Introduction

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Decision Making

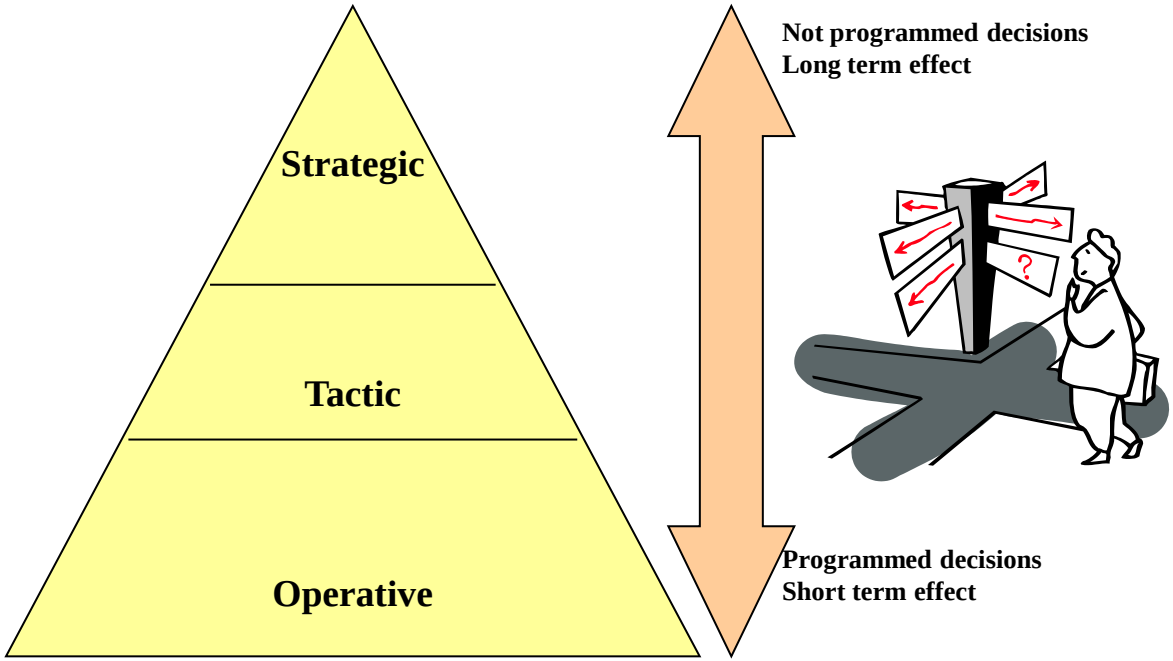
- **Decision making** can be defined as the mental processes (cognitive process) resulting in the selection of a course of action among several alternatives. Every decision making process produces a final choice. The output can be an action or an opinion of choice.

  - Exploration: search and discovery
  - Exploitation: refinement and institutionalization

How is a decision?

- It is a judgment
- There is no right or wrong decision
- They imply commitment
- Must be made at the right time and right cost
- Could be proactive or reactive

Taxonomy


Strategic
Tactic
Operative
Not programmed decisions
Long term effect
Programmed decisions
Short term effect

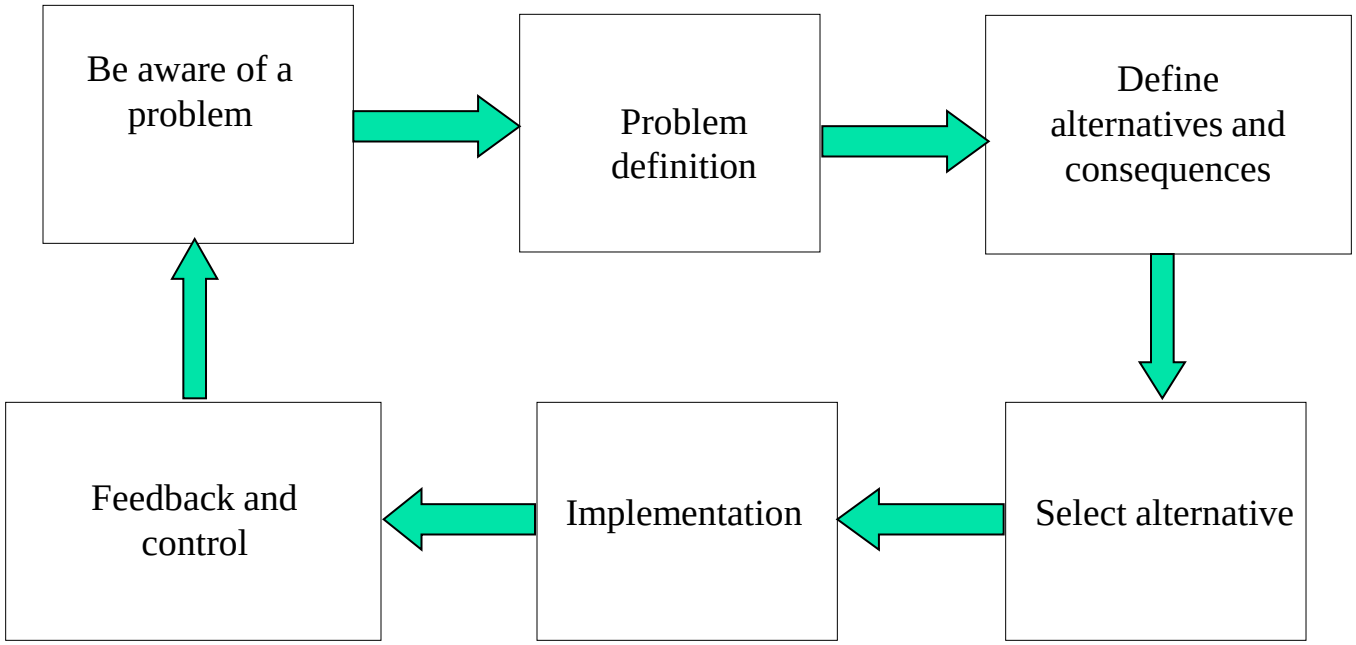
Principles that frame the decision making process:

- Efficiency and Effectiveness
- Planned approach
- Multiple hypotheses
- Limiting factors
- Flexibility

Theories in decision making

- **Rational Theory**
  - Alternatives are known
  - Consequences are known
  - Prioritizing rules
  - Decision rules and criteria
  - Optimal solution

