Multi-Criteria Analysis (MCA)

☆ In most real decision situations, choice of a best action must be based on multiple *aspects* or *criteria*

☆ In *personal life*, the *job* we choose may depend on its **prestige**, **location**, **salary**, **advancement opportunities**, **working conditions**, etc.

☆ The *car* we buy may be characterised in terms of **price**, **horsepower**, and **riding comfort**

☆ The location for a *vacation* may be selected in terms of **price**, **climate**, **social opportunities**, **sports activities**, etc.

☆ In *business*, a manager's choice of *corporate strategy* would depend on the **company's profit over time**, its **stock price**, **share of market**, **goodwill**, **labour relations**, **corporate image**, **societal obligations**, etc.

☆ The manager's choice of secretary may depend on her **typing speed**, **shorthand skills**, **cooperativeness**, etc.

☆ His/her choice of *pricing policy* for a new product would depend on **profitability**, **market share**, **prevention of competitive entry**, etc.

☆ The company's choice of a *computer* would depend on such factors as **speed**, **memory capacity**, **input-output capability**, **maintainability**, **service** and **support**, etc.

☆ In *medicine*, choice of *treatment* may depend on **cost**, **probability of side effects**, **probability of cure**, **probability of complications**, **probability of relapse**, **days in bed with various levels of discomfort**, etc.

☆ In *government*, the choice of a *weapons system* for the military may be selected on the basis of **vulnerability**, **reliability**, **cost**, **yield**, etc.

☆ The choice of a *national energy policy* would consider such factors as **ecology**, **international politics**, **health impacts**, etc.

☆ In *local government*, the choice of a new *highway* would consider such **savings in travel time**, **ecological impact**, **social disruption**, **cost**, **air pollution**, etc.

☆ **Multi-criteria analysis** (MCA) is a generic term for a *range* of methods for evaluating a set of alternative projects in terms of a set of conflicting and incommensurate objectives or criteria

☆ Other terms are **multi-criteria evaluation** (MCE), **multi-criteria decision analysis** (MCDA), **multi-objective decision analysis** (MODA), **multi-attribute decision making** (MADM)

☆ Formally, MCA means 'making preference decisions' (e.g. evaluation, prioritisation, selection) over the available alternatives that are characterised by mutually, conflicting criteria

☆ MCA is rigorous but normative, aimed at improving decision quality

☆ MCA can be applied to a wide range of human choices - professional, political, managerial, technical, personal

✮ Basic structure for multiple criteria or multiple objective decision making is an **outcome matrix** or **decision matrix** $X = [x_{ij}]_{IxJ}$, expressed more fully as
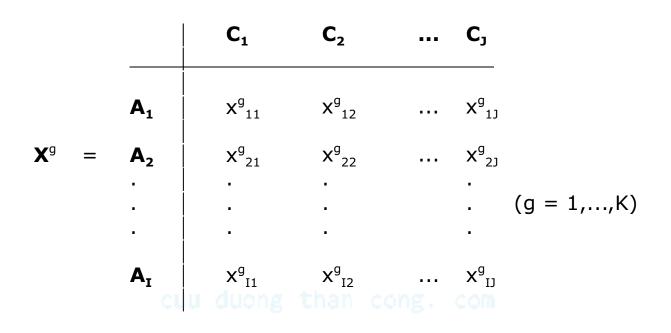
$$
X = \begin{array}{c|cccc}
 & C_1 & C_2 & \dots & C_J \\
\hline
A_1 & x_{11} & x_{12} & \dots & x_{1J} \\
A_2 & x_{21} & x_{22} & \dots & x_{2J} \\
. & . & . & & . \\
. & . & . & & . \\
. & . & . & & . \\
A_I & x_{I1} & x_{I2} & \dots & x_{IJ}
\end{array}
$$

✮ x_{ij} represents the outcome of the ith project (alternative = A) with respect to the jth criterion or objective C_j

✮ I is the number of projects and J is the number of criteria or objectives

☆ When there are multiple interest groups/stakeholders, g = 1,...,K, the outcome matrix may be represented as K, I × J 'slices', $\mathbf{X}^g = [x^g_{ij}]$, or

$$
\mathbf{X}^g =
\begin{array}{c|cccc}
 & C_1 & C_2 & \ldots & C_J \\
\hline
A_1 & x^g_{11} & x^g_{12} & \ldots & x^g_{1J} \\
A_2 & x^g_{21} & x^g_{22} & \ldots & x^g_{2J} \\
. & . & . & & . \\
. & . & . & & . \\
. & . & . & & . \\
A_I & x^g_{I1} & x^g_{I2} & \ldots & x^g_{IJ}
\end{array}
\qquad (g = 1,\ldots,K)
$$

☆ x^g_{ij} is the outcome for project A_i with respect to objective or criterion C_j for interest group g

☆ Associated with each objective or criterion (C_j) is a positive **weight** or **priority** represented by w_j

☆ Set of weights for all J criteria $\{w_1, w_2, \ldots, w_J\}$, if ratio-scaled are often normalised so that $\Sigma_j \, w_j = 1$

☆ There are numerous MCA methods

✰ Can distinguish between *non-compensatory* and *compensatory* methods

✰ **Non-compensatory** methods do not permit tradeoffs between or among criteria

✰ Comparisons are made on a criterion by criterion basis, and, in general, multidimensional characterisations are not amalgamated into a single utility number, e.g. *dominance*, *maximin* (or *minimax*), *maximax*, *satisficing* (*conjunctive* and *disjunctive*), *lexicographic* methods

✰ **Compensatory** methods permit tradeoffs between criteria

✰ That is, changes in one criterion can be offset by opposing changes in any other criterion

✰ With compensatory methods, a single utility is assigned to each multidimensional characterisation representing an alternative

✰ Tradeoffs between criteria are generated by different characterisations that have equal utilities, e.g. *additive utility, configural (nonlinear) utility*