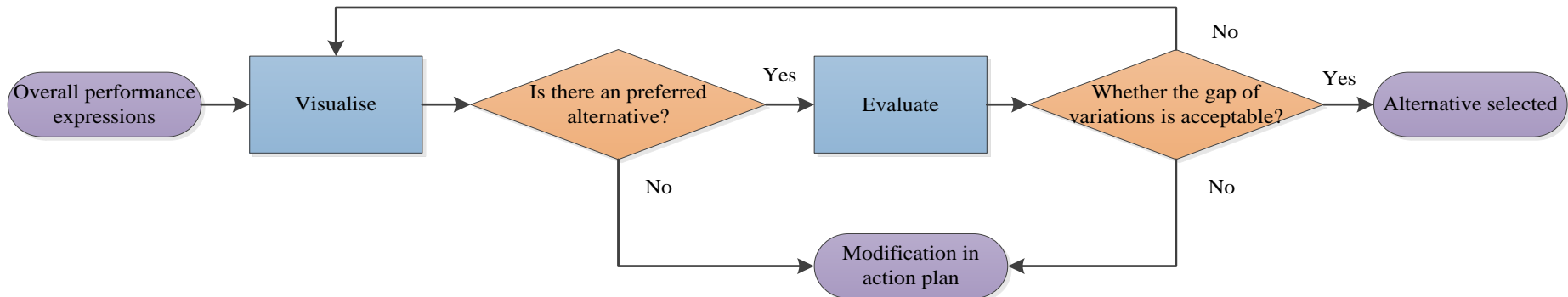


❖ Objective

To present the aggregated results in a visual way (*graph with performance dimensions*) to ease decision making

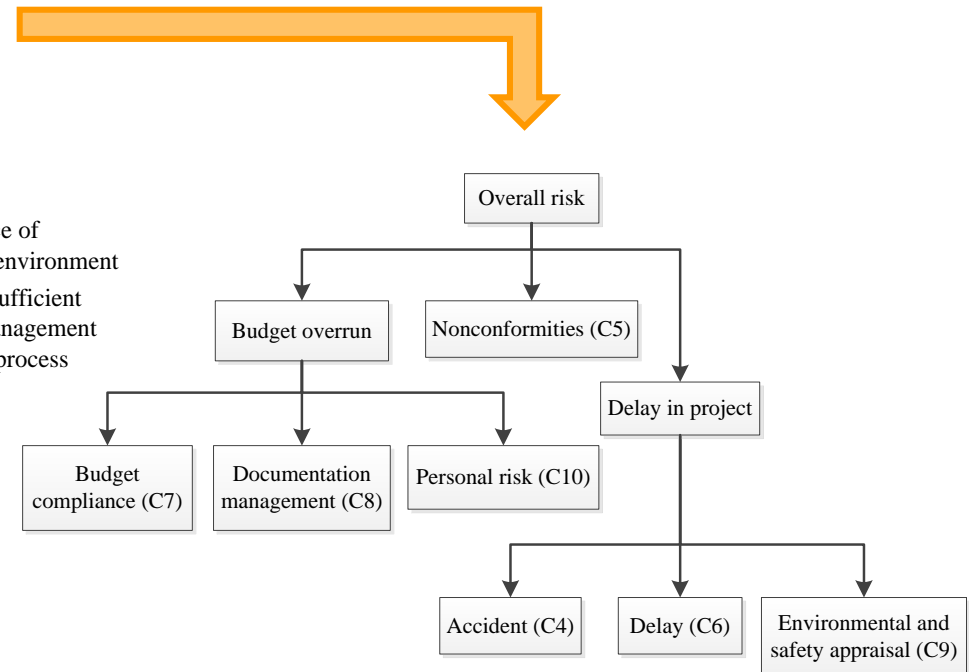
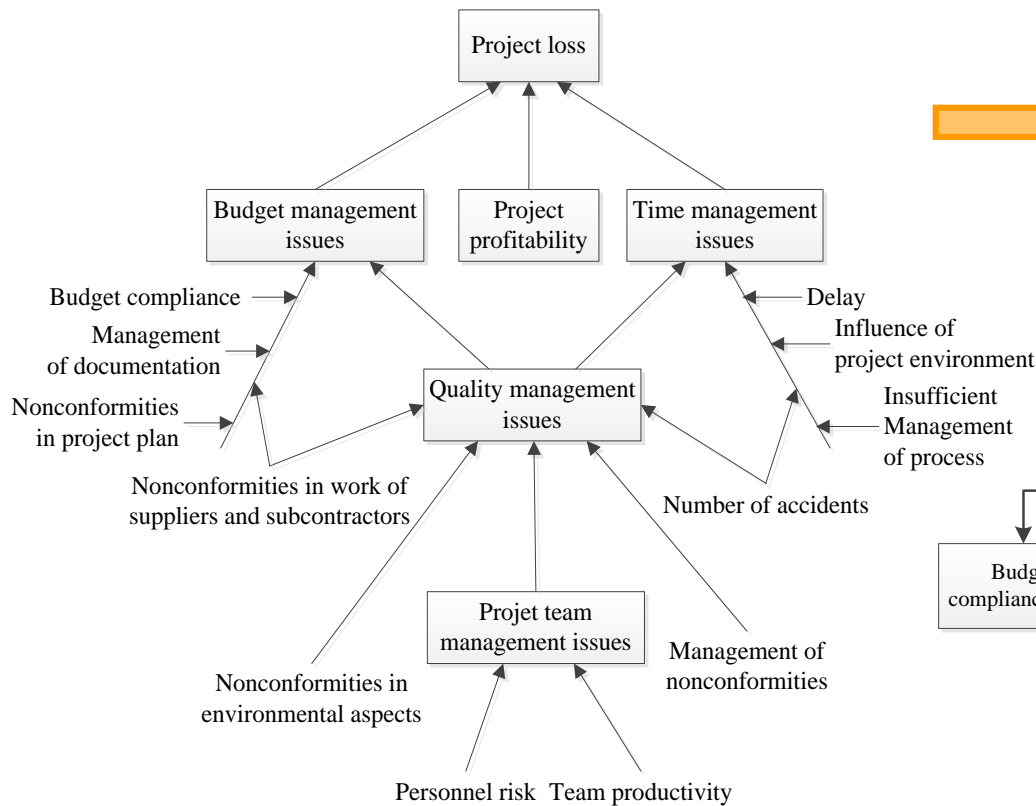
❖ Deliverables