The Rational Process



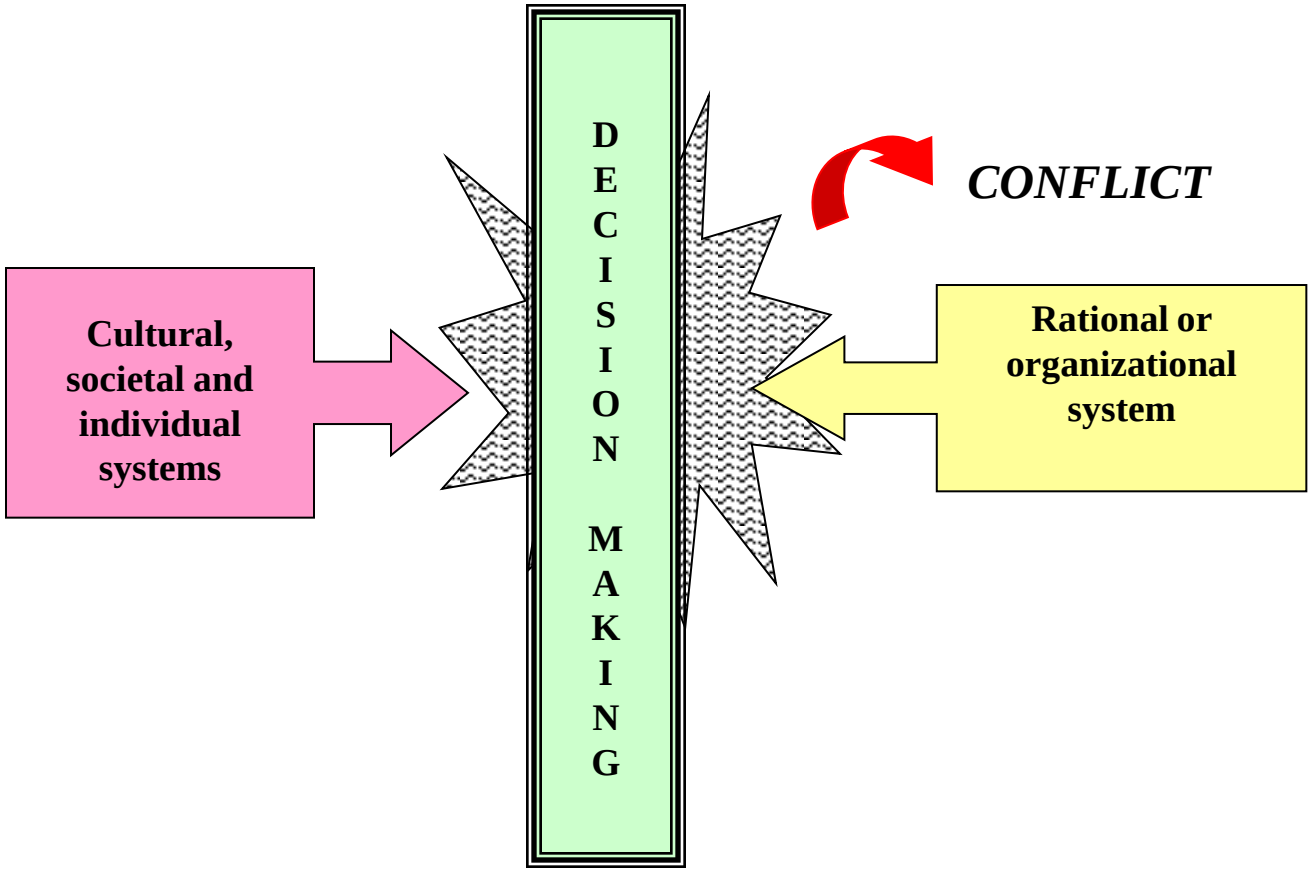
Theories in decision making

- **Bounded Rationality**
  - Modifies the Rational Theory
  - Partial knowledge of alternatives
  - Limited knowledge of consequences
  - Prioritizing rules
  - Decision rules and criteria
  - Looks for satisfaction: local optima

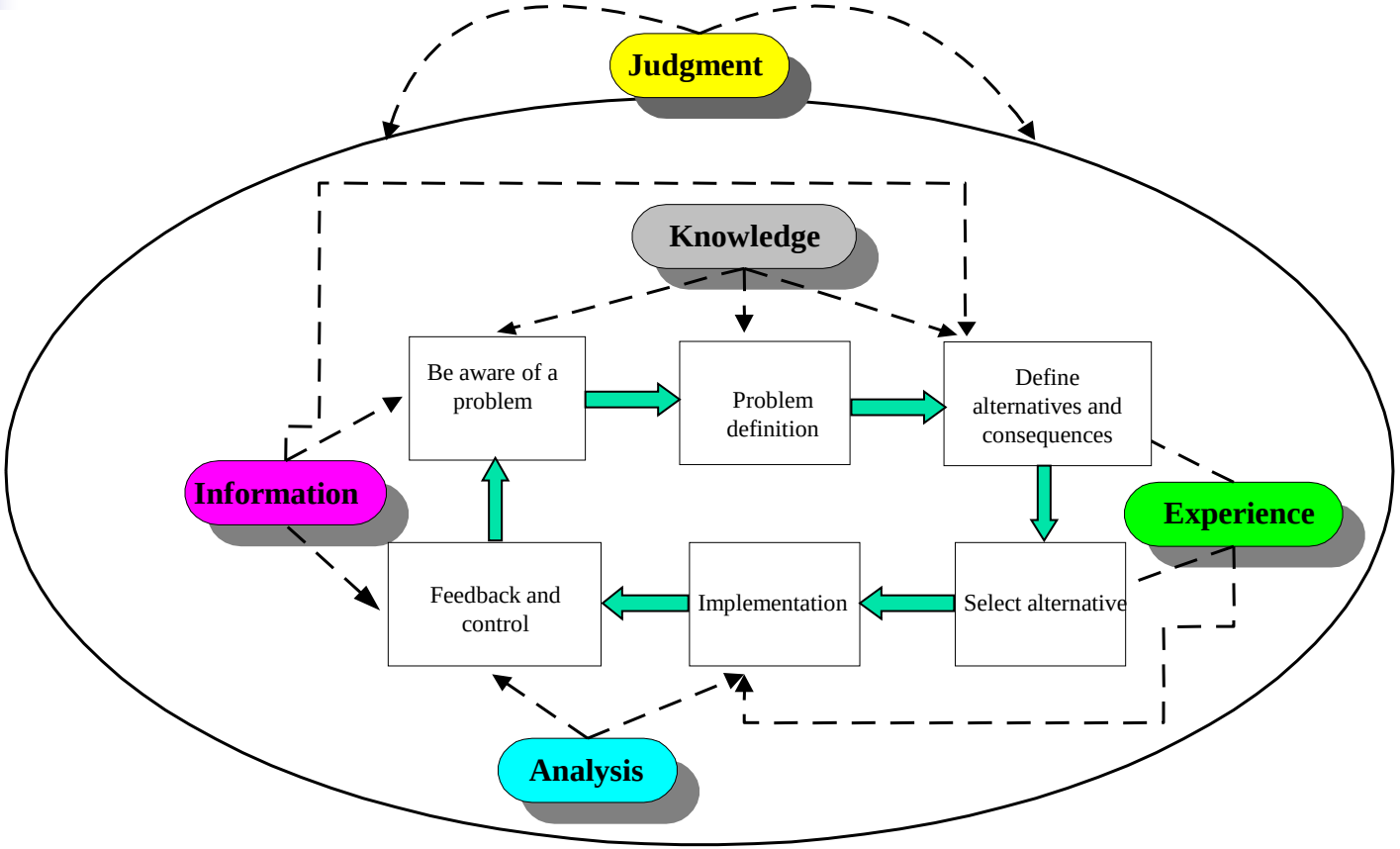
Theories in decision making

- **Decisions based on rules**
  - More realistic approach
  - Decisions based on procedures, rules, policies, bylaws, etc.
  - Rules appear based on:
    - Identity: decisions based on a particular situation.
    - Situation: are classified on categories with rules associated with the identity.
    - Relations: specific actions to handle situations according to identities.

Conflicts in decision making



Elements in decisions

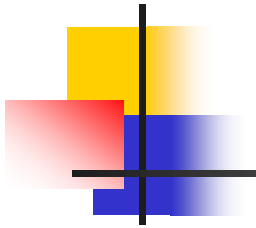


Characteristics of a decision

- **Future effects**
- **Reversibility**
- **Impact**
- **Quality**
- **Periodicity**

Problems affecting decision making

- Erroneous information
- Sample selection
- Bias
- Use of mean
- Selectivity
- Interpretation
- Rushed conclusions
- Insignificant superiority
- Connotation
- Societal status



