

# A Sample Glossary of Systems Analysis

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**IIASA Working Paper** 

WP-78-012

1978

Findeisen, W., Yastrebov, A.P., Lande, A., Lindsay, J., Quade, E.S. and Pearson, M.M.L. (1978) A Sample Glossary of Systems Analysis. IIASA Working Paper. WP-78-012 Copyright © 1978 by the author(s). http://pure.iiasa.ac.at/891/

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## A SAMPLE GLOSSARY OF SYSTEMS ANALYSIS

# (Prepared for the Preliminary Version of the Handbook of Applied Systems Analysis)

Compiled by: W. Findeisen, A. Iastrebov, R. Lande, J. Lindsay, M. Pearson, E.S. Quade

April 1978

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WP-78-12

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Laxenburg International Institute for Applied Systems Analysis Austria

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# CONTENTS

Introduction	v
Key Index v:	ii
Glossary	1
Russian-English Index	45
Expanded Index	57

#### INTRODUCTION

<u>Glossary</u>: A partial dictionary that gives, for a collection of terms, brief and inaccurate explanations.

- R.D. Specht

Every short statement...is misleading (with the possible exception of my present one).

~ Alfred Marshall

Every activity -- and systems analysis is no exception -tends to develop its own vocabulary. Indeed, systems analysis, because of its interdisciplinary nature, has been more prone than most not only to invent new words for new concepts but also -and more often -- to borrow established terms from the disciplines it employs and to change their meaning, sometimes slightly, sometimes grossly, sometimes inconsistently. The result of this can be confusion, misunderstanding, and failure of communication.

This glossary is an attempt at resolving part of the ambiguity. Sometimes, the best that can be hoped is that the reader will be warned of a pitfall, for we cannot hope to fill them all in, or even to identify them all. For example, when a word in common use in systems analysis has three different meanings, whose differences are often not to be determined by context, there is little we can do beyond noting this unfortunate practice. Clearly, we are in no position to dictate "proper" usage to the disparate community of systems analysts. On the other hand, we have made judgments about the wise use of terminology -stressing some meanings and ignoring others. We hope that the result will be of use not only to the reader who is not well versed in the literature of systems analysis but also to all members of the systems analysis community.

The glossary, as it stands now, is tentative. It has been prepared for the preliminary version of the <u>Handbook of Applied</u> <u>Systems Analysis</u>, and the terms included are those used in the <u>Handbook</u>. We invite criticism and suggestions from our readers: What terms should be added or deleted? What definitions are incorrect or incomplete? Does the glossary "work" as intended?

- v -

The glossary, besides being part of the <u>Handbook</u>, is also the beginning of a major task: the compilation of a multilingual glossary of terms of systems analysis. We would therefore appreciate it if comments and proposed additions were divided into two parts: one with respect to the <u>Handbook</u> glossary, and the second with respect to the projected multilingual glossary.

#### The Way It Works

The structure of the glossary is designed to highlight interrelations among concepts -- among the terms we sought to explain. The present sample consists of some 50 articles arranged in alphabetical order; approximately 170 terms are defined. A defined term is an "entry." Entries are marked by underscoring and double brackets [[\_\_\_\_\_]] and may head an article or occur within an article. Each term has only one entry, which may be located by referring to the index. If a term is simply underscored within an article, it is a cross reference, i.e., it is defined as an entry somewhere else in the glossary, and the index should be referred to. The final version of the index will use page numbers to indicate the location of entries and in addition will register all occurrences of a term (cross references as well as entries). A rough version of this expanded index is appended, as is a Russian-English index to the glossary's entries.

The glossary and its index were prepared by means of the ED and NROFF text processing programs on IIASA's UNIX Operating System. This accounts for some anomalies of punctuation and for the use of double brackets and underscoring, which may seem less than ideal. The final version will be typeset, and these unaesthetic elements eliminated.

a fortiori analysis action, feasible action space actor alternative alternative, feasible analysis, a fortiori analysis, contingency analysis, cost-benefit analysis, costeffectiveness analysis, decision analysis, feasibility analysis, input-output (Leontief) analysis, Leontief [Syn. for: input-output (Leontief) analysis] analysis, policy analysis, resource analysis, risk analysis, risk [Syn. for: risk assessment] analysis, risk-benefit analysis, sensitivity analysis, value analytic model attribute, valuerelevant benefit causal model chance-constrained problem coefficient, technological

SEE:

.....constraint .....consequence .....role-playing .....constraint .....a fortiori analysis ..... analysis .....systems analysis .....systems analysis .....systems analysis .....systems analysis ..... (Leontief) analysis .....input-output (Leontief) analysis .....systems analysis ..... analysis ....risk, .....risk .....systems analysis .....sensitivity analysis .....value .....model .....consequence .....consequence .....model ....optimization ..... (Leontief) analysis

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SEE:

jectivesobjective	
computer simulation simulation	
conditional forecastforecast	
conflict situation	
conflicting objectives	
conjoint measurement	
theoryvalue	
consequence	
consequence, feasible	
consequence, multiattri-	
bute	
consequence, single-	
attribute	
consequence space	
consequence tree	
constraint	
constraint, elasticconstraint	
constraint, long-run	
constraint, removable	
[Syn. for: elastic	
constraint]constraint	
constraint, short-runconstraint	
constraint, stiffconstraint	
constraint, unquestion-	
able [Syn. for:	
<pre>stiff constraint]constraint</pre>	
contingency analysis	
correlation modelmodel	
cost	
cost, opportunity	st
cost-benefit analysis	is
cost-effectiveness	
analysis	is
course of action	
criterion /	
decision analysis	is
decision maker	
decision maker, risk-	
averse	
decision maker, risk~	
neutral	
decision maker, risk-	
proneutility	

SEE:

..... decision decision, primary .....decision decision, secondary decision taker [Syn. for: decision mak-.....decision maker er] decision theory decision under certainty .....decision theory decision under risk .....decision theory decision under uncertainty .....decision theory decision variables .....optimization Delphi method demand demand function .....demand deterministic model .....model discount rate discretization .....optimization .....economy of scale diseconomy of scale dominance dynamic model .....model dynamic optimization problem .....optimization economy of scale effectiveness efficiency elastic constraint ......constraint environment equilibrium price .....demand estimation, model .....model evaluation expected utility .....utility experimentation externality feasibility analysis .....systems analysis feasible action ....,.....constraint feasible alternative .....constraint feasible consequence .....constraint feasible objective ......constraint feasible set .....constraint feasible solution ••••••optimization <u>forecast</u> forecast, conditional .....forecast forecast, selffulfilling .....forecast

- ix -

forecasting horizon [Syn. for: forecasting lead] forecasting lead formal model gamble [Syn. for: lottery] game, multiperson game theory game, two-person game, zero-sum gaming goal hierarchy of objectives horizon, forecasting [Syn. for: forecasting lead] identification, model impact implementation input-output (Leontief) analysis input-output model integer programming interdependence matrix, technological interest rate [Syn. for: discount rate] iterative process judgmental model Leontief analysis [Syn. for: input-output (Leontief) analysis] linear model linear programming long-run constraint lottery man-machine model

man-machine simulation

.....forecast .....forecast .....model ....utility .....game theory .....game theory .....game theory .....role-playing .....objective ....objective .....forecast .....model ..... (Leontief) analysis .....optimization ..... (Leontief) analysis .....discount rate .....model ..... (Leontief) analysis .....model .....optimization .....constraint ....utility .....model .....simulation

SEE:

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marginal utility	utility
max~max rule	theory
max-min rule	theory
model	
model, analytic	
model, causal	
model, correlation	model
model, deterministic	model
model estimation	model
model, formal	model
model identification	model
model, input-output	(Leon-
	tief) analysis
model, judgmental	model
model, linear	model
model, man-machine	model
model, optimization	model
model parameters	model
model, role-playing	model
model, simulation	
model, static	model
model, stochastic	model
model structure	•••••••••••••model
multiattribute conse-	
quence	••••••••••••consequence
multiattribute utility	
function	utility
multiattribute value	
function	•••••••••••••value
multiobjective optimiza-	
tion	optimization
multiperson game	game theory
multiple objectives	objective
nonlinear programming	••••••••••••••optimization
objective	
objective, feasible	
objective function	optimization
objective, proxy	•••••••••••••objective
objective, scalar-valued	optimization
objective space	•••••••••••••objective
objective, vector-valued	optimization
objectives, conflicting	objective
objectives, hierarchy of	objective
· · · · ·	

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TERM	SEE:
objectives, multiple operational research	••••••••••objective
[Syn. for: opera- tions research]	research
operations research opportunity cost	
optimal control problem [Syn. for: dynamic	
optimization prob-	
lem]	optimization
optimal solution	••••••••••••••optimization
optimization	
optimization model	
optimization, multiob-	
jective	••••••••••••••optimization
optimization problem,	
dynamic	optimization
optimization, single-	
objective	optimization
optimum strategy	game theory
option [Syn. for: alter-	
nativej	alternative
outcome [Syn. for:	
Consequence]	••••••••••••••••••••••••••••••••••••••
play playor [Syn for actor]	role-playing
player [Syn. Ior. actor]	ame theory
policy analysis	systems analysis
prediction	forecast
price, equilibrium	demand
primary decision	secondary decision
probabilistic program-	
ming	
probability, subjective	the theory
program evaluation	•••••••••••evaluation
programming, integer	optimization
programming, linear	
programming, nonlinear	optimization
programming, stochastic	••••••••••••••••••••••••••••••••••••••
proxy objective	objective
removable constraint	
[Syn. for: elastic	
constraint]	•••••••••••constraint

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resource analysis risk risk analysis ....risk risk analysis [Syn. for: risk assessment] .....risk risk assessment ....risk .....decision theory risk, decision under risk-averse decison mak-.....utility er .....systems analysis risk-benefit analysis risk-neutral decision .....utility maker risk-prone decision mak-.....utility er role-playing role-playing model .....model satisficing scalar-valued objective ....optimization scenario secondary decision self-fulfilling forecast .....forecast sensitivity analysis short-run constraint .....constraint simulation simulation, computer .....simulation simulation, man-machine .....simulation simulation model .....model simulation, stochastic ......model single-attribute consequence .....consequence single-objective optimization ....optimization spillover ....externality state of nature [Syn. .....environment for: environment] state of the world static model .....model stiff constraint .....constraint stochastic model .....model ....optimization stochastic programming stochastic simulation .....model strategy, optimum .....game theory subjective probability .....decision theory

suboptimization supply function .....demand systems analysis ....objective target target point .....objective target set .....objective target value .....objective technological coefficient ..... (Leontief) analysis technological inter-..... (Leondependence matrix tief) analysis trade-off two-person game .....game theory uncer<u>tainty</u> uncertainty, decision .....decision theory under unquestionable constraint [Syn. for: stiff constraint] .....constraint utility utility, expected ....utility utility function, multiattribute .....utility utility function .....utility utility function [Syn. for: welfare functionl .....utility utility, marginal .....utility utility theory .....utility validation value value analysis ....value value function, multiat-....value tribute value function .....value value-relevant attribute vector-valued objective ....optimization verification welfare function .....utility zero-sum game .....game theory

- xiv ~

SEE:

# [[<u>a fortiori analysis</u>]]

A fortiori analysis is a method of treating uncertainty that stacks the cards against one <u>alternative</u> (often the one intuitively preferred) by resolving questions of uncertainty in favor of another alternative. If the initially preferred alternative is still preferable, one has a stronger case in its favor. See also: sensitivity analysis, contingency analysis.