Visualised presentation for overall performance expressions



Performance evaluation of three construction projects during the implementation stage to make decision on the allocation of enterprise resources

❖ Breakdown analysis



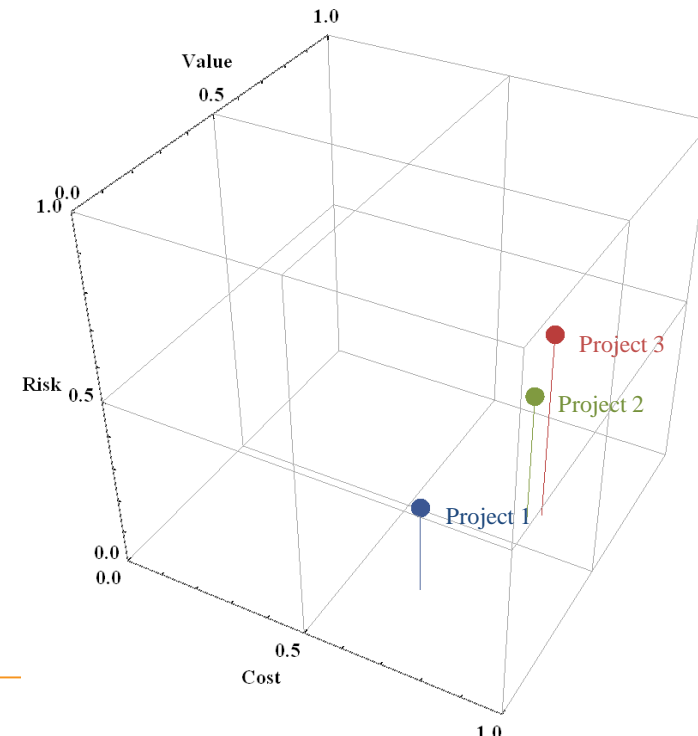
❖ Aggregation operation

	Cost variables		Value variables			Risk variables		
	Estimated expenditures	Additional costs	Budget management	Profitability	Quality management	Budget overrun	Nonconformities	Delay in project
Project 1	0.74	0.41	0.42	0.33	0.26	0.28	0.70	0.47
Project 2	0.82	0.67	0.60	0.60	0.63	0.41	0.50	0.41
Project 3	0.85	0.66	0.97	0.73	0.69	0.66	0.60	0.56
v_i	0.86	0.14	0.11	0.63	0.26	0.52	0.14	0.34
I_{ij}	I_{12}	-	I_{12}	I_{13}	I_{23}	I_{12}	I_{13}	I_{23}
	0.17		0.25	0.51	0.56	0.15	0.75	0.31

❖ Overall performance expressions

	Project 1	Project 2	Project 3
Overall cost	0.67	0.79	0.81
Overall value	0.25	0.60	0.63
Overall risk	0.27	0.40	0.57

❖ Graphical decision support



- ❖ Overall performance of a project/process/system can be managed by evaluating four dimensions: benefit, cost, value and risk (BCVR)
- ❖ BCVR based methodology to model, measure and evaluate the overall industrial performance for decision support
 - Considers the multi-dimensionality and relativeness aspects of industrial performance
 - Integrates the four selected assessment axes into a common framework
 - Proposes an efficient and pragmatic methodology with global structure and detailed operations
 - Proposes a visualisation means to support decision makers in evaluating the different scenarios



- ❖ To develop an IT tool to allow automated computation regarding the various operations of the whole evaluation process
- ❖ To extend the aggregated overall performance expressions with tolerable levels of cost, value and risk
- ❖ To validate and improve the proposed methodology with different cases in other decision making contexts
 - Product/service design
 - Process planning
 - Project management
 - Control of production systems



THANK YOU FOR YOUR ATTENTION !