The Modeling Process

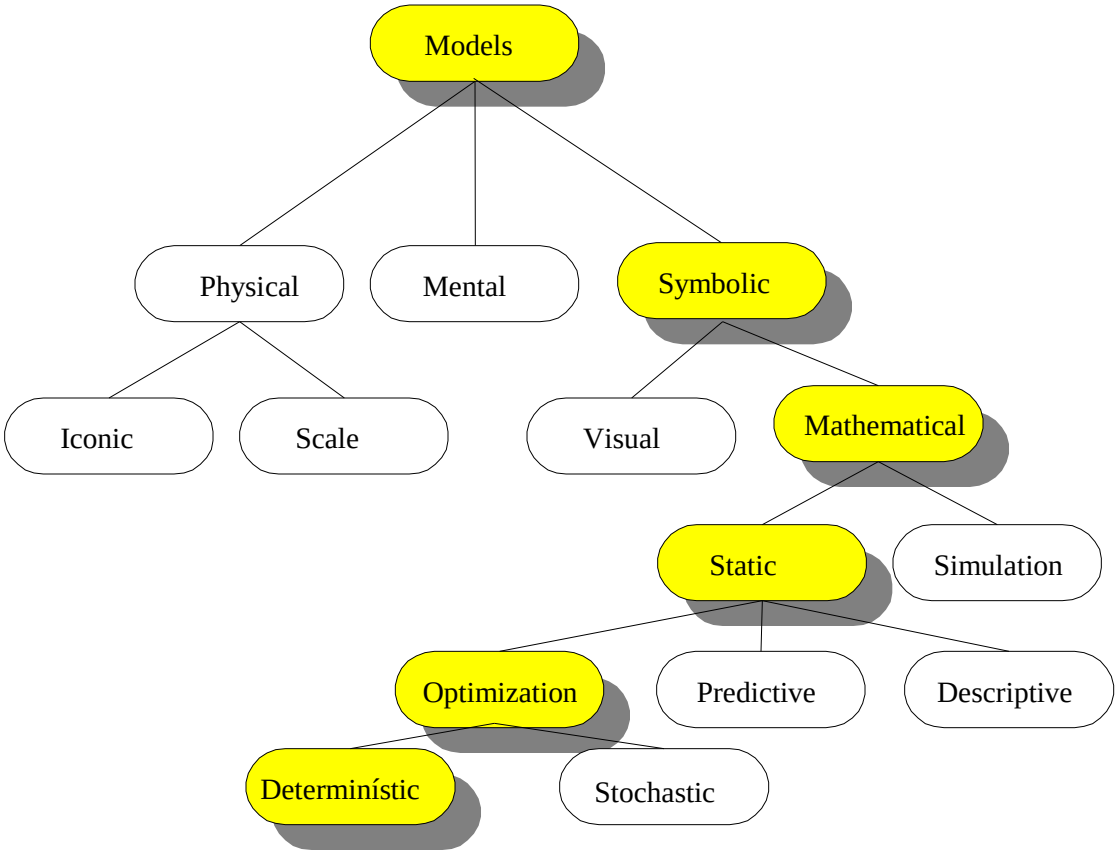
Models and decision making

- The rational approach to decision making uses models and mathematical rules.
- These models and rules allow for a systematic decision making process.
- The use of models is not new: equations, maps, graphs, and diagrams have been used for centuries.

What is a model?

- A model is a representation of a group of objects or ideas somewhat different to the real entity.
  - They are abstractions from reality
  - They are ideal
  - They are not exact
- They main objective is to learn how changes in variables can affect the behavior of a system.

Taxonomy


Models
Physical
Mental
Symbolic
Iconic
Scale
Visual
Mathematical
Static
Simulation
Optimization
Predictive
Descriptive
Determinístic
Stochastic

Mathematical Models

- They are idealized expressions in terms of mathematical symbols and formulations. (Mckeon, 1980)
- Describe functional relationships of the form: Y = $f(.)$

Elements of a mathematical model

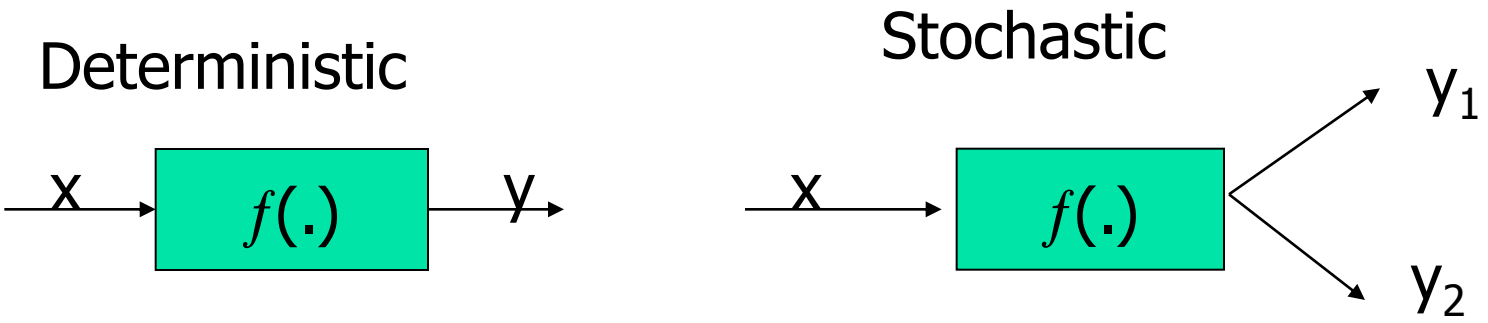
- Variables
  - **Independent**: they define the conditions of the system at certain time
    - Endogenous
    - Exogenous
  - **Dependent**: they define the model response as a function of the independent variables
- Mathematical function

Categories of mathematical modeling techniques

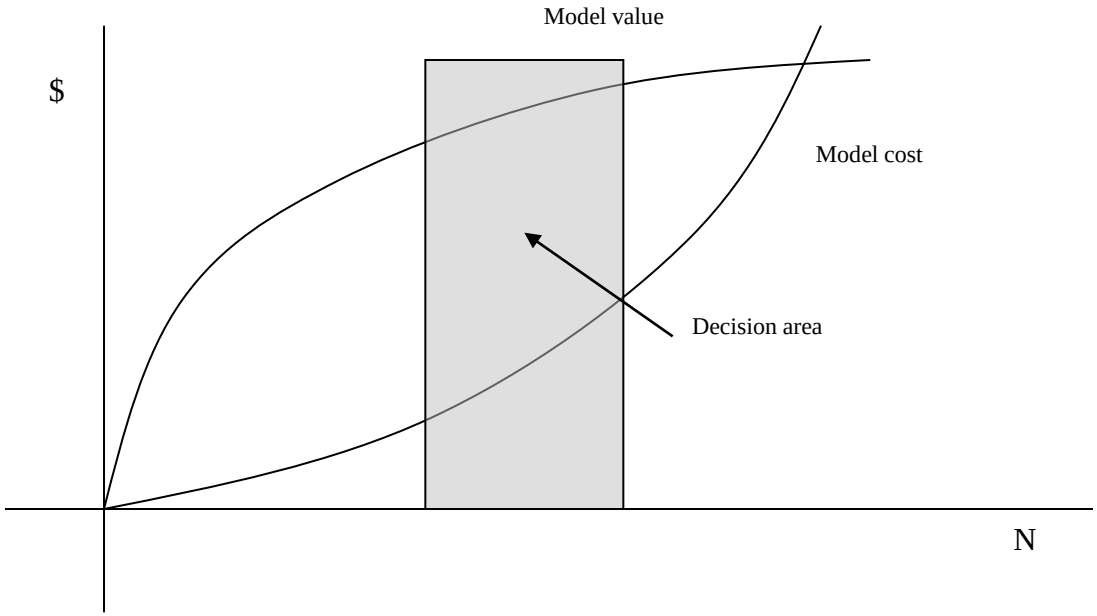
	Model Characteristics		
Category	Form of $f(.)$	Values of independent variables	Quantitative technique
Prescriptive or optimization	Known, well defined	Known or under control of the decision maker	Linear programming, Networks, Integer programming, Nonlinear programming, EOQ, Goal programming
Predictive	Unknown, ill defined	Known or under control of the decision maker	Regression analysis, Time series analysis
Descriptive	Known, well defined	Unknown or uncertain	Simulation, Queuing analysis, Inventory models

Types of relationships

- As a function of their mathematical relation: linear or non linear
- As a function of their outcomes:

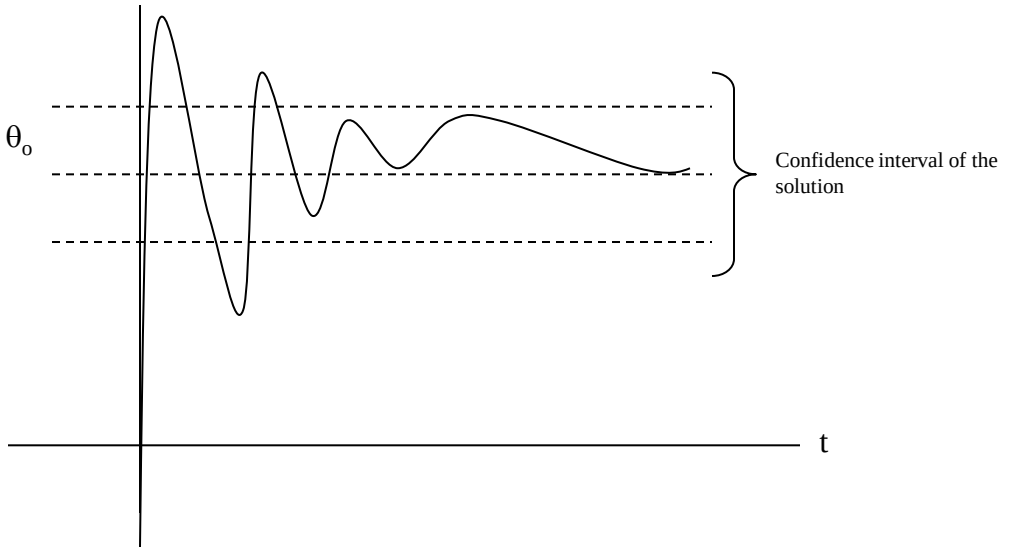


Cost vs. value



Model characteristics

- Treatability
- Tractability
- Feasibility
- Convergence



Good decisions vs. good outcomes

- Not necessarily good decisions result in good outcomes
- The effect of uncertainty can affect the outcomes
- Risk vs. Certainty
- Minimize risk minimizing its elements:
  - Human
  - Environmental