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## [[alternative]]

One of the mutually exclusive <u>courses</u> of <u>action</u> that are considered as means of attaining the <u>objectives</u>. Typically, the alternatives differ in their nature or character, not only in quantitative details. By mutually exclusive we mean that the alternatives are competitive in the sense that if A is selected, B cannot be chosen. A course of action that combines features selected from both A and B would be a new alternative. (The synonym "option" is often used in association with the <u>decision</u> maker, as in "the decision maker's options were...")

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- 1 -

[[consequence]]

A consequence is a result of a <u>course of action</u> (or of a decision) taken by the <u>decision maker</u> (Synonym: outcome; see impact).

In analysis, the consequences of a course of action are determined (predicted) by the use of models.

The consequences that one would like to have, particularly those that contribute positively to the attainment of <u>objectives</u>, are referred to as [[<u>benefits;</u>]] the consequences that one would like to avoid or minimize are [[costs.]]

The consequences that do not bear very much on the main objectives and are not evaluated in the analysis but that may affect the objectives of other groups of people are referred to as spillovers or <u>externalities</u>.

A [[consequence tree]] is a graph showing what further consequences will be caused by some direct consequence of a course of action. For example, one alternative to stimulate the economy may be to lower taxes. This will result in an increase of average family income, which will in time influence the number of cars, which will have an impact on traffic conditions, on environmental pollution, and so on.

In the literature on <u>decision</u> theory it is customary to

- 2 -

speak about one [[<u>multiattribute consequence</u>]] of a course of action instead of saying "the action has several consequences." Accordingly, the term [[<u>single-attribute consequence</u>]] is used when the course of action has only one consequence that is being considered (e.g., monetary profit). Within the context of decision theory, attributes are those features of a consequence that are taken into account in the evaluation of this consequence by the decision maker. One speaks, more precisely, about [[<u>value-relevant attributes.]</u>]

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In mathematical formulations one speaks about a mapping from the space of courses of action [[(action space)]] into the space of consequences [[(consequence space).]] In a deterministic case the mapping from action space to consequence space is a pointto-point mapping. This means that a given course of action has a given and certain consequence. In a case of <u>risk</u> or <u>uncertainty</u> the mapping from action space to consequence space is a pointto-set mapping; that is, a given course of action may have any one of the consequences contained in a given set.

In analysis, the mapping from action space to consequence space is described by a model.

- 3 -

## [[constraint]]

Constraints are limitations imposed by nature or by man that do not permit certain actions to be taken. Constraints may mean that certain objectives cannot be achieved.

The actions, <u>alternatives</u>, <u>consequences</u>, and objectives that are not precluded by the constraints are referred to as [[<u>feasible</u>.]]

In a particular analysis study, some constraints may have to be considered [[stiff]] or unquestionable, others - from among those imposed by prior decisions - may be [[elastic]] or removable if the analysis proves a good case for it. For example, the natural water supply in a region is a stiff constraint, while the money or manpower allocated to fulfill a certain task may be an elastic constraint.

It is useful to distinguish [[<u>short-run</u>]] and [[<u>long-run</u>]] constraints: for example, existing legislation is a constraint in the short run, but not necessarily in the long run.

¥

In mathematical terms, if the notions of <u>action</u> <u>space</u>, <u>consequence</u> <u>space</u>, and <u>objective</u> <u>space</u> are introduced, the constraints determine a [[feasible set]] in each of those spaces.

- 4 -

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# [[contingency analysis]]

Contingency analysis is a method of treating <u>uncertainty</u> that explores the effect on the <u>alternatives</u> of changes in the <u>environment</u> in which the alternatives are to function. This is a "what-if" type of analysis, with the what-ifs being external to the alternative, in contrast to a <u>sensitivity analysis</u>, where the parameters of the alternatives are varied.

See also: a fortiori analysis.

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# [[course of action]]

A means available to the <u>decision</u> <u>maker</u> by which the objectives may be attained.

A <u>systems</u> <u>analysis</u> usually considers several possible courses of action, which are then referred to as <u>alternatives</u> or as the decision makers's <u>options</u>.

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# [[criterion]]

A criterion is a rule or standard by which to rank the <u>alternatives</u> in order of desirability. The use of "criterion" to mean "objective" is incorrect.

See objective.

- 5 -

# [[decision maker]]

A decision maker is a person, or group of people (e.g., a committee), who makes the final choice among the <u>alternatives</u>. Synonym: decision taker.

-----

# [[decision theory]]

Decision theory is a body of knowledge and related analytical techniques of different degrees of formality designed to help a decision maker choose among a set of alternatives in light of their possible consequences. Decision theory can apply to conditions of certainty, risk, or uncertainty. [[Decision under\_ certainty]] means that each alternative leads to one and only one consequence, and a choice among alternatives is equivalent to a choice among consequences. In [[decision under risk]] each alternative will have one of several possible consequences, and the probability of occurrence for each consequence is known. Therefore, each alternative is associated with a probability distribution, and a choice among alternatives is equivalent to a choice among probability distributions. When the probability distribuabout tions unknown, one speaks [[decision under are uncertainty.]]

Decision theory recognizes that the ranking produced by us-

ing a <u>criterion</u> has to be consistent with the decision maker's <u>objectives</u> and preferences. The theory offers a rich collection of techniques and procedures to reveal preferences and to introduce them into <u>models</u> of decisions. It is not concerned with defining objectives, designing the alternatives or assessing the consequences; it usually considers them as given from outside, or previously determined.

Given a set of alternatives, a set of consequences, and a correspondence between those sets, decision theory offers conceptually simple procedures for choice. In a decision situation under certainty the decision maker's preferences are simulated by a single-attribute or <u>multiattribute value function</u> that introduces ordering on the set of consequences and thus also ranks the alternatives.

Decision theory for risk conditions is based on the concept of utility (see <u>utility</u>, sense B). The decision maker's preferences for the mutually exclusive consequences of an alternative are described by a <u>utility function</u> that permits calculation of the <u>expected utility</u> for each alternative. The alternative with the highest expected utility is considered the most preferable.

For the case of uncertainty, decision theory offers two main approaches. The first exploits criteria of choice developed in a

- 7 -

broader context by <u>game theory</u>, as for example the [[<u>max-min</u> <u>rule</u>,]] where we choose the alternative such that the worst possible consequence of the chosen alternative is better than (or equal to) the worst possible consequence of any other alternative, or the [[<u>max-max rule</u>]] where we choose the alternative such that the best possible consequence of the chosen alternative is better than (or equal to) the best possible consequence of any other alternative.

The second approach is to reduce the uncertainty case to the case of risk by using [[subjective probabilities,]] based on expert assessments or on analysis of previous decisions made in similar circumstances.

See also: game theory, optimization, utility, value.

# ------

## [[Delphi method]]

A technique to arrive at a group position regarding an issue under investigation, the Delphi method consists of a series of repeated interrogations, usually by means of questionnaires, of a group of individuals whose opinions or judgments are of interest. After the initial interrogation of each individual, each subsequent interrogation is accompanied by information regarding the preceding round of replies, usually presented anonymously. The individual is thus encouraged to reconsider and, if appropriate,

- 8 -

to change his previous reply in light of the replies of other members of the group. After two or three rounds, the group position is determined by averaging.

-----

# [[demand]]

[A] As a term in economics, demand means the amount of a commodity (good or service) that would be purchased at a given price. An associated term is [[demand function,]] which presents the demand-versus-price relationship. A demand function for a given commodity is compared with a corresponding [[supply function]] to determine the [[equilibrium price:]] a price at which the supply offered matches the demand.

[B] In another usage, demand means the amount of a commodity required for a certain purpose. It often relates to the future, as in: "the world energy demand in the year 2030 will be 35 terawatts." Implicit in this statement is that the price of energy as well as other economic conditions will be such that 35 terawatts will be consumed (purchased) if technically available.

#### -----

# [[discount rate]]

It is assumed that a monetary unit received today is worth more than a monetary unit to be received a year from now. This

- 9 -

assumption requires that, in order to determine the present value of future sums, the analyst use an interest rate to discount these future sums. If i is the assumed annual interest or discount rate, expressed as a decimal, the present value of x monetary units to be received n years from now is given by the formula:

Present value = \_\_\_\_\_\_\_(l+i)n

Discount rates are used when comparing alternatives that differ in the time-character of their flows of <u>costs</u> and <u>benefits</u>; to compare them, costs and benefits are discounted to the same year. There are no clearcut rules as to what an appropriate discount rate should be in a given case.

-----

[[dominance]]

An <u>alternative</u> is said to be dominant with respect to a second alternative whenever one or more of the <u>consequences</u> of the first are superior (i.e., preferred according to some <u>criterion</u>) to the corresponding consequences of the second, and all others are equally valued.

- 10 -

# [[economy of scale]]

Relative saving ("economy") realized when the size of a plant, enterprise, etc., is increased. For example, lower production cost of an automobile due to production of a large number of cars of the same type is due to economy of scale.

There may also exist a [[diseconomy of scale,]] where the increased size contributes to an increase in unit cost.

-----

# [[effectiveness]]

In <u>systems analysis</u>, the effectiveness of an <u>alternative</u> is usually represented by an aggregative expression approximating the totality of output or performance aspects of that alternative that are relevant to goal attainment. Ideally, it is a single quantitative measure that can be used to evaluate the performance level achieved in attaining the objectives.

# -----

# [[efficiency]]

Program A is said to be more efficient than program B if, for a given cost, a chosen aggregated measure of its positive results (such as <u>effectiveness</u> or <u>benefit</u>) is greater than that for program B.

1

# [[environment]]

Environment is most often used as a synonym of state of nature, a concept useful in modeling. It embraces all external factors or forces that are beyond the influence of the <u>decision</u> <u>maker</u> but nevertheless affect the <u>consequences</u> of his action.

