The Essentials of the Analytic Network Process with Seven Examples (3)

Decision Making with Dependence and Feedback

Thomas L. Saaty

Step 4. Determine Clusters and Elements

- For each control criterion or subcriterion, determine the clusters of the general feedback system with their elements
- Connect them according to their outer and inner dependence influences.
- An arrow is drawn from a cluster to any cluster whose elements influence it.
- Describe the decision problem in detail including its objectives, criteria and subcriteria, actors and their objectives and the possible outcomes of that decision.

Step 5. Determine the approach

- Determine the approach you want to follow in the analysis of each cluster or element, influencing (the preferred approach) other clusters and elements with respect to a criterion, or being influenced by other clusters and elements.
- The sense (being influenced or influencing) must apply to all the criteria for the four control hierarchies for the entire decision.

Step 6. Supermatrix Construction

- For each control criterion, construct the supermatrix by laying out the clusters in the order they are numbered and all the elements in each cluster both vertically on the left and horizontally at the top.
- Enter in the appropriate position the priorities derived from the paired comparisons as subcolumns of the corresponding column of the supermatrix.

Step 7. Perform Paired Comparisons

- Perform paired comparisons on the elements within the clusters themselves according to their influence on each element in another cluster they are connected to (outer dependence) or on elements in their own cluster (inner dependence).
- Comparisons of elements according to which element influences a given element more and how strongly more than another element it is compared with are made with a control criterion or subcriterion of the control hierarchy in mind.

Step 8. Paired Comparisons on the Clusters

- Perform paired comparisons on the clusters as they influence each cluster to which they are connected with respect to the given control criterion.
- The derived weights are used to weight the elements of the corresponding column blocks of the supermatrix. Assign a zero when there is no influence. Thus obtain the weighted column stochastic supermatrix.

Step 9. Compute Limit Priorities of the Stochastic Supermatrix

Compute the limit priorities of the stochastic supermatrix according to whether it is

- irreducible (primitive or imprimitive [cyclic]) or
- reducible with one being a simple or a multiple root and whether the system is cyclic or not.

Two kinds of outcomes are possible.

- In the first all the columns of the matrix are identical and each gives the relative priorities of the elements from which the priorities of the elements in each cluster are normalized to one.
- In the second the limit cycles in blocks and the different limits are summed and averaged and again normalized to one for each cluster.

Step 10. Synthesize the Limiting Priorities

- 10. Synthesize the limiting priorities by weighting each idealized limit vector by the weight of its control criterion and adding the resulting vectors for each of the four merits: Benefits (B), Opportunities (O), Costs (C) and Risks (R).
- There are now four vectors, one for each of the four merits. An answer involving marginal values of the merits is obtained by forming the ratio BO/CR for each alternative from the four vectors. The alternative with the largest ratio is chosen for some decisions.
- Companies and individuals with limited resources often prefer this type of synthesis.

Step 11. Determine the strategic criteria and their priorities

- Determine strategic criteria and their priorities to rate the four merits one at a time. Normalize the four ratings thus obtained.
- For each alternative, subtract the costs and risks from the sum of the benefits and opportunities.
- At other times one may add the weighted reciprocals of the costs and risks.
- Still at other times one may subtract the costs from one and risks from one and then weight and add them to the weighted benefits and opportunities.
- In all, we have four different formulas for synthesis.

Step 12. Sensitivity Analysis

- Perform sensitivity analysis on the final outcome and interpret the results of sensitivity observing how large or small these ratios are.
- Can another outcome that is close also serve as a best outcome? Why?
- By noting how stable this outcome is. Compare it with the other outcomes by taking ratios. Can another outcome that is close also serve as a best outcome? Why?