Advantages of modeling

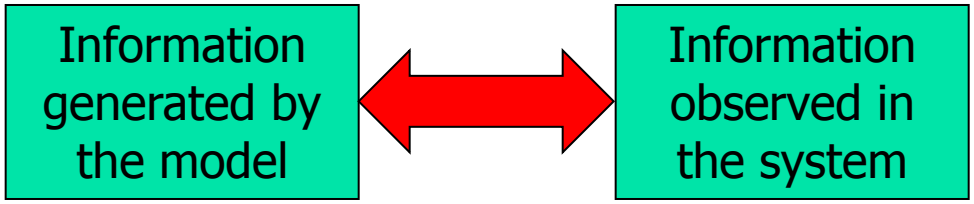
- Allows learning about and from the system
- Allows contrasting the system and possible changes
- Gives an idea about relevant details
- Allows better manipulation of the system's variables
- Facilitates analysis
- Better problem definition
- Better control of variation sources
- Less costs in experimentation

Disadvantages of modeling

- Timely and costly effort
- Is not an exact representation of the real system
- Ill relations might generate wrong outcomes

Model validation

- A model should be a valid representation of a system through realism and simplicity
- In the validation it is necessary to compare:



- Through
  - Reexamining model's formulation
  - Verifying model's relations and dimensionality
  - Changing input parameters
  - Using historical data

Operations research

- Also known as OR/MS
- The science of decision making
- It is an interdisciplinary branch of applied mathematics and formal science that uses advanced analytical methods such as mathematical modeling, statistical analysis, and mathematical optimization to arrive at optimal or near-optimal solutions to complex decision-making problems.
- It is often concerned with determining the maximum (of profit, performance, or yield) or minimum (of loss, risk, or cost) of some real-world objective.

What is it?

- A scientific and objective approach to decision making and managerial problem solving
- Implies:
  - Construction of a symbolic model
  - Analysis of relationships between variables, decisions and actions.
  - Development of a solution technique

Supports scientific approach to decision making

- Provides logical tools
- Allows for quantification and precision
- Better view
- Formalization
- Allows for better planning, organization, operation and control systems.

When is it used?

- In the combinatorial domain when enumeration is impossible.
- When randomness is present
- In concurring situation
- When problems cannot be solved by analytical or numerical approaches

Some history

- The first formal activities of Operations Research (OR) were initiated in England during World War II, when a team of British scientists set out to make scientifically based decisions regarding the best utilization of war material.
- After the war, the ideas advanced in military operations were adapted to improve efficiency and productivity in the civilian sector.
  - Manufacturing
  - Transportation
  - Logistic
  - Finance
  - Health Care

Using OR

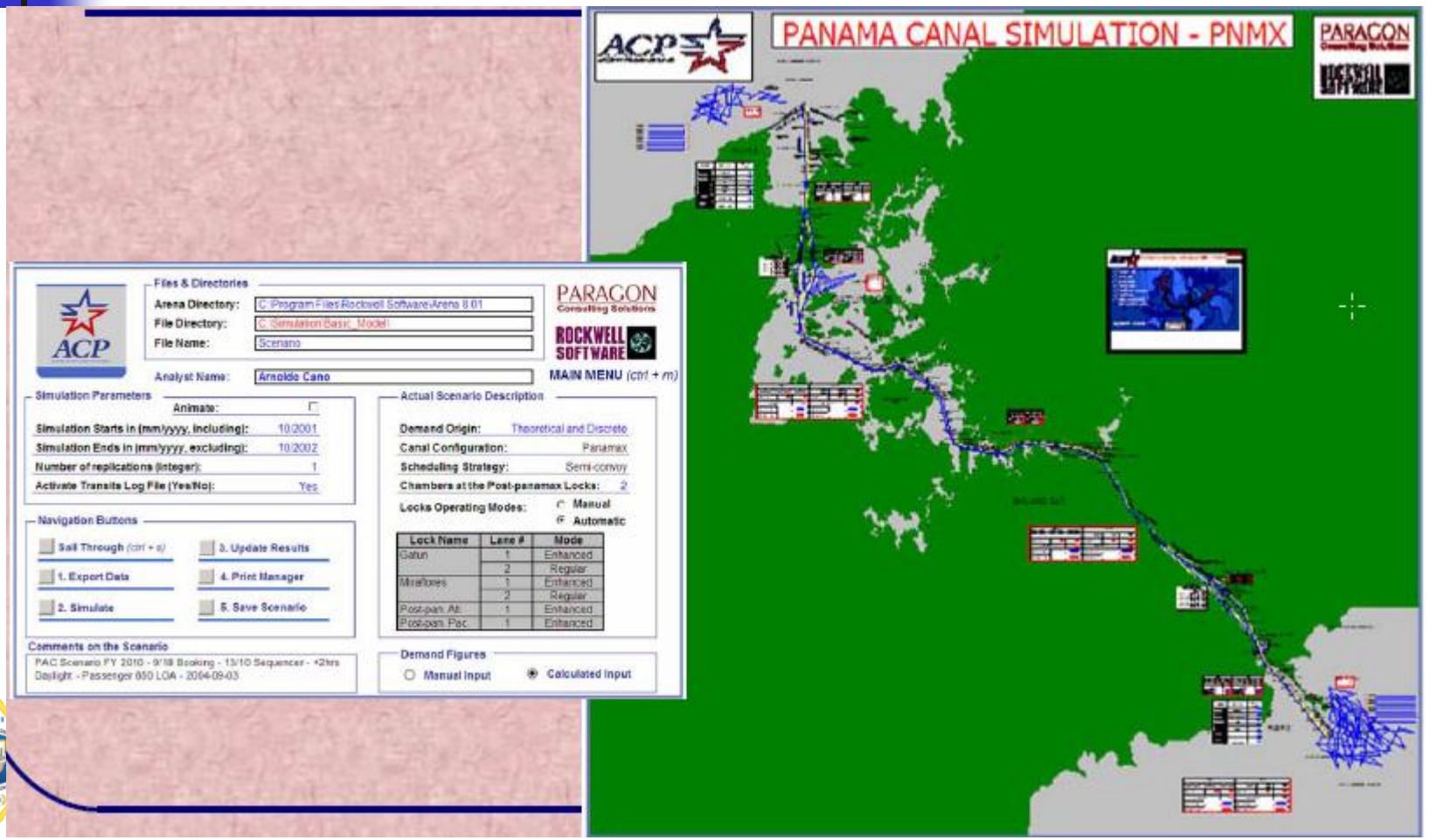
1. Problem definition and formulation
2. Model construction
3. Model validation
4. Model solution
5. Implementation

Some OR topics

- Mathematical programming/Optimization
  - Linear Programming, Nonlinear Programming, Convex Optimization, Integer Programming, Dynamic Programming, Semidefinite Programming, Semi-infinite programming, Conic Programming, Stochastic Programming, Robust Optimization etc.
- Queuing Models
- Network Models
- Decision Analysis
- Game Theory
- Mathematical Finance
- Simulation/Software tools