---------

Environment is also occasionally used as a synonym of <u>state</u> of <u>the world</u>. The difference between the two concepts is that state of the world can include the consequences of a course of action as well as the external factors, while the state of nature comprises the external factors only.

#### -----

# [[evaluation]]

Evaluation as used in a technical sense in the United States means assessment of a government program's past or ongoing performance. The key issue in [[program evaluation]] is to determine the extent to which the program, rather than other factors, has caused any changes that have been observed.

#### -----

# [[experimentation]]

In systems analysis, experimentation is the process of determining the results of a proposed course of action or program

by conducting an experiment on a smaller scale in which the course of action is applied to a sample drawn from the future target group. An example would be a test of a new health policy in a restricted region instead of the whole country, or a test on a randomly selected sample of the population. The results are best when the experiment is controlled -- i.e., when the test and control groups are chosen before program implementation in such a way that they are as similar as possible. In this way, any differences that are observed during the experiment can be ascribed to the program.

Experimentation is used whenever current knowledge and understanding of factors such as social attitudes and group preferences are not sufficient to provide dependable model-based predictions. (See: model)

-----

# [[externality]]

An externality is a <u>consequence</u> not considered in analysis. An externality that affects the interests of other groups of people or other <u>decision makers</u> is referred to as a [[<u>spillover</u>.]] If the effects of an externality are appreciable, it may have to be taken into account (internalized) in the analysis.

The term externality derives from economics, where externalites are costs or benefits not taken into account in a transac-

- 13 -

tion or system of transactions. For example, the cost borne by others when an industry pollutes a stream would be referred to as an externality.

-----

# [[forecast]]

A forecast is a statement, usually in probabilistic terms, about the future state or properties of a system based on a known past and present.

A [[conditional forecast]] states in probabilistic terms what the future will be if a course of action is taken.

A forecast that states with a high degree of confidence what the future will be is referred to as [[prediction.]]

A forecast that is a hypothesis rather than a formally justified inference from past data is referred to as a <u>scenario</u>.

Forecasting techniques range from expert judgements to mathematical forecasting <u>models</u>. The [[forecasting lead]] (forecasting horizon), is the length of time ahead of now for which one can make a reasonable forecast. It depends, in the general sense, on available data.

A forecast that makes itself come true is referred to as a [[self-fulfilling forecast.]] For example, a forecast for the rapid growth of a certain city may encourage business to locate there, thus causing the forecast to be realized.

-----

# [[game theory]]

Game theory is a branch of mathematical analysis developed to study decision making in [[conflict situations.]] Such a situation exists when two or more <u>decision makers</u> who have different <u>objectives</u> act on the same system or share the same resources. There are [[<u>two-person</u>]] and [[<u>multiperson games</u>.]] Game theory provides a mathematical process for selecting an [[<u>optimum strategy</u>]] (that is, an optimum decision or a sequence of decisions) in the face of an opponent who has a strategy of his own.

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In game theory one usually makes the following assumptions:

- (1) Each decision maker [["<u>player</u>"]] has available to him two or more well-specified choices or sequences of choices (called [["<u>plays</u>").]]
- (2) Every possible combination of plays available to the players leads to a well-defined end-state (win, loss, or draw) that terminates the game.

- 15 -

- (3) A specified payoff for each player is associated with each end-state (a [[zero-sum game]] means that the sum of payoffs to all players is zero in each end-state).
- (4) Each decision maker has perfect knowledge of the game and of his opposition; that is, he knows in full detail the rules of the game as well as the payoffs of all other players.
- (5) All decision makers are rational; that is, each player, given two alternatives, will select the one that yields him the greater payoff.

The last two assumptions, in particular, restrict the application of game theory in real-world conflict situations. Nonetheless, game theory has provided a means for analyzing many problems of interest in economics, management science, and other fields.

[[impact]]

Impact is used in three different ways:

[A] as synonymous with consequence;

[B] to mean any consequence (beneficial or adverse) that reaches beyond the direct purpose of a given course of action, as

- 16 -

in: "the impact of the new steel plant on employment opportunities in the region;"

[C] as in [B], but the meaning restricted to adverse consequences, as in: "the impact of industrial growth on the ecological environment."

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[[implementation]]

Implementation means the process of carrying out a course of action. Implementation starts at the decision and terminates when the objectives are attained.

[[input-output (Leontief) analysis]]

Input-output (Leontief) analysis is a technique developed for quantitatively analyzing the interdependence of producing and consuming units in an economy. Input-output analysis studies the interrelations among producers as buyers of each other's outputs, as users of resources, and as sellers to final consumers. For example, if a planner wishes to expand the activities of some industry, or some component of final consumption, an input-output analysis can tell what amount of other manufactured goods, resources, and labor this requires.

- 17 -

In an [[<u>input-output model</u>]] the output product of each sector of the economy is set equal to the input consumption of that product by other industries plus the consumption by final consumers. All inputs and outputs are expressed in the same units (usually in monetary units per unit of time, for example in schillings/year). One denotes  $a_{ij}$  the worth of output product of sector i required as input by sector j to produce one unit's worth of its product. Then, if we denote  $x_1, x_2, \dots, x_n$  the output products of the sectors, the basic relation of the <u>model</u> is:

$$x_{i} = \sum_{j=1}^{n} a_{ij}x_{j} + y_{i}$$

where  $y_i$  is the consumption of product i by final consumers. In a model with three sectors, we have, for example, for the output product  $x_2$ :

$$\mathbf{x}_2 = \mathbf{a}_{21}\mathbf{x}_1 + \mathbf{a}_{22}\mathbf{x}_2 + \mathbf{a}_{23}\mathbf{x}_3 + \mathbf{y}_2$$

which reads: "out of the total output  $x_2$  the amount  $a_{21}x_1$  is used by sector 1 to produce output  $x_1, \ldots$ , and the amount  $y_2$  is con-

- 18 -

sumed by final consumers."

The parameters a<sub>ij</sub> are referred to as [[<u>technological</u> <u>coefficients</u>.]] They are usually arranged into a table called the [[<u>technological interdependence matrix</u>]] for the system being modeled.

[[iterative process]]

An iterative process is a process for calculating a desired result by means of a repeated cycle of operations. An iterative process should be convergent, i.e., it should come closer to the desired result as the number of iterations increases.

# 

[[<u>model</u>]]

A model is a device, scheme, or procedure typically used in <u>systems analysis</u> to predict the <u>consequences</u> of a <u>course of</u> <u>action</u>; a model usually aspires to represent the real world (to the degree needed in analysis) -- for example, a relation between some observed phenomena.

A model can be [[formal]] (e.g., a mathematical expression, a diagram, a table) or [[judgmental]] (e.g., as formed by the deductions and assessments contained in the mind of an expert).

- 19 -

Some models are [[causal]] -- i.e., they reflect causeeffect relationships. Others are [[correlation models,]] which do not necessarily reveal whether some of the observed phenomena are the cause of the others. An example is correlation models used for weather forecasting; note that the farmer who predicts rain on the basis of some observed phenomena and his past experience is using a judgmental correlation model.

A [[deterministic model]] generates the response to a given input by one fixed law; a [[stochastic model]] picks up the response from a set of possible responses according to a fixed probability distribution (stochastic models are used to simulate the behavior of real systems under random conditions.

A [[<u>dynamic model</u>]] can describe the time-spread phenomena (dynamic processes) in a system. A [[<u>static model</u>]] describes the system at a given instant of time and in an assumed state of equilibrium.

Among the formal, mathematical models an [[analytic model]] is formed by explicit equations. It may permit an analytic or numerical solution.

An analytic model is [[<u>linear</u>]] if all equations in the model are linear.

We speak of a [[simulation model]] if the solution, i.e.,

- 20 -

the answer to the question which the analyst has posed, is obtained by experiments on the model rather than by an explicit solution algorithm. A typical example is [[stochastic <u>simulation</u>,]] where one wants to obtain probabilistic properties of a system's response by evaluating the results of a large number of simulation runs on the model.

In some analyses the model by which one predicts the outcome of a course of action must take into account that this outcome depends also on actions taken by other decision makers. If the assumption can be made that those decision makers optimize some defined objective functions, and all the other aspects of the system can also be formalized, an [[optimization model]] (e.g., a <u>linear programming model</u>) can be used to determine the system's response to a course of action. In [[role-playing models]] those decision makers (and perhaps some other elements of the system as well) are simulated by human actors.

In a [[<u>man-machine model</u>]] an actor or actors play roles while other parts of the model are implemented on a computer.

A formal model has a [[<u>structure</u>]] (the form of an equation, for example) and [[<u>parameters</u>]] (the values of coefficients in an equation, for example). Determination of both the structure and parameters is [[<u>model identification;</u>]] determination of parameters on the basis of experimental data is [[model estimation.]]

- 21 -

The check of a proposed model against experimental data other than those used for parameter estimation is model <u>validation</u>. See also <u>verification</u>.

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# [[objective]]

An objective is something that a <u>decision maker</u> seeks to accomplish or to obtain by means of his decision. A decision maker may have more than one objective (the [[<u>multiple-objectives</u>]] case).

An objective may be specified in a more or less general fashion, may be quantified or not quantified, and is usually part of a [[hierarchy of objectives.]] The term [[goal]] is sometimes used to denote a very general objective (at the top of the nierarchy) and [[target]] is used to mean a very definite objective. Example: "The goal of allocating money to the municipality was to increase the quality of urban life. The immediate objectives were to improve public transportation and fire services. A 10% reduction of average travel time from home to work and a 70% decrease of average alarm-to-action time taken by the fire brigades were set forth as targets".

The multiple objectives of a single decision maker are usually [[competitive:]] i.e., the improvement in one of them is associated with a deterioration in another (usually because of lim-

- 22 -
ited resources or because of other constraints).

Competitive objectives are sometimes referred to as [[conflicting objectives.]] However, one should speak about a conflict and about conflicting objectives only if there are two or more decision makers who have different objectives and who act on the same system or share the same resources. In the example given above, the director of urban transportation and the director of city fire services have conflicting objectives. At the same time the mayor of the city, if he were the single decision maker, would look at these objectives as competitive.

If the two directors are left without a coordinating influence by the mayor (who would, for example, decide how to allocate the resources), a <u>conflict</u> <u>situation</u> may result. (see <u>game</u> <u>theory</u>).

With the mayor's interventions, the system becomes a hierarchy of decision makers, and the conflict may be resolved.

When the extent to which an objective is attained is measurable on some appropriate scale, one can speak about the degree of attainment of the objective.

In systems analysis, one often uses [[proxy objectives:]] objectives other than the original ones, but such that are

- 23 -

measurable and can be quantitatively discussed. A proxy objective should at least point in the same direction as the original one; for example, "reduction of mean travel time" in urban transportation is a proxy for "improved services."