Outline of the Steps of the ANP

- Describe the decision problem in detail including its objectives, criteria and subcriteria, actors and their objectives and the possible outcomes of that decision. Give details of influences that determine how that decision may come out.
- comparisons are made simply in terms of benefits, opportunities, costs, and risks in the aggregate without using control criteria and subcriteria.
- 3. Determine the most general network of clusters (or components) and their elements that applies to all the control criteria. To better organize the development of the model as well as you can, number and arrange the clusters and their elements in a convenient way (perhaps in a column). Use the identical label to represent the same cluster and the same elements for all the control criteria.
- 4. For each control criterion or subcriterion, determine the clusters of the general feedback system with their elements and connect them according to their outer and inner dependence influences. An arrow is drawn from a cluster to any cluster whose elements influence it.
- 5. Determine the approach you want to follow in the analysis of each cluster or element, influencing (the preferred approach) other clusters and elements with respect to a criterion, or being influenced by other clusters and elements. The sense (being influenced or influencing) must apply to all the criteria for the four control hierarchies for the entire decision.
- 6. For each control criterion, construct the supermatrix by laying out the clusters in the order they are numbered and all the elements in each cluster both vertically on the left and horizontally at the top. Enter in the appropriate position the priorities derived from the paired comparisons as subcolumns of the corresponding column of the supermatrix.
- 7. Perform paired comparisons on the elements within the clusters themselves according to their influence on each element in another cluster they are connected to (outer dependence) or on elements in their own cluster (inner dependence). In making comparisons, you must always have a criterion in mind. Comparisons of elements according to which element influences a given element more and how strongly more than another element it is compared with are made with a control criterion or subcriterion of the control hierarchy in mind.
- 8. Perform paired comparisons on the clusters as they influence each cluster to which they are connected with respect to the given control criterion. The derived weights are used to weight the elements of the corresponding column blocks of the supermatrix. Assign a zero when there is no influence. Thus obtain the weighted column stochastic supermatrix.
- 9. Compute the limit priorities of the stochastic supermatrix according to whether it is irreducible (primitive or imprimitive [cyclic]) or it is reducible with one being a simple or a multiple root and whether the system is cyclic or not. Two kinds of outcomes are possible. In the first all the columns of the matrix are identical and each gives the relative priorities of the elements from which the priorities of the elements in each cluster are normalized to one. In the second the limit cycles in blocks and the different limits are summed and averaged and again normalized to one for each cluster. Although the priority vectors are entered in the supermatrix in normalized form, the limit priorities are put in idealized form because the control criteria do not depend on the alternatives.
- 10. Synthesize the limiting priorities by weighting each idealized limit vector by the weight of its control criterion and adding the resulting vectors for each of the four merits: Benefits (B), Opportunities (O), Costs (C) and Risks (R). There are now four vectors, one for each of the four merits. An answer involving marginal values of the merits is obtained by forming the ratio BO/CR for each alternative from the four vectors. The alternative with the largest ratio is chosen for some decisions. Companies and individuals with limited resources often prefer this type of synthesis.
- 11. Governments prefer this type of outcome. Determine strategic criteria and their priorities to rate the four merits one at a time. Normalize the four ratings thus obtained and use them to calculate the overall synthesis of the four vectors. For each alternative, subtract the costs and risks from the sum of the benefits and opportunities. At other times one may add the weighted reciprocals of the costs and risks. Still at other times one may subtract the costs from one and risks from one and then weight and add them to the weighted benefits and opportunities. In all, we have four different formulas for synthesis.
- 12. Perform sensitivity analysis on the final outcome and interpret the results of sensitivity observing how large or small these ratios are. Can another outcome that is close also serve as a best outcome? Why? By noting how stable this outcome is. Compare it with the other outcomes by taking ratios. Can another outcome that is close also serve as a best outcome? Why?
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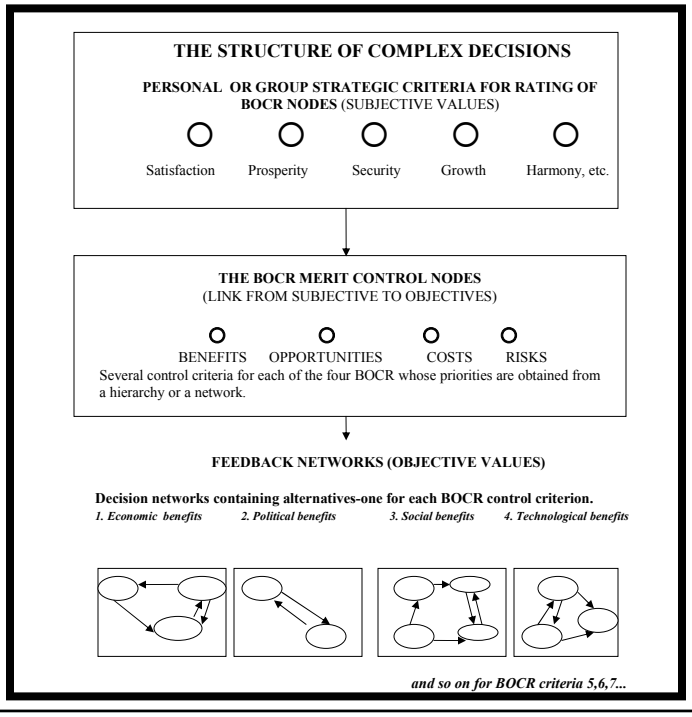
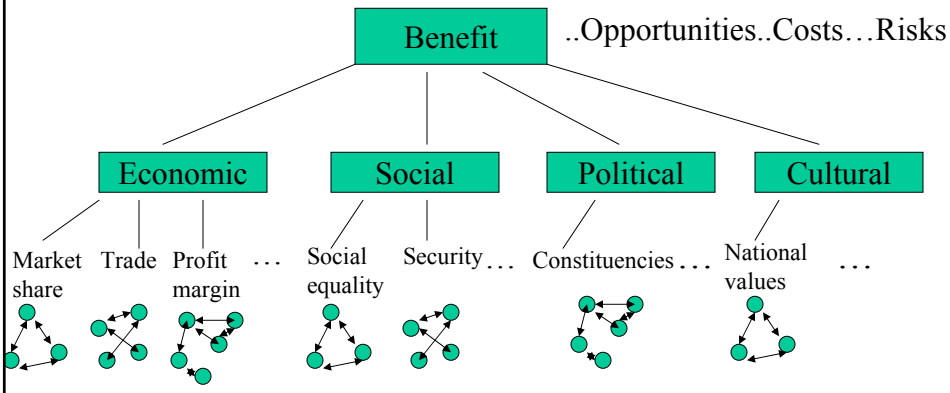