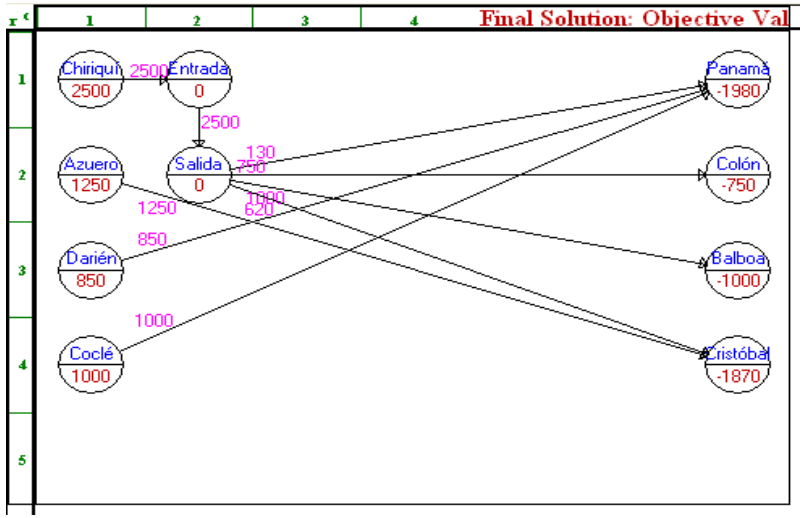
SOME APPLICATIONS

Capacity planning



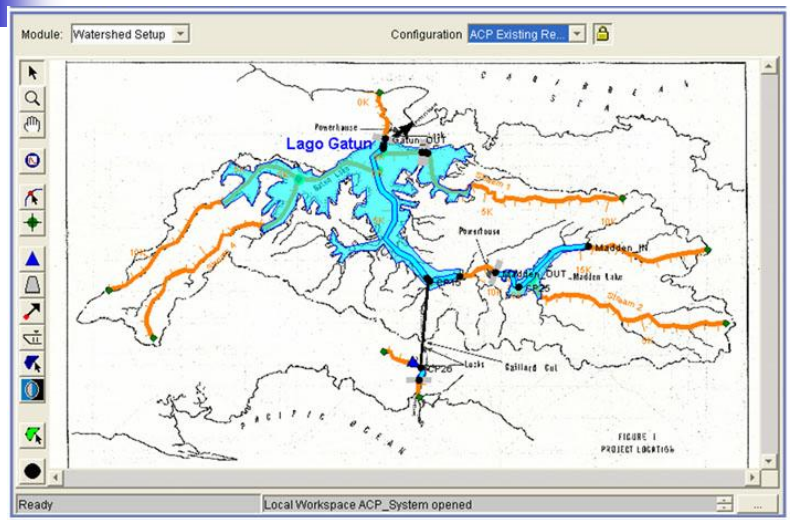
Optimal route

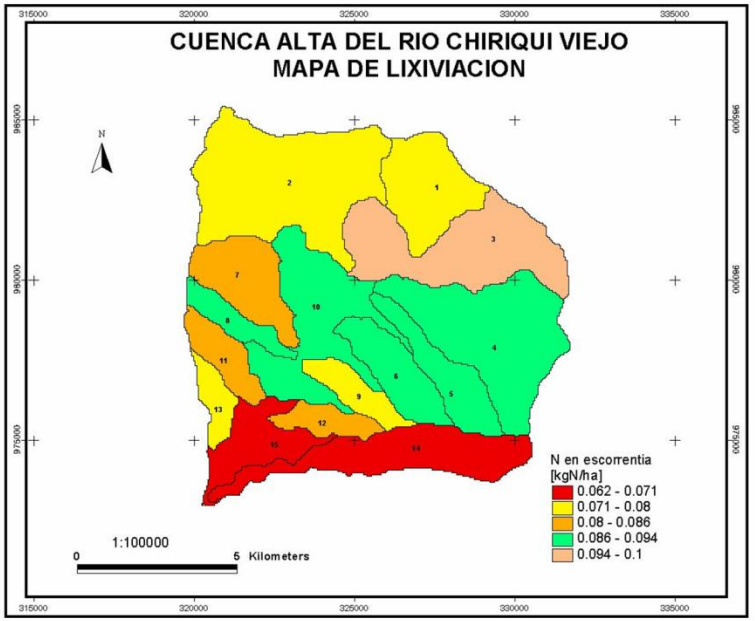
02-25-2008	From	To	Flow	Unit Cost	Total Cost	Reduced Cost
1	Chiriquí	Entrada	2500	20	50000	0
2	Azuero	Cristóbal	1250	42	52500	0
3	Darién	Panamá	850	15	12750	0
4	Coclé	Panamá	1000	22	22000	0
5	Entrada	Salida	2500	5	12500	0
6	Salida	Panamá	130	15	1950	0
7	Salida	Colón	750	20	15000	0
8	Salida	Balboa	1000	15	15000	0
9	Salida	Cristóbal	620	20	12400	0
	Total	Objective	Function	Value =	194100	