In a mathematical description, the measures of the multiple objectives  $Q_1, Q_2, \ldots, Q_n$  are considered to be coordinates of a point in the n-dimensional [[objective space.]] Then, the [[target values]]  $T_1, T_2, \ldots, T_n$  prescribed for the n objectives are considered to be coordinates of the [[target point]] in this space. When the target value requirements are set forth as some intervals rather than single numbers, they define a region in the objective space that is referred to as a [[target set.]]

### [[operations research]]

Operations research (operational research in Britain) as understood today is essentially identical to <u>systems analysis</u>. Historically, it was a narrower area of activity that stressed guantitative methods and did not concern itself with <u>trade-offs</u> between <u>objectives</u> and means or with problems of equity. It was defined by the Operational Research Society of Great Britain as follows (Operational Research Quarterly, 13(3): 282, 1962):

- 24 -

Operational research is the attack of modern science on complex problems arising in the direction and management of large systems of men, machines, materials and money in industry, business, government and defence. Its distinctive approach is to develop a scientific model of the system, incorporating measurements of factors such as chance and risk, with which to predict and compare the outcomes of alternative decisions, strategies or controls. The purpose is to help management determine its policy and actions scientifically.

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### [[opportunity cost]]

Opportunity cost is defined as the advantage forgone as the result of the acceptance of an <u>alternative</u>. It is measured as the <u>benefits</u> that would result from the next best alternative use of the same resources that was rejected in favor of the one accepted. Opportunity cost is difficult, perhaps impossible, to measure precisely.

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### [[optimization]]

Optimization is an activity that aims at finding the best (i.e., optimal) solution to a problem. For optimization to be meaningful there must be an objective function (see below) to be

- 25 -

optimized and there must exist more than one [[feasible solution,]] i.e., a solution which does not violate the constraints.

The term optimization does not apply, usually, when the number of solutions permits the best to be chosen by inspection, using an appropriate criterion (see <u>decision theory</u>).

One distinguishes [[<u>single-objective</u>]] and [[<u>multiobjective</u> <u>optimization</u>.]] In the first case the objective is [[<u>scalar-valued</u>]] (it can be measured by a single number); in the second, the objective is [[<u>vector-valued</u>]] (its value is expressed by an n-tuple of numbers).

In mathematical terms, the formulation of an optimization problem involves [[decision variables,]] x<sub>1</sub>,x<sub>2</sub>,...,x<sub>n</sub>, the [[objective function,]]

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 $Q = f(x_1, x_2, ..., x_n)$ 

and constraint relations, usually of the form

 $g_i(x_1, x_2, \dots, x_n) \le 0$ ,  $i = 1, 2, \dots, m$ .

The [[optimal solution]] (or "solution to the optimization problem") are values of decision variables  $\hat{x}_1, \hat{x}_2, \dots, \hat{x}_n$  that satisfy the constraints and for which the objective function at-

- 26 -

tains a maximum (or a minimum, in a minimization problem).

Very few optimization problems can be solved analytically, that is, by means of explicit formulae. In most practical cases appropriate computational techniques of optimization (numerical procedures of optimization) must be used. Among those techniques [[linear programming]] permits the solution of problems in which the objective function and all constraint relations are linear; [[nonlinear programming]] does not have this restriction, but can manage many fewer decision variables and constraints; [[integer programming]] serves to solve problems where the decision variinteger values; [[stocha'stic]] or ables can take only [[probabilistic programming]] must be used for problems where the objective function or constraint relations contain random-valued parameters (in the latter case, the problem is referred to as a a [[chance-constrained problem).]]

A special class is [[<u>dynamic optimization problems</u>,]] where the decision variables are not real numbers or integers but functions of one or more independent variables -- functions of time or space coordinates, for example. Dynamic optimization problems are sometimes referred to as "optimal control problems." There exist special techniques to solve such problems; they often make use of [[<u>discretization</u>]] of the independent variables, for example dividing the time axis into a number of intervals and considering the solutions to be constant over those intervals. A single-objective optimization problem may have (and usually does have) a single-valued, unique solution.

The solution to a multiobjective problem is, as a rule, not a particular value, but a set of values of decision variables such that, for each element in this set, none of the objective functions can be further increased without a decrease of some of the remaining objective functions (every such value of a decision variable is referred to as [[Pareto-optimal].]]

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### [[resource analysis]]

The process of determining the economic resource <u>impacts</u> of alternative proposals for future <u>courses of action</u>. While in resource analysis, physical quantities are often ultimately translated into monetary terms, the real aim is to measure the probable "resource drain" on the economy that would result from various possible actions. The resource analyst must not only give attention to economic costs but also has to determine if it is feasible to obtain needed physical material and manpower in the required time period.

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# [[<u>risk</u>]]

[A] In decision theory and in statistics risk means

<u>uncertainty</u> for which the probability distribution is known. Accordingly, [[<u>risk analysis</u>]] means a study to determine the outcomes of decisions along with their probabilities -- for example, answering the question: "what is the likelihood of achieving a 1,000,000 schilling profit in this alternative?"

In <u>systems analysis</u>, a <u>decision maker</u> is often concerned with the probability that a project (the chosen alternative) cannot be carried out with the time and money available. This risk of failure may differ from alternative to alternative and should be estimated as part of analysis.

[B] In another usage, risk means an uncertain and strongly adverse <u>impact</u>, as in "the risks of nuclear power plants to the population are...." In that case, risk analysis or [[<u>risk</u> <u>assessment</u>]] is a study composed of two parts, the first dealing with the identification of the strongly adverse impacts, and the second with determination of their respective probabilities. Compare risk-benefit analysis.

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# [[<u>role-playing</u>]]

A type of <u>simulation</u> in which persons (referred to as [[actors]] or players), sometimes with the aid of computers, act out roles as parts of the system being analyzed.

- 29 -

For example, experts in different fields may be called upon to simulate the behavior (to predict the response) of specific segments of a regional or national economy being studied.

A role-playing simulation in which the actors (players) act out roles as <u>decision makers</u> is called [[gaming.]] In gaming, the players usually have different and conflicting <u>objectives</u> (in business gaming and war gaming, for example). The players may act as individuals or may be combined into coalitions, or opposing teams.

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# [[satisficing]]

Satisficing is an alternative to <u>optimization</u> for cases where there are <u>multiple</u> and <u>competitive</u> <u>objectives</u> in which one gives up the idea of obtaining a "best" solution.

In this approach one sets lower bounds for the various objectives that, if attained, will be "good enough" and then seeks a solution that will exceed these bounds. The satisficer's philosophy is that in real-world problems there are too many uncertainties and conflicts in values for there to be any hope of obtaining a true optimization and that it is far more sensible to set out to do "well enough" (but better than has been done previously).

- 30 -

# [[scenario]]

A scenario is an outline of a hypothesized chain of events. The term is used to denote [A] a <u>forecast</u> based on loose assumptions rather than on a more formal inference from the past or [B] a synopsis of a proposed <u>course of action</u>.

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### [[secondary decision]]

Secondary decisions are those choices made by the analyst that determine the way in which <u>systems analysis</u> of a given problem or issue will be performed. They include making the simplifying assumptions by which a complex issue will be made tractable in analysis, choosing the forms of <u>models</u>, selecting the techniques of computation and <u>simulation</u>, deciding what data have to be acquired, judging what support by experts of various disciplines to use in performing the analysis, and so on.

The secondary decisions are distinguished from [[primary decisions,]] that is, the decisions to be taken by the decision maker and related to the object problem or issue to which a systems analysis is applied.

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- 31 -

#### [[sensitivity analysis]]

A procedure to determine the sensitivity of the <u>outcomes</u> of an <u>alternative</u> to changes in its parameters (as opposed to changes in the <u>environment</u>; see <u>contingency analysis</u>, <u>a fortiori</u> <u>analysis</u>). If a small change in a parameter results in relatively large changes in the outcomes, the outcomes are said to be sensitive to that parameter. This may mean that the parameter has to be determined very accurately or that the alternative has to be redesigned for low sensitivity.

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# [[simulation]]

Simulation is the term applied to the process of modeling the essential features of a situation and then predicting what is likely to happen by operating with the <u>model</u> case by case -i.e., by estimating the results of proposed actions from a series of imaginary experiments (imaginary because they are performed on the representation of the situation, the model, rather than on the situation itself).

Most frequently, the simulation is a [[<u>computer simulation</u>]] in which the representation is carried out numerically on a digital computer. It may also be done on an analogue computer or by means of a physical representation, say by a wooden airfoil in a wind tunnel. [[<u>Man-machine simulation</u>]] is a simulation that em-

- 32 -

ploys a <u>man-machine model</u>.

Also see: role playing, gaming.

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### [[state of the world]]

State of the world, in connection with a <u>course of action</u>, means the aggregate of natural, economic, social, cultural, and other conditions on which the presumed <u>consequences</u> must depend and to which the course of action must be matched. A <u>forecast</u> of the state of the world is required to predict the results of any course of action.

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See environment.

# [[suboptimization]]

Suboptimization refers to the analysis to assist a lower level decision as a step toward the attainment of a higher level objective to which the lower level decision is to contribute. Thus, an <u>optimization</u> of a city's streetcar operations would be a suboptimization if the higher level aim is to optimize the entire public transport system.

Analysts and decision makers must always suboptimize -- that is, consider actions that pertain to only part of the elements that enter a problem -- neglecting some things and fixing others arbitrarily. Even if all suboptimization problems relevant for a higher level problem are successfully solved, this will not mean, usually, that the higher level problem will be optimized. One could usually do better by treating all partial problems and their interrelationships, simultaneously.

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#### [[systems analysis]]

This term has many different meanings. In the sense adopted for the Handbook, systems analysis is an explicit formal inquiry carried out to help someone (referred to as the <u>decision maker</u>) identify a better <u>course of action</u> and make a better decision than he might otherwise have made. The characteristic attributes of a problem situation where systems analysis is called upon are complexity of the issue and uncertainty of the outcome of any course of action that might reasonably be taken.

Systems analysis usually has some combination of the following: identification (and re-identification) of <u>objectives</u>, <u>constraints</u>, and alternative courses of action; examination of the probable <u>consequences</u> of the alternatives in terms of <u>costs</u>, <u>benefits</u>, and <u>risks</u>; presentation of the results in a comparative framework so that the decision maker can make an informed choice from among the alternatives.

The typical use of systems analysis is to guide decisions on

- 34 -

issues such as national or corporate plans and programs, resource use and protection policies, research and development in technology, regional and urban development, educational systems, and health and other social services. Clearly, the nature of these problems requires an interdisciplinary approach.

There are several specific kinds or focuses of systems analysis, for which different terms are used.