BOCR SUBCRITERIA (CONTROL CRITERIA)

Each of the four BOCR has a hierarchy of control criteria and subcriteria with respect to which a decision network of influences that includes the alternatives is evaluated.



THE PRIORITIZATION OF COMPLEX DECISIONS

PERSONAL OR GROUP CRITERIA FOR RATING OF BOCR NODES (SUBJECTIVE VALUES)

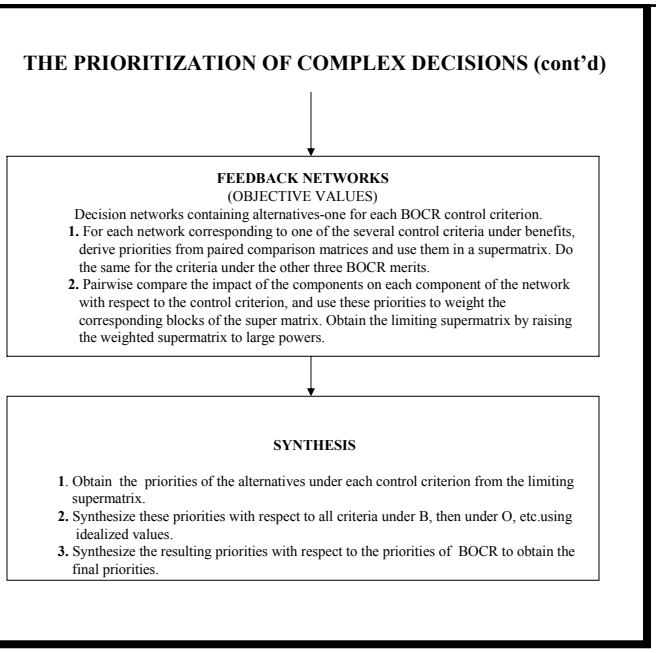
1. Identify and prioritize personal or group criteria and subcriteria applied to all decisions you make.
2. Establish intensities and prioritize