Crew and equipment assignment

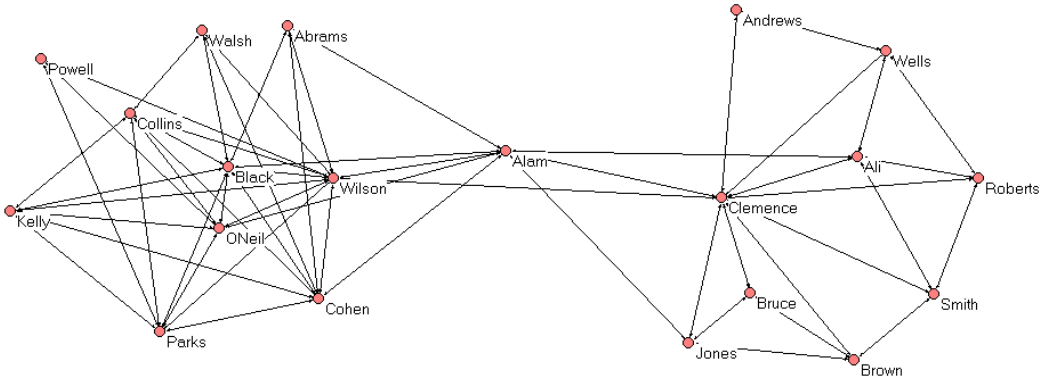
Management of Natural Resources



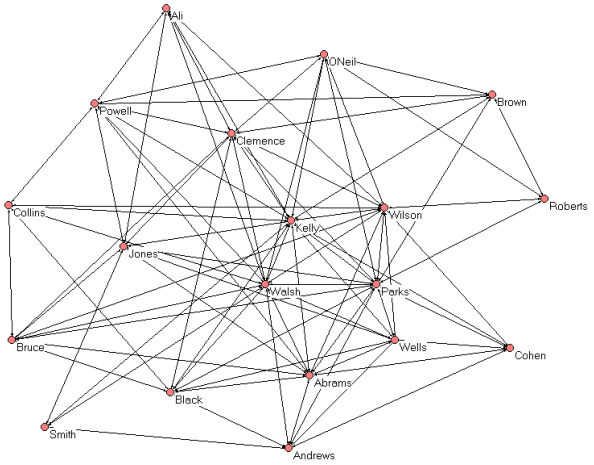


Social Network Analysis

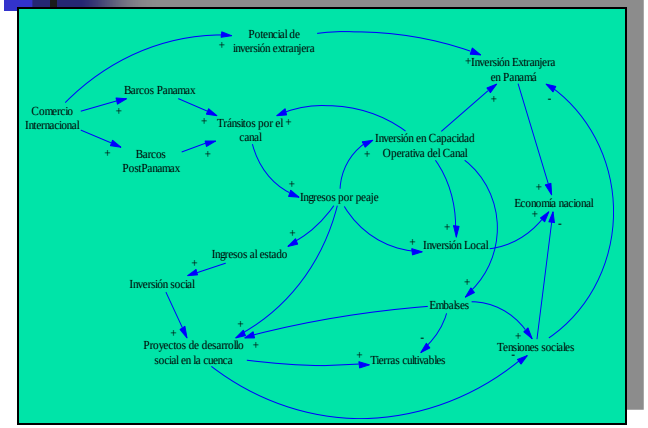
From…

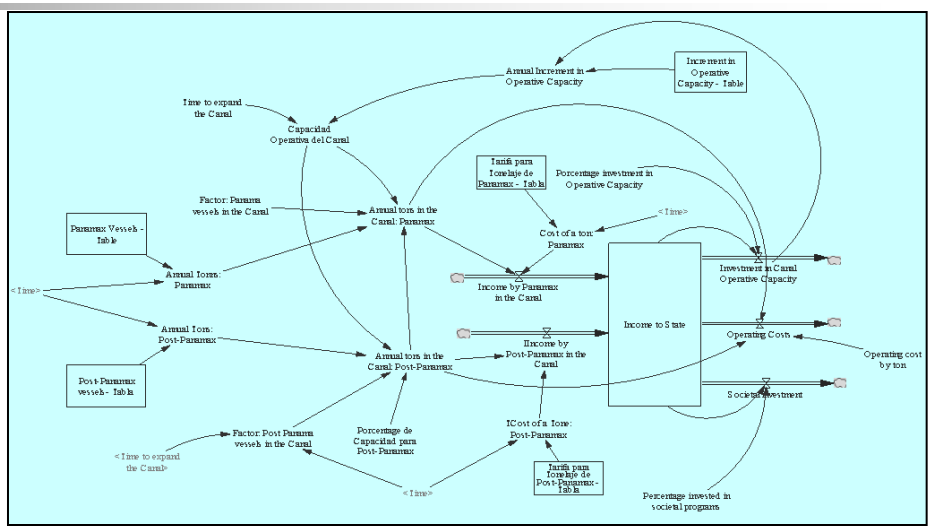


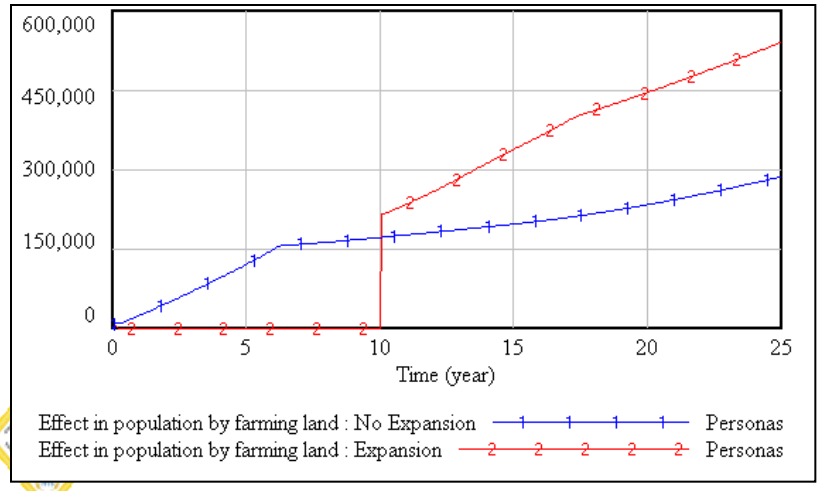
To …



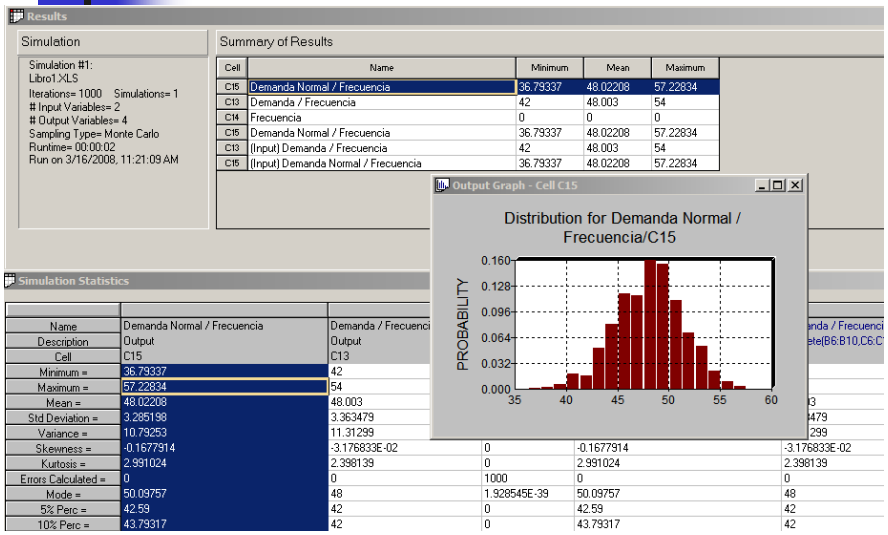
Systems Dynamics







Risk Analysis



Results

Simulation

Simulation #1:
Libro1.XLS
Iterations= 1000 Simulations= 1
# Input Variables= 2
# Output Variables= 4
Sampling Type= Monte Carlo
Runtime= 00:00:02
Run on 3/16/2008, 11:21:09 AM

Summary of Results

Cell	Name	Minimum	Mean	Maximum
C15	Demanda Normal / Frecuencia	36.79337	48.02208	57.22834
C13	Demanda / Frecuencia	42	48.003	54
C14	Frecuencia	0	0	0
C15	Demanda Normal / Frecuencia	36.79337	48.02208	57.22834
C13	(Input) Demanda / Frecuencia	42	48.003	54
C15	(Input) Demanda Normal / Frecuencia	36.79337	48.02208	57.22834

Output Graph - Cell C15

Distribution for Demanda Normal / Frecuencia/C15

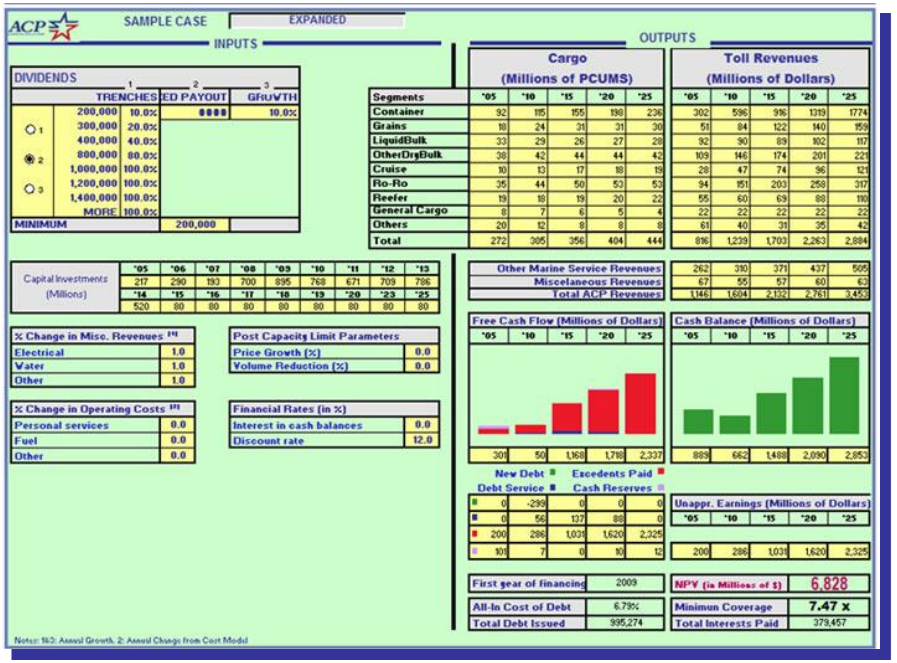
PROBABILITY

0.160
0.128
0.096
0.064
0.032
0.000

35 40 45 50 55 60

Simulation Statistics

Name	Demanda Normal / Frecuencia	Demanda / Frecuenci			nda / Frecuenci
Description	Output	Output			ete(B6:B10,C6:C
Cell	C15	C13			
Minimum =	36.79337	42			
Maximum =	57.22834	54			
Mean =	48.02208	48.003			3
Std Deviation =	3.285198	3.363479			479
Variance =	10.79253	11.31299			299
Skewness =	-0.1677914	-3.176833E-02	0	-0.1677914	-3.176833E-02
Kurtosis =	2.991024	2.398139	0	2.991024	2.398139
Errors Calculated =	0	0	1000	0	0
Mode =	50.09757	48	1.928545E-39	50.09757	48
5% Perc =	42.59	42	0	42.59	42
10% Perc =	43.79317	42	0	43.79317	42



ACP

SAMPLE CASE | EXPANDED

INPUTS

DIVIDENDS

			1 TRENCHES	2 ED PAYOUT	3 GRUVTH
○ 1	200,000	10.0%			10.0%
	300,000	20.0%			
	400,000	40.0%			
◉ 2	800,000	80.0%			
	1,000,000	100.0%			
○ 3	1,200,000	100.0%			
	1,400,000	100.0%			
	MORE	100.0%			
MINIMUM				200,000	

OUTPUTS

Cargo (Millions of PCUMS)

Segments	'05	'10	'15	'20	'25
Container	92	115	155	198	236
Grains	18	24	31	31	30
LiquidBulk	33	29	26	27	28
OtherDryBulk	38	42	44	44	42
Cruise	10	13	17	18	19
Ro-Ro	35	44	50	53	53
Reefer	19	18	19	20	22
General Cargo	8	7	6	5	4
Others	20	12	8	8	8
Total	272	305	356	404	444

Toll Revenues (Millions of Dollars)