A systems analysis related to public decisions is often referred to as a [[policy analysis]] (in the United States the terms are used interchangeably).

A systems analysis that concentrates on comparison and ranking of alternatives on the basis of their known characteristics is referred to as [[decision analysis.]]

That part or aspect of systems analysis that concentrates on finding out whether an intended course of action violates any constraints is referred to as [[feasibility analysis.]]

A systems analysis in which the alternatives are ranked in terms of effectiveness for fixed cost or in terms of cost for equal effectiveness is referred to as [[cost-effectiveness analysis.]]

[[<u>Cost-benefit analysis</u>]] is a study where for each alternative the time stream of costs and the time stream of benefits

- 35 -

(both in monetary units) are discounted (see: <u>discount rate</u>) to yield their present values. The comparison and ranking are made in terms of net benefits (benefits minus cost) or the ratio of benefits to costs.

In [[risk-benefit analysis,]] cost (in monetary units) is assigned to each risk, so as to make possible a comparison of the discounted sum of these costs (and of other costs as well) with the discounted sum of benefits that are predicted to result from the decision. The risks considered are usually events whose probability of occurrence is low, but whose adverse consequences would be important (e.g., events such as an earthquake or explosion of a plant).

See: operations research.

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#### [[trade-off]]

Trade-off means an exchange of one quality or thing for another. Thus, in comparing alternative configurations for transport aircraft, it may be possible to trade off speed for payload and still maintain the same total transport capability per month in the system.

In <u>value analysis</u> and <u>decision theory</u> the concept of tradeoffs in the <u>decision maker's</u> preferences is used extensively as a basis for establishing multiattribute value functions and

- 36 -

# multiattribute utility functions. See: value, utility.

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### [[uncertainty]]

Because of an unfortunate use of terminology, in systems analysis discourse, the word "uncertainty" has both a precise technical meaning and its loose natural meaning of an event or situation that is not certain.

In <u>decision theory</u> and statistics a precise distinction is made between a situation of <u>risk</u> and one of uncertainty. There is an uncontrollable random event inherent in both of these situations. The distinction is that in a risky situation the uncontrollable random event comes from a known probability distribution, whereas in an uncertain situation the probability distribution is unknown.

# [[utility]]

[A] In economics, utility means the real or fancied ability of a good or service to satisfy a human want. An associated term is [[welfare function]] (synonym: utility function -- not to be confused with <u>utility function</u> in <u>decision theory</u>; see below), which relates the utility derived by an individual or group to

- 37 -

the goods and services that it consumes. [[<u>Marginal utility</u>]] is the change in utility due to a one-unit change in the quantity of a good or service consumed.

[B] In <u>decision theory</u>, utility is a measure of the desirability of <u>consequences</u> of courses of action that applies to decision making under <u>risk</u> -- that is, under <u>uncertainty</u> with known probabilities.

The concept of utility applies to both <u>single-attribute</u> and <u>multiattribute</u> consequences.

The fundamental assumption in [[<u>utility theory</u>]] is that the <u>decision maker</u> always chooses the <u>alternative</u> for which the expected value of the utility [[(expected utility)]] is maximum.

If that assumption is accepted, utility theory can be used to predict or prescribe the choice that the decision maker will make, or should make, among the available alternatives. For that purpose, a utility has to be assigned to each of the possible (and mutually exclusive) consequences of every alternative. A [[utility function]] is the rule by which this assignment is done, and depends on the preferences of the individual decision maker.

In utility theory, the utility measures u of the conse-

- 38 -

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quences are assumed to reflect a decision maker's preferences in the following sense:

- (i) the numerical order of utilities for consequences preserves the decision maker's preference order among the consequences;
- (ii) the numerical order of expected utilities of alternatives (referred to, in utility theory, as gambles or [[lotteries)]] preserves the decision maker's preference order among these alternatives (lotteries).

For example if alternative A can have three mutually exclusive consequences, x,y,z, and the decision maker prefers z to y and y to x, the utilities  $u_1, u_2, u_3$  assigned to x,y,z must be such that  $u_3 > u_2 > u_1$ .

If the probabilities of the consequences x,y,z are  $p_1,p_2,l-p_1-p_2$ , respectively, the expected utility of alternative A is calculated as

$$E(u|P) = P_1u_1 + P_2u_2 + (1-P_1-P_2)u_3$$

where P means the probability distribution, characteristic for the alternative (i.e.  $p_1, p_2, l-p_1-p_2$ ).

If the decision maker prefers alternative B, which has probability distribution Q, to alternative A, the utility assign-

- 39 -

ments in both alternatives must be such that

Utility theory provides a basis for the assignment of utilities to consequences by formulating necessary and sufficient conditions to satisfy (i) and (ii).

A utility function is defined mathematically as a function  $u(\cdot)$  from the set of consequences Y into the real numbers that provides for satisfaction of (i) and (ii).

There exist various methods for constructing utility functions. The best-known method is based on indifference judgments of the decision maker about specially constructed alternatives (lotteries).

Utility theory permits one to distinguish [[<u>risk-prone</u>,]] [[<u>risk-neutral</u>]] and [[<u>risk-averse</u> <u>decision</u> <u>makers</u>.]]

For example, if the mutually exclusive payoffs  $x_1, x_2, x_3$  of an alternative A are all expressed in the same units (e.g., schillings), the decision maker is risk-prone if he prefers the alternative A (prefers the lottery) to receiving, with no risk, the expected value of the payoffs (calculated directly as E(x|P)=  $p_1x_1 + p_2x_2 + (1-p_1-p_2)x_3$ ). This preference can also be expressed as

- 40 -

#### E(u|P) > u(E(x|P))

i.e., the expected utility of the lottery to the risk-prone decision maker is larger than the utility of the expected value of the consequence.

The risk-neutral and risk-averse decision makers are defined accordingly.

The [[multiattribute utility function]] is defined as a function u(.) from the set of multiattribute consequences into the real numbers. This means that it applies to cases where each of the mutually exclusive consequences has several attributes. Multiattribute utility functions, besides having properties (i) and (ii), also express the decision maker's <u>trade-offs</u> among the attributes (compare <u>multiattribute value function</u>). Several special forms of multiattribute utility functions have been developed, including the additive and the multiplicative forms.

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#### [[validation]]

Validation is the process of increasing the confidence that the outputs of the <u>model</u> conform to reality in the required range. In some cases the model's output can be compared to data from historical sources or from an experiment conducted for validation. A model can never be completely validated; we can never

- 41 -

prove that its results conform to reality in all respects; it can only be invalidated. Predictive models can be validated only by judgment, since a model may fit past data well without having good predictive qualities.

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### [[value]]

Value can be either objective or subjective; in the latter case it means subjective worth or importance. For example, "the value of future <u>benefits</u> to the <u>decision maker</u>," "the value of clean air to the society".

For the purposes of analysis, the subjective values must be measured on some scale. These measures of value should be based on preferences expressed by the person or group of interest.

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In [[value analysis,]] one considers that the value v is related to the physical or other objective measure y of a consequence by a subjectively defined [[value function,]] so that v = f(y). A value function usually departs from proportionality, i.e., it usually is a nonlinear dependence.

A typical example is the subjective value of money to an individual: the first 1,000 schillings in his savings account are probably of more value to him than the 1,000 schillings that

- 42 -

would increase the state of his account from 100,000 to 101,000 schillings.

The value of a multiattribute consequence with <u>value-relevant attributes</u>  $y_1, y_2, \dots, y_n$  can be expressed by a [[<u>multiattribute value function</u>,]]  $v(y_1, y_2, \dots, y_n)$ .

A multiattribute value function must satisfy the following condition:

$$v(y_1, y_2, \dots, y_n) \geq v(y_1, y_2, \dots, y_n)$$

if and only if the multiattribute consequence  $(y_1, y_2, \dots, y_n)$  is preferred or indifferent to  $(y_1^i, y_2^i, \dots, y_n^i)$ .

Several theories exist according to which a multiattribute value function  $v(\cdot)$  can in appropriate cases be expressed as an aggregate of single-attribute functions  $v_i(\cdot)$ . For example, the additive [[conjoint measurement theory]] assumes that

$$v(y_1, y_2, ..., y_n) = \sum_{i=1}^n v_i(y_i).$$

See also: utility, decision theory.

- 43 -

# [[verification]]

A (computer) <u>model</u> is said to be verified if it behaves in the way that the model builder wanted it to behave. This means that the instructions are correct and have been properly programmed. One check for verification is to hold some of the variables constant to determine whether the output changes in anticipated ways as other variables are changed. Another typical check is to test how the model behaves in limit situations.

Compare: validation.

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#### GLOSSARY INDEX RUSSIAN-ENGLISH 9K8381CA5

TEPMNH CM+ альтеркатива (alternative) ....alternative альтернатива (course of action) .....ourse of action альтернатива (option) ····alternative ....evaluation аналив (evaluation) SHANNS MODENN HS адекватность (vali-....validation dation) анализу оченка программы (program evalua-....evaluation tion) PAOISM ON ENNERS (cost-benefit analysis) .....analysis RADISM ON ENNERS ···Baibaimэффективностьуя (cost-effectiveness analysis) ....analysis SHANNS NO METOAN \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* (risk-benefit analysis) ....analysis аналия ресурсов (resource analysis) .....analysis анализ решений (decision .....analysis analysis) анализ риска (risk analysis) •••••risk анализ риска (risk assessmerit) •••••risk зналив социальноэкономических Решений (Policy analysis) .....analysis аналия чувствительности альтернативы (к изменениям внешней CPEAW) (contingency analysis)

TEPMKH

C'M +

.....analysis аналив чивствительности альтернативы (к изменениям. характеризующих ее napamerpos)(sensi-......analysis tivity analysis) аналитическая модель (analytic model) .....model афортнори зналив (а fortiori analysis) .....a fortiori analysis **Чачансовая** модель (input-output ..... (Leonmodel) tief) analysis вариант решения (alternative) ....alternative вариант решения (course of action) .....of action BEKTOPRES ONTHMUBELUS (multiobjective op-....optimization timization) векторная чель (vectorvalued objective) ....ortimization вербальная модель (judsmental model) .....model верификация (verification) ....verification BANANNE (impact) ....impact внешняя среда (епуітопmont.) .....environment возможность нечавчи (risk of failure) ••••••••••••••• выгода (benefit) .....consequence ....same theory вымгрыш (рауоff) ГОДОВЗЯ НОРМА АИСКОНТА времени (discount .....discount rate rate) POPNBORT RPOPHOBNPOBBRNS (forecasting lead) ....forecast ACPEBO NCXOAOB (CONSOauence tree) •••••••••••••••consequence **ДЕТЕРМИНИРОВАННАЯ МОДЕЛЬ** (deterministic model) .....model