	'05	'10	'15	'20	'25
	302	596	916	1319	1774
	51	84	122	140	159
	92	90	89	102	117
	109	146	174	201	229
	28	47	74	96	121
	94	151	203	258	317
	55	60	69	88	110
	22	22	22	22	22
	61	40	31	35	42
	816	1,239	1,703	2,263	2,884

Capital Investments (Millions)

'05	'06	'07	'08	'09	'10	'11	'12	'13
217	290	193	700	895	768	671	709	786
'14	'15	'16	'17	'18	'19	'20	'23	'25
520	80	80	80	80	80	80	80	80

Other Marine Service Revenues
Miscelaneous Revenues
Total ACP Revenues

'05	'10	'15	'20	'25
262	310	371	437	505
67	55	57	60	63
1,146	1,604	2,132	2,761	3,453

% Change in Misc. Revenues [1]

Electrical	1.0
Water	1.0
Other	1.0

Post Capacity Limit Parameters

Price Growth (%)	0.0
Volume Reduction (%)	0.0

% Change in Operating Costs [1]

Personal services	0.0
Fuel	0.0
Other	0.0

Financial Rates (in %)

Interest in cash balances	0.0
Discount rate	12.0

Free Cash Flow (Millions of Dollars)

'05	'10	'15	'20	'25
301	50	1,168	1,718	2,337

Cash Balance (Millions of Dollars)

'05	'10	'15	'20	'25
889	662	1,488	2,090	2,853

New Debt | Excedents Paid
Debt Service | Cash Reserves

0	-299	0	0	0
0	56	137	88	0
200	286	1,031	1,620	2,325
101	7	0	10	12

Unappr. Earnings (Millions of Dollars)

'05	'10	'15	'20	'25
200	286	1,031	1,620	2,325

First year of financing	2009	NPV (in Millions of $)	6,826
All-In Cost of Debt	6.79%	Minimum Coverage	7.47 x
Total Debt Issued	995,274	Total Interests Paid	379,457

Notes: %): Annual Growth, 2: Annual Change from Cost Model

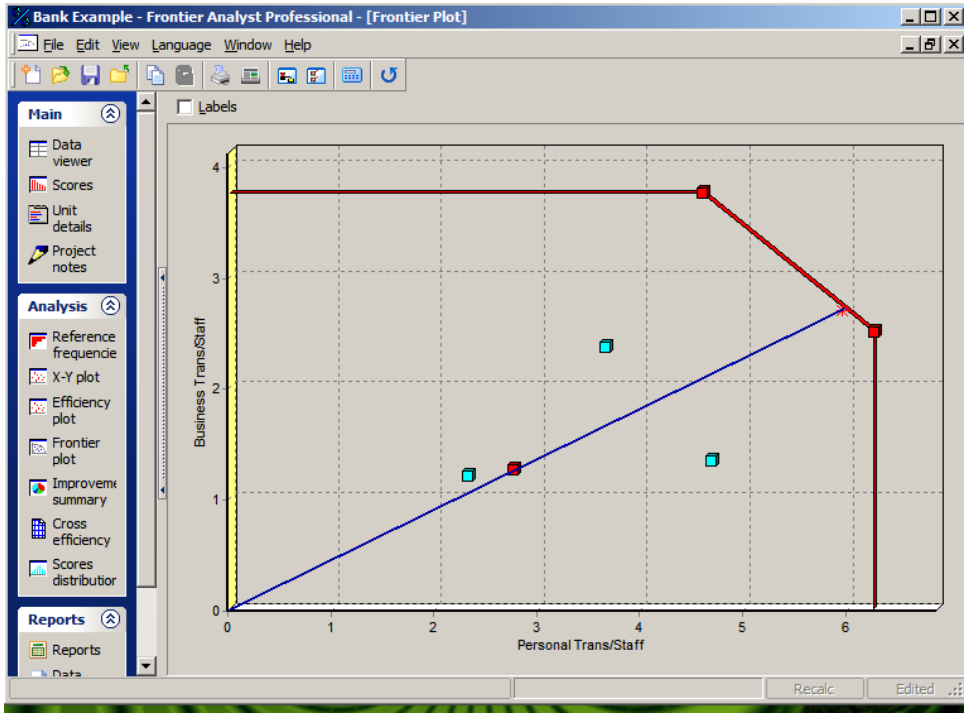
Benchmarking

$$\max h_o = \frac{\sum_{r=1}^{s} u_r y_{r,0}}{\sum_{i=1}^{m} v_i x_{i,0}}$$

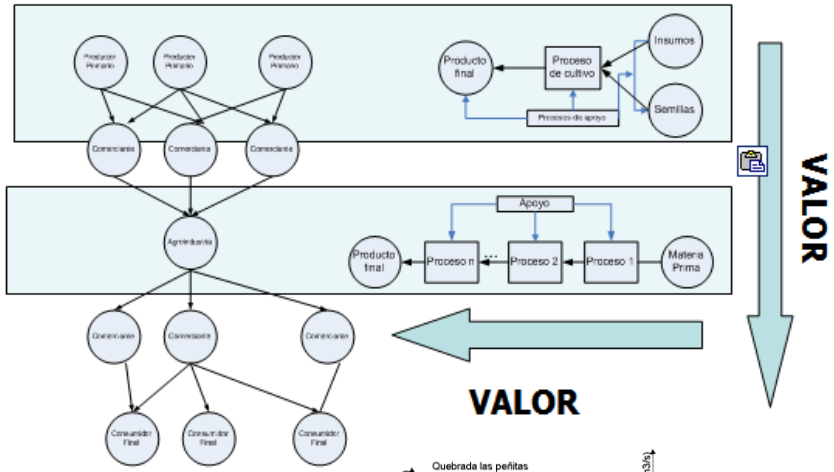
s.a.:

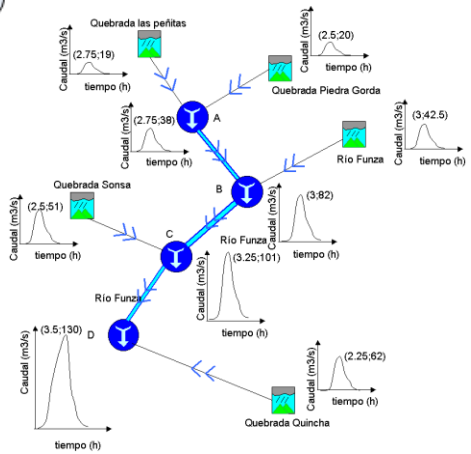
$$\frac{\sum_{r=1}^{s} u_r y_{r,j}}{\sum_{i=1}^{m} v_i x_{i,j}} \le 1 \; \forall \; j = 1, 2, \ldots, n; r = 1, 2, \ldots, s; i = 1, 2, \ldots, m$$

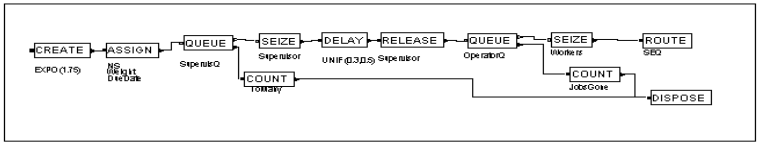
$$y_{r,j}, x_{i,j}, u_r, v_i \ge 0$$

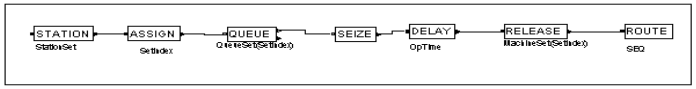


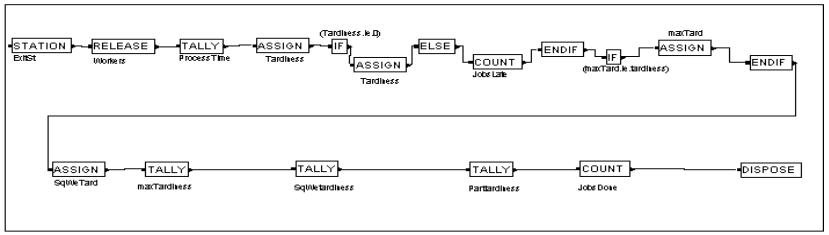
Process simmulation



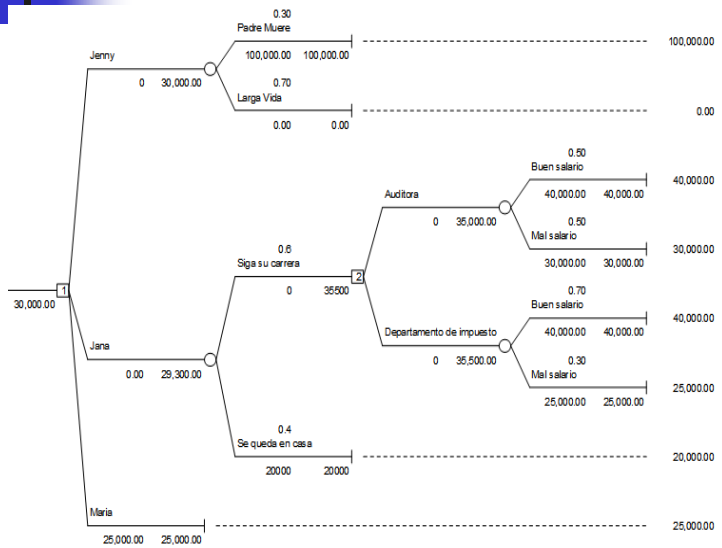


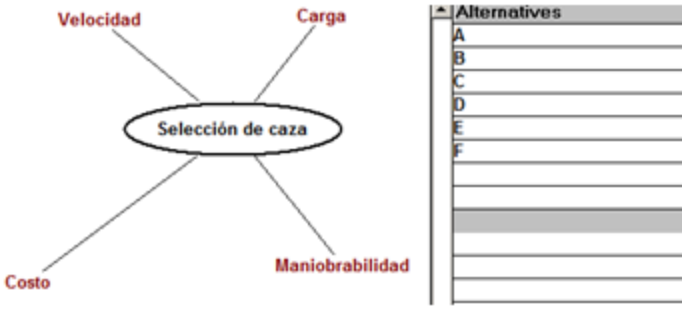


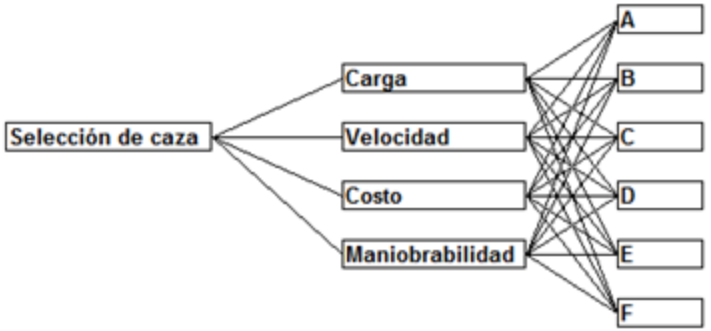




Decision making







Lowest Level	A	B	C	D	E	F	Model
Carga	0.830	0.830	1.000	0.580	0.750	0.500	0.044
Velocidad	0.780	0.940	0.780	1.000	0.830	1.000	0.313
Costo	1.000	0.500	1.000	0.000	0.500	0.000	0.244
Maniobrabilidad	1.000	0.780	0.890	0.780	1.000	0.670	0.399
Results	0.924	0.764	0.887	0.650	0.814	0.602	

Modeling a Distribution Network of Agricultural Products in Panama




$$min\ Z = \sum_i \sum_j C_{i,j} x_{i,j} + \sum_i \sum_j \sum_k b_{i,j}^{(k)} y_{i,j}^{(k)}$$

Subject to:

Weekly capacity of the sources: $\sum_i x_{i,i} \leq S_i \ \forall j$

No inventory in the transshipment points: $\sum_i x_{i,l} = \sum_j x_{li} \ \forall l$

Weekly capacity of the distribution points: $\sum_I x_{i,l} \leq W_l$

Weekly availability of vehicles: $\sum_k \sum_j y_{i,j}^{(k)} \leq N_i^{(k)} \ \forall k, j$

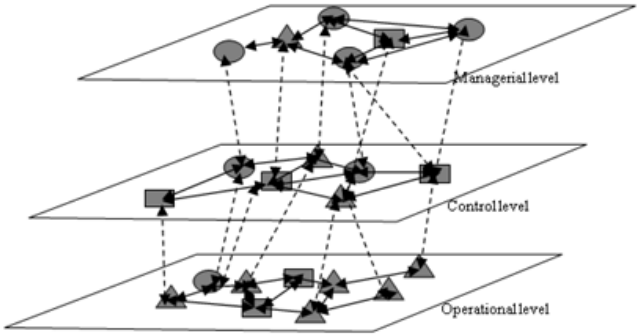
Weekly transportation capacity of the vehicles at every distribution point:

$$\sum_j A^{(k)} y_{i,j}^{(k)} - \sum_j x_{i,j} \geq 0$$

All variables are integer and bounded by their upper limits:

$$x_{ij};\ y_{ij}^{(k)} \in I;\ \forall \begin{cases} i = 1, \ldots, n \\ j = 1, \ldots, m \\ l = 1, \ldots, L \\ k = 1, .., K \end{cases}$$

Social Network Analysis for Humanitarian Logistics Operations in Latin America



$$C_D(G) = \frac{\sum_{i=1}^{|V|} [C_D(v*) - C_D(v_i)]}{H}$$

$$C_C(v) = \sum_{t \in V \setminus v} 2^{-d_G(v,t)}.$$

$$C_B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

$$x_v = \frac{1}{\lambda} \sum_{t \in M(v)} x_t = \frac{1}{\lambda} \sum_{t \in G} a_{v,t} x_t$$

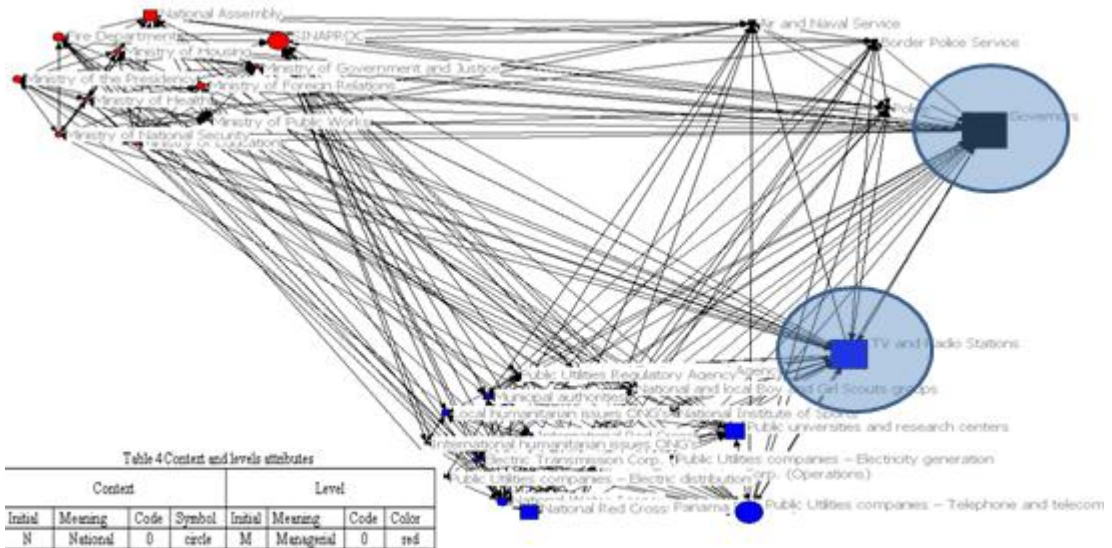
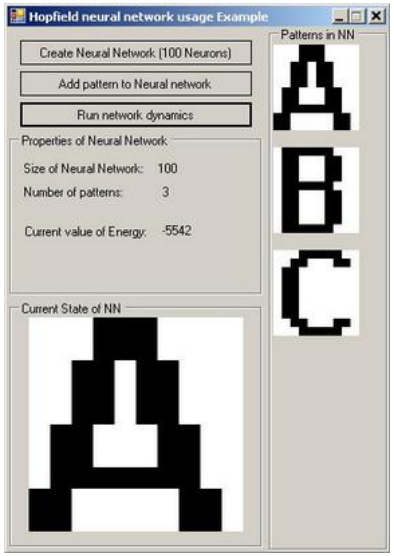


Table 4 Content and levels attributes

Content				Level			
Initial	Meaning	Code	Symbol	Initial	Meaning	Code	Color
N	National	0	circle	M	Managerial	0	red
L	Local	1	square	C	Control	1	black
I	International	2	triangle	O	Operational	2	blue

Data mining and pattern recognition



New approaches