#### термин

CM+

динамическая модель	
(dynamic model)	model
Аригосрочное ограничение	
(lons-run con-	
straint)	
доминирование (domi-	
nance)	dominance
АОПЧСІИМАЯ ЗЛЬТЕРНАІИВА	
(feasible action)	
аопустимая альтернатива	
(feasible alterna-	
tive)	
долустимая (т.е.,	
<b>ЧАОВЛЕТВОРЯЮ</b> АЗЯ	
ограничениям) чель	
(feasible objec-	
tive)	
допустимое действие	
(feasible action)	
АОЛУСТИМОЕ РЕНЕНИЕ	
(feasible solution)	
АОЛУСТИМЫЙ РЕСУЛЬТАТ	
(feasible conse-	
auence)	
допустимый (т.е.у	
ЧДОВЛЕТВОР ЯК <b>МИЙ</b>	
ограничениям) исх-	
ОДУ РЕСУЛЬТАТ	
(feasible conse-	
auence)	
жесткое ограничение	
(stiff constraint)	·····
задача оптимального	
чправления (optimal	
control problem)	
задача оптимизачии в	
динамической лос-	
тановке (dynamic	
optimatization	·
problem)	
вадачи оптимивачии со	
CTOX8CT NHECK NMN	
ограничениями	
(chance-constrained	
problem)	·····

#### термин

Barpara (cost) вначение (value) значение цели (tarset value) Wrpa (play) игра двях лиц (twoperson same) игра многих инц (multiperson same) ИГРА С НУЛЕВОЙ СУММОЙ (zero-sum same) ИГРОВАЯ ИМИТАЦИОННАЯ MOACNE (roleplaying model) ИГРОВОЕ ИМИЗАЦИОННОЕ MOACANPOBSHME (role-playing) Nrpok (player) ИДЕНТИФИКАЦИЯ МОДЕЛИ (model identification) иерархия целей (hierarchy of objectives) имитачионная модель (simulation model) имитачионные игры (затins) имизация (simulation) исследование операций (operations research) ИСХОА (ПРИ МНОГИХ критериях) (multiattribute conseauence) ИСХОА (ПРИНИМВЕМЫХ решений) (conseauence) итеративный прочесс (iterative process) компромис (tradeoff) КОНКРЕТНО ОПРЕДЕЛЕННАЯ чель (tarset)

**************************************
•••••••••••same theory
theory
theory
•••••••••••••model
theory
••••••
••••••
·····
·····samins
•••••••••••••••simulation
research
••••••
•••••
process
•••••

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- 48 -

#### TEPMAH CH. конфликтная ситчачия (conflict situation) .....same theory конфликтные чели (сопflicting objectives) ....objective КОРРЕЛЯЧИОННАЯ МОДЕЛЬ (correlation model) ....model кратко-срочное ограниченийе (short-run constraint) .....constraint ....attribute критерий (attribute) критерий (criterion) КРИТЕРИЙУ ЧЧИТЫВВЕМЫЙ при оченке решения (value relevant attribute) .....consequence курс действий (alternative) ....alternative КУРС ДЕЙСІВИЙ (COUrse of action) .....of action ....alternative курс действий (option) линейная модель (linear model) .....model линейное программиро-Banne (linear pro-....optimization gramming) личот принимающее Pewerne (decision maker) .....maker ЛИЧОУ ПРИНИМЗЮЩЕЕ решение, кейтрально OTHOCHREPO K PHCKY (risk-neutral deci-.....utility sion maker) личо, принимающее DEMENNES CRYOHHOE избегать риска (risk-averse decision maker) ....utility личо, принимающее DEMENNES CRYOHHOG K PHCKY (risk-prone .....utility decision maker)

- 49 -

лотерея (lottery) максимаксный критерий – (max-max rule) максиминный кризерий (max-min rule) маргинальная полевность (marsinal utility) Матрича, описывающаяся davake (technological interdependence matrix) машикная имитация (сопputer simulation) машкниая модель (computer model) метод уздельфиуу (де]рhi method) методология построения и аналкаа оалансовых MORENEN (inputoutput (Leontief) analysis) многокритериальная ФЧНКЦИЯ ПОЛЕВНОСТИ (multiattribute utility function) многокритеризльная ФАНКЛИЧ НЕННОСІМ (multiattribute value function) множество долнстимых) целей, альтернатив, и т.д. (feasible set) MORENE (model) модель, резлизчемая на эвм (computer

model) модель, ччитываккая причинно-

> CAEACIBERHUE CBABN (causal model)

TEPMAR

....utility .....theory .....theory ....utility tief) analysis ....simulation ....model ....Belphi method .....input-output (Leontief) analysis ....utility ....value .....constraint ....model .....model

....model

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# ТЕРМИН Инейнов Про

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нелилнейное программиро-	
вание (nonlinear	
programming)	ortimization
неолределенность (uncer-	
tainty)	
НЕЧЧИТЫВЗЕМОС ПРИ ЗНЗИ-	
ИЗЕ ВЛИЯНИЕ РЕШСНИЯ	
НЭ ВНЕШНИЕ СИСТЕМЫ	
(spillover)	
неччитываемое при анал-	
ИЗЕ ПОСЛЕАСТВИЕ	
решения (externali-	
ty)	•••••••••••••externality
ограничение (constraint)	•••••••••••••constraint
ОАНОКРИТЕРИЗЛЬНОЕ	
HOCAEACTBNE	
(single-attribute	
consequence)	• • • • • • • • • • • • • • • • • • •
ОДНОКРИТЕРИЗЛЬНЫЙ ИСХОД	
(sinsle-attribute	
consequence)	•••••••••••••••CONSEQUENCE
ОХИДЗЕМВЯ ПОЛЕВНОСТЬ	,
(expected utility)	•••••••••••••utility
ОПРЕДЕЛЕНИЕ ДОПИСТИМЫХ	
чели, решений и	
T.A. (feasibility	
analysis)	analysis
ОПРЕДЕЛЕНИЕ ЧЕННОСТИ	
0066K108 N KOHKPE1-	
ных значений	
OODEKINBHO NBMEPEH-	
HUX BEANANH (VBIUE	<b>N</b>
analysis)	••••••••••••••••••••••••••••••••••••••
ОПТИМВЛЬНАЯ СТРАТЕГИЯ	
(OP <b>timum</b> stratesy)	•••••••••••••••same theory
ONTHMANSHOE PEWEHNE (OP-	
TIMBI SOLUTION)	••••••••••••••••••••••••••••••••••••••
UNITAMBANNAN AD ABPETO	and in implication
(rareto-optimal)	•••••••••••••••••0%%1m128%10N

#### термин

.....model

ONTHMUSSHNORKSA MODENE (optimization model) оптимивация (optimization) ОПТИМИВАЧИЯ ПРИ НВЛИЧИИ ОАНОЙ ЧЕЛЕВОЙ Фчнкции (singleobjective optimization) осучествление (implementation) отказ от поиска OULAWSVPHOLO решения (satisficing) OMERKA (evaluation) ОЧЕНКА АЛЬТЕРНАТИВ ПРИ неблагопринатных внешних человиях (а fortiori analysis) OLEHKS MOREAN (model estimation) napamerp (attribute) лараметры модели (model parameters) партия (ріач) nepemennue (decision variable) переход от непрерывной к АКСКРЕТНОЙ ПОСтановке задачи (discretization) nnaiex (payoff) платежная Фчикчия (payoff function) NONEBHOCTE (utility) последствие принимаемых PEWEHNA (conseauence) последствие решения (ітpact) потери от принимаемого решения (opportunity cost)

••••••••••••••••••••••••••••••••••••••
•••••••••••••implementation
evaluation
a fortiori analysis
•••••••••••••••model •••••••
••••••••••••••••••••••••••••••••••••••
••••••••••••••consequence
impact
copportunity cost

#### TEPMKH

norpedkocts (demand) предсказание (prediction) прикятие решений в ACVOBNAX неопределенности (decision under uncertainty) прикятие решений в ЧСЛОВИЯХ ОПРЕДЕЛЕН-HOCIN (decision under certainty) ПРИКЯТИЕ РЕШЕНИЙ В человиях риска (decision under risk) NPOBCPKa (verification) nporkos (forecast) пространство альтернатив (action space) пространство исходов (consequence space) пространство челей (об-Jective space) пространство челей (tarset set) ПРОТИВОРЕЧИВЫЕ ЧЕЛИ (competitive multi-PEBANBBUNG (implementation) PEBHADIBI NPN MHORNX кризериях (multiattribute conseauerice) PESAVEISI UENHNWSEMMY решений (солзеauence) решение (основное) (ртіmary decision) решение о тому как про-ВОАИТЬ СИСТЕМНЫЙ ananna (secondary decision)

.....demarid ....forecast .....decision theory .....theory .....theory ....verification ....forecast .....consequence .....consequence .....objective ....objective ....objective ....implementation •••••••••••••••consequence ••••••••••••••Consequence .....decision

..... decision

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#### TEPMAH

PHCK (risk) ....risk РОВКавесная чена (equilibrium price) самовыполняющийся прог-HOB (selffulfilling forecast) системный акалив (595tems analysis) Скаляркая оптимизация (single-objective optimization) скалярная цель (scalarvalued objective) СНИЖЕНИЕ ЧАСЛЬНЫХ ЗЭТРЭТ при расширении производства (есопomy of scale) COCIORNNE MNPa (state of the world) состояние мира (state of the world) состояние природы (state of nature) cnpoc (demand) статическая модель (static model) стохастическая имитация (stochastic simulation) стохастическая модель (stochastic model) стохастическое программирование (ртораbilistic programmins) стохастическое программирование (stochastic programming) структура модели (model structure) ••••••••••••••••model суболлимивачия (suboptimization) ......subortimization

.....demand ....forecast ....alysis ••••••imization ....optimization .....of scale ..... of the world ....environment •••••demand .....model .....model .....model ....optimization

#### термин

СЧОРЕКТИВНАЯ ВЕРОЯТНОСТЬ (subjective probahility) сченарий (scenario) TEOPNS MEP (Same theory) теория полезности (utility theory) теория принятия решений (decision theory) теория сопряженных измерений (conjoint measurement theory) технологический козффи-HeH) (technological coefficient) точка в пространстве челей (tarset point) ЭВЕЛИЧЕНИЕ НАСЛЬКЫХ ВАтрат при расширении производства (diseconomy of scale) человный прогнов (conditional forecast) ччастник игры (actor) ччастник игры (decision maker) **АНЭСЛНИК ЗКОПЕРИМЕНТЭ** (player)

Формальная модель (formal model) Функция благосостояния (welfare function) Функция выигрыма (разоff function) Функция полевности (utility function) Функция предложения (supply function) Функция спроса (demand function) Функция ценности (value

function)

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.....theory ....scenario ....utility .....theory ....value ..... (Leontief) analysis ....objective .....of scale .....forecast ....same theory .....model ....utility .....theory •••••••••••••utility ••••demand •••••demarid ....value

#### термин

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характеристика (attri- 🎈	
bute)	attribute
челевая Фянкция (орјес	
tive function)	optimization
чели (multiple objec-	
tives)	objective
челочисленное програм-	
мирование (inteser	
programming)	optimization
чель (soal)	objective
чель (objective)	objective
чель (вытекающая из исх	
ОДНЫХ И СФОРМЧЛИРО-	
ванная фолее	
конкретно) (ртоху	
objective)	objective
ченность (value)	value
человеко-машинная имита-	
чия (man-machine	
simulation)	••••••••••••simulation
человеко-машинная модель	
(man-machine model)	
эксперимент (ехрегімел—	
tation)	experimentation
экспериментирование (ех-	Υ.
perimentation)	•••••••••••••••experimentation
эластичные ограничения	
(elastic con-	
straint)	
эффективность (effec-	
tiveness)	effectiveness
эффективность (efficien-	
CH)	

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extended.index Page 1

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```
a fortiori analysis. *X Ent: contingency analysis
a fortiori analysis **X Ent: sensitivity analysis
a fortiori analysis *E
action, feasible **E(kwic for: feasible action) Ent: constraint
action space, *X
                    Ent: constraint
action space **E
                    Ent: consequence
      **E Ent: role-playing
actor
actor **X Ent: model
alternative *X Ent: dominance
alternative?"
              *X Ent: risk
alternative *X Ent: sensitivity analysis
alternative
             *X
                 Ent: utility
alternative
             *х
                    Ent: a fortiori analysis
alternative *X
                   Ent: effectiveness
alternative. *X
                    Ent: opportunity cost
alternative *E
alternative, feasible **E(kwic for: feasible alternative)
                                                          Ent: constraint
alternatives *X Ent: decision theory
              * X
alternatives,
                     Ent: constraint
alternatives *X
                     Ent: contingency analysis
alternatives *X
                    Ent: course of action
alternatives *X
                    Ent: criterion
alternatives. *X
                     Ent: decision maker
analysis, a fortiori **E (kwic for: a fortiori analysis)
analysis, contingency **E (kwic for: contingency analysis) -
analysis, cost-benefit **E(kwic for: cost-benefit analysis) Ent: systems analysis
analysis, cost-effectiveness **C(kwic for: cost-effectiveness analysis) Ent: systems analysis
analysis, decision **E(kwic for: decision analysis) Ent: systems analysis
analysis, feasibility **E(kwic for: feasibility analysis) Ent: systems analysis
analysis, input-output (Leontief) **E (kwic for: input-output (Leontief) analysis)
analysis, Leontief **S (kwik for: Leontief analysis) Ent: input-output (Leontief) analysis Syn. for: input-output (Leontief)
analysis, policy **E(kwic for: policy analysis) Ent: systems analysis
analysis, resource **E (kwic for: resource analysis)
analysis, risk **E(kwic for: risk analysis) Ent: risk
analysis, risk **S (kwik for: risk analysis) Ent: risk Syn. for: risk assessment
analysis, risk-benefit **E(kwic for: risk-benefit analysis) Ent: systems analysis
analysis, sensitivity **E (kwic for: sensitivity analysis)
analysis, value **E(kwic for: value analysis) Ent: value
analytic model *E 'Ent: model
attribute, value-relevant **E(kwic for: value-relevant attribute) Ent: consequence
benefit **E
               Ent: consecuence
benefit
         **X
               Ent: efficiency
         **X
benefit
               Ent: discount rate
benefits *X
               Ent: externality
benefits
         *X
              Ent: value
benefits
         *X
               Ent: opportunity cost
tenefits, *X
                  Ent: systems analysis
causal model **E
                    Ent: model
chance-constrained problem **D
                                  Ent: optimization
coefficient, technological **E(kwic for: technological coefficient) Ent: input-output (Leontief) analysis
competitive multiple objectives **E
                                      Ent: objective
                             Ent: satisficing
competitive objectives *X
computer simulation *E Ent: Simulation
conditional forecast *E
                        Ent: forecast
conflict situation *X
                         Ent: objective
```

extended.index Page 2

```
conflict situation **E -Ent: game theory
conflicting objectives. *E Ent: objective
conjoint measurement theory *E Ent: value
consequence *X Ent: externality
consequence; *X Ent: impact
consequence *E
consequence, feasible **E(kwic for: feasible consequence) Ent: constraint
consequence, multiattribute **E(kwic for: multiattribute consequence) Ent: consequence
consequence, single-attribute **E(kwic for: single-attribute consequence) Ent: consequence
consequence space, *X Ent: constraint
consequence space **E
                       Ent: consequence
consequence tree *E Ent: consecuence
consequences. *X Ent: decision theory
consequences *X Ent: dominance
consequences *X Ent: environment
consequences *X Ent: state of the world
consequences *X Ent: utility
consequences, - *X
                   Ent: constraint
consequences *X
                    Ent: model
consequences *X
                    Ent: systems analysis
constraint **X Ent: optimization
constraint *E
constraint, elastic **E(kwic for: elastic constraint) Ent: constraint
constraint, long-run **E(kwic for: long-run constraint) Ent: constraint
constraint, removable **S (kwik for: removable constraint) Ent: constraint Syn. for: elastic constraint
constraint, short-run **E(kwic for: short-run constraint) Ent: constraint
constraint, stiff **E(kwic for: stiff constraint) Ent: constraint
constraint, unquestionable. **S (kwik for: unquestionable constraint) Ent: constraint Syn. for: stiff constraint
constraints). *X
                     Ent: objective
                    Ent: systems analysis
constraints, *X
contingency analysis. *X Ent: sensitivity analysis
contingency analysis. *X Ent: a fortiori analysis
contingency analysis *E
correlation model **E
                         Ent: model
cost **E Ent: consequence
cost **X Ent: discount rate
cost, opportunity **E (kwic for: opportunity cost)
                                                                                  \supset
cost-benefit analysis **E Ent: systems analysis
cost-effectiveness analysis. *E Ent: systems analysis
costs *X Ent: externality
costs, *X
              Ent: systems analysis
course of action *X Ent: experimentation
course of action, *X Ent: state of the world
course of action *X Ent: consequence
course of action; *X Ent: model
course of action. *X Ent: scenario
course of action *X Ent: systems analysis
course of action **X Ent: impact
course of action *E
courses of action *X Ent: alternative
courses of action. *X Ent: resource analysis
criterion *X Ent: decision theory
criterion *X
                 Ent: optimization
criterion **X Ent: dominance
criterion *S
decision analysis. *E Ent: systems analysis
```

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extended.index Page 3

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decision maker,
                 *X
                    Ent: alternative
decision maker
                *X
                     Ent: decision theory
               *X
                     Ent: environment
decision maker
               *x
                     Ent: risk
decision maker
decision maker
               *x
                     Ent: secondary decision
               *X
decision maker
                     Ent: utility
decision maker, *X Ent: value
decision maker *X Ent: consequence
decision maker *X Ent: course of action
               *X Ent: objective
decision maker
decision maker
               **X Ent: systems analysis
decision maker **X Ent: externality
decision maker
              **X Ent: game theory
decision maker *E
decision maker, risk-averse **E(kwic for: risk-averse decison maker) Ent: utility
decision maker, risk-neutral **E(kwic for: risk-neutral decision maker) Ent: utility
decision maker, risk-prone **E(kwic for: risk-prone decision maker) Ent: utility
decision makers *X Ent: role-playing
                     Ent: trade-off
decision maker's *X
decision, primary **E(kwic for: primary decision) Ent: secondary decision
decision, secondary **E(kwic for: secondary decision) Ent: secondary decision
decision taker ***S Ent: decision maker Syn. for: decision maker
decision theory *X
                      Ent: risk
                      Ent: trade-off
decision theory
                *X
                *X
                      Ent: uncertainty
decision theory
               *X
                     Ent: utility
decision theory,
decision theory; *X
                     Ent: utility
decision theory. *X
                     Ent: value
                *X
decision theory
                      Ent: consequence
decision theory). *X Ent: optimization
decision theory *E
decision under certainty **E Ent: decision theory
decision under risk *E Ent: decision theory
decision under uncertainty. *E Ent: decision theory
decision variables, *E Ent: optimization
Delphi method *E
demand *E
demand function, *E Ent: demand
ceterministic model *E Ent: model
discount rate **X Ent: systems analysis
discount rate *E
oiscretization *E
                     Ent: optimization
diseconomy of scale, *E Ent: economy of scale
dominance *E
aynamic model *E Ent: model
gynamic optimization problem **E
                                   Ent: optimization
economy of scale *E
effectiveness *X
                     Ent: efficiency
effectiveness *E
efficiency *E
elastic constraint
                  **E
                          Ent: constraint
environment; *X Ent: sensitivity analysis
             *X Ent: state of the world
environment.
environment *X
                   Ent: contingency analysis
environment *E
equilibrium price: *E Ent: demand
```

extended.index Page 4

estimation, model \*\*E(kwic for: model estimation) Ent: model evaluation \*E expected utility \*X Ent: decision theory excected utility \*\*E Ent: utility excerimentation \*E externalities. \*X Ent: consequence externality \*E feasibility analysis, \*E Ent: systems analysis feasible action \*\*E Ent: constraint feasible alternative **\*\***E(kwic for: feasible alternative) Ent: constraint feasible consequence \*\*E(kwic for: feasible consequence) Ent: constraint feasible objective **\*\***E(kwic for: feasible objective) Ent: constraint feasible set \*E Ent: constraint feasible solution, \*E Ent: optimization forecast \*X Ent: state of the world forecast #X Ent: scenario forecast \*E forecast, conditional \*\*E(kwie for: conditional forecast) Ent: forecast forecast, self-fulfilling \*\*E(kwic for: self-fulfilling forecast) Ent: forecast forecasting horizon \*\*\*S Ent: forecast Syn, for: forecasting lead forecasting lead \*E Ent: forecast formal model \*\*E Ent: model gample \*\*\*S Ent: utility Syn. for: lottery game, multiperson \*\*E(kwic for: multiperson game) Ent: game theory game theory, \*X Ent: decision theory game theory, \*X Ent: decision theory game theory). \*X Ent: objective game theory \*E game, two-person \*\*E(kwid for: two-person game) Ent: game theory game, zero-sum \*\*E(kwic for: zero-sum game) Ent: game theory gaming. \*X Ent: simulation gaming \*\*E Ent: role-playing goal \*E Ent: objective hierarchy of objectives. \*E Ent: objective horizon, forecasting \*\*5 (kwik for: forecasting horizon) Ent: forecast Syn. for: forecasting lead identification, model \*\*E(kwic for: model identification) Ent: model impact, \*X Ent: risk impact). \*X Ent: consequence impact \*E inpacts \*X Ent: resource analysis implementation \*E input-output (Léontief) analysis \*E input-output model \*E Ent: input-output (Leontief) analysis integer programming \*E Ent: optimization interdependence matrix, technological \*\*E(kwic for: technological interdependence matrix) Ent: input-output (Leontief) interest rate \*\*\*S Ent: discount rate Syn. for: discount rate iterative process \*E judgmental model \*\*E Ent: model Leontief analysis \*\*S (kwik for: Leontief analysis) Ent: input-output (Leontief) analysis Syn. for: input-output (Leonlinear model \*\*E Ent: model linear programming \*E Ent: optimization linear programming \*X Ent: model long-run constraint \*\*E Ent: constraint lottery \*\*E Ent: utility man-machine model \*E Ent: model man-machine model. =X Ent: simulation

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```
man-machine simulation **E Ent: simulation
marginal utility **E Ent: utility
max-max rule *E Ent: decision theory
max-min rule, *E Ent: decision theory
model *X Ent: input-output (Leontief) analysis
model *X Ent: simulation
model *X Ent: validation
model *X Ent: verification
model. *X Ent: consequence
model **X Ent: experimentation
model *E
model, analytic **E(kwic for: analytic model) Ent: model
model, causal **E(kwic for: causal model) Ent: model
model, correlation **E(kwic for: correlation model) Ent: model
model, geterministic **E(kwic for: deterministic model) Ent: model
model estimation. *E Ent: model
model, formal **E(kwic for: formal model) Ent: model
model identification; *E Ent: model
model, input-output **E(kwic for: input-output model) Ent: input-output (Leontief) analysis
model, judgmental **E(kwic for: judgmental model) Ent: model
model, linear **E(kwic for: linear model) Ent: model
model, man-machine **E(kwic for: man-machine model) Ent: model
model, optimization **E(kwic for: optimization model) Ent: model
model parameters **E Ent: model
model, role-playing **E(kwic for: role-playing model) Ent: model
model, simulation **E(kwic for: simulation model) Ent: model
model, static **E(kwic for: static model) Ent: model
model, stochastic **E(kwic for: stochastic model) Ent: model
model structure **E Ent: model
models *X Ent: decision theory
models, *X Ent: secondary decision
models. *X
             Ent: consequence
models. *X
              Ent: forecast
multiattribute consequence *E Ent: consequence
multiattribute consequence **X Ent: utility
multiattribute utility function *E Ent: utility
multiattribute utility functions. *X Ent: trade-off
multiattribute value function, *E Ent: value
multiattribute value function *X Ent: decision theory
multiattribute value function). *X Ent: utility
multiattribute value functions *X Ent: trade-off
multiobjective optimization. *E Ent: optimization
multiperson game **E Ent: game theory multiple objectives **E Ent: objective
multiple objectives **X Ent: satisficing
nonlinear programming *E Ent: optimization
objective. *X Ent: criterion
objective **X Ent: role-playing
objective *E
objective, feasible **E(kwic for: feasible objective) Ent: constraint
objective function, *E Ent: optimization
objective, proxy **E(kwic for: proxy objective) Ent: objective
objective, scalar-valued **E(kwic for: scalar-valued objective) Ent: optimization
objective space. *E Ent: objective
objective space *X Ent: constraint
objective, vector-valued **E(kwic for: vector-valued objective) Ent: optimization
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1 61 extended.index Page 6

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objectives. *X Ent: alternative
objectives *X
                 Ent: decision theory
objectives
           *X
                 Ent: game theory
objectives *X
                 Ent: operations research
objectives, *X
                    Ent: consequence
objectives *X
                   Ent: constraint
objectives *X
                   Ent: course of action
objectives. *X
                    Ent: effectiveness
objectives, *X
                    Ent: systems analysis
objectives, conflicting ** £ (kwic for: conflicting objectives.) Ent: objective
objectives, hierarchy of **E(kwic for: hierarchy of objectives) Ent: objective
objectives, multiple **E(kwic for: multiple objectives) Ent: objective
operational research ***S Ent: operations research Syn. for: operations research
                     *X Ent: systems analysis
operations research.
operations research *E
opportunity cost *E
optimal control problem ***S Ent: optimization Syn. for: dynamic optimization
optimal solution *E Ent: optimization
optimization, *X Ent: decision theory
optimization *X
                    Ent: satisficing
optimization *X
                    Ent: suboptimization
optimization *E
optimization model *E Ent: model-
optimization, multiobjective **E(kwic for: multiobjective optimization)
                                                                       Ent: optimization
optimization problem, dynamic **E(kwic for: dynamic optimization problem) Ent: optimization
optimization, single-objective **E(kwic for: single-objective optimization) . Ent: optimization
optimum strategy *E Ent: game theory
option ***S Ent: alternative Syn. for: alternative
options. *X
                Ent: course of action
outcome ***5 Ent: consequence Syn. for: consequence
outcomes *X Ent: sensitivity analysis
Pareto optimal **E
                      Ent: optimization
play **E Ent: game theory
player **E Ent: game theory
player ***S Ent: role-playing Syn. for: actor
policy analysis *E Ent: systems analysis
prediction. *E Ent: forecast
price, equilibrium **i.(kwic for: equilibrium price)
                                                    Ent: demand
primary decision **E Ent: secondary decision
probabilistic programming *E Ent: optimization
probability, subjective **E(kwic for: subjective probability) Ent: decision theory
problem
program evaluation *E Ent: evaluation
programming, integer **E(kwic for: integer programming) Ent: optimization
programming, linear **E(kwic for: linear programming) Ent: optimization
programming, nonlinear **E(kwic for: nonlinear programming) Ent: optimization
programming, stochastic **E(kwic for: stochastic programming) Ent: optimization
proxy objective **E
                       Ent: objective
removable constraint ***S Ent: constraint Syn. for: elastic constraint
resource analysis *E
risk, *X Ent: decision theory
risk *X Ent: uncertainty
lisk *X Ent: utility
risk *X
             Ent: consequence
risk *E
risk analysis *E Ent: risk
```

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risk analysis ***S Ent: risk Syn. for: risk assessment
      risk assessment *E Ent: risk
      risk, decision under **E(kwic for: decision under risk) Ent: decision theory
      risk-averse decison maker **E Ent: utility
      risk-benefit analysis. *X Ent: risk
      risk-tenefit analysis **E Ent: systems analysis
      risk-neutral decision maker **E Ent: utility
      risk-prone decision maker **E Ent: utility
      risks: *X Ent: systems analysis
      role playing, *X Ent: simulation
      role-playing *E
      role-playing model **E Ent: model
      satisficing *E
      scalar-valued objective **E Ent: optimization
      scenario. *X
                      Ent: forecast
      scenario *E
      secondary decision *E
      self-fulfilling forecast. *D Ent: forecast
      sensitivity analysis, *X Ent: a fortiori analysis
      sensitivity analysis, *X
                                 Ent: contingency analysis
      sensitivity analysis *E
      shert-run constraint **E
                                Ent: constraint
      simulation *X Ent: role-playing
1
      simulation, *X Ent: secondary decision
      simulation *E
σ
      simulation, computer **E(kwic for: computer simulation) Ent: simulation
ω
      simulation, man-machine **E(kwic for; man-machine simulation) Ent: simulation
1
      simulation model *E Ent: model
      simulation, stochastic **E(kwic for: stochastic simulation) Ent: model
      single-attribute consequence *E Ent: consequence
      single-attribute consequences **X Ent: utility
      single-objective optimization **E
                                       Ent: optimization
      scillover. *E Ent: externality
      spillovers *X
                      Ent: consequence
      state of nature ***S Ent: environment Syn. for: environment
      state of the world **X Ent: environment
      state of the world *E
      static model *E Ent: model
      stiff constraint **E Ent: constraint
      stochastic model *E Ent: model
      stochastic programming **E Ent: optimization
      stochastic simulation, *E Ent: model
      strategy, optimum **E(kwic for: optimum strategy) Ent: game theory
      subjective probability **E Ent: decision theory
      suboptimization *E
      subply function *E Ent: demand
      systems analysis, *X Ent: experimentation
                            Ent: operations research
      systems analysis. *X
      systems analysis. *X
                            Ent: risk
                             Ent: secondary decision
      systems analysis *X
                             Ent: course of action
      systems analysis *X
                             Ent: effoctiveness
      systems analysis, *X
      systems analysis *X
                             Ent: model
                             Ent: objective
      systems analysis, *X
      systems analysis *E
      target *E Ent: objective
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target point . *E Ent: objective
target set. *E Ent: objective
target value **E Ent: objective
technological coefficient **E Ent: input-output (Leontief) analysis
technological interdependence matrix *E Ent: input-output (Leontief) analysis
tief) analysis
trade-off *E
trade-offs *X Ent: operations research
trade-offs *X Ent: utility
two-verson game **8 Ent: game theory
Uncertainty. *X Ent: decision theory
uncertainty *X Ent: risk
uncertainty *X Ent: utility
undertainev *X
                   Ent: consequence
uncertainty *X
                   Ent: contingency analysis
uncertainty *E
uncertainty, decision under **E(kwic for: decision under uncertainty) Ent: decision theory
un autionable constraint ***S Ent: constraint Syn. for: stiff constraint
utility, *X Ent: decision theory
utility. *X Ent: trade-off
utility, *X Ent: value
utility *E
utility, expected **E(kwic for: expected utility) Ent: utility
utility function *X Ent: decision theory
utility function **E Ent: utility
utility function ***S Ent: utility Syn. for: welfare function
utility function, multiattribute **E(kwic for: multiattribute utility function) Ent: utility
utility, marginal **E(kwic for: marginal utility) Ent: utility
utility theory *E Ent: utility
validation. *X Ent: verification
validation. *X
                  Ent: model
validation *E
value. *X Ent: decision theory
value, *X Ent: trace-off
value *E
value analysis. *E Ent: value
value analysis *X Ent: trade-off
value function. *E Ent: value
value function, multiattribute **E (kwic for: multiattribute value function) Ent: value value-relevant attribute **E Ent: consequence
value-relevant attribute **X Ent: value
vector-valued objective **E
                                 Ent: optimization
verification. *X
                     Ent: model
verification *E
welfare function *E Ent: utility
zero-sum game *E Ent: game theory
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- 54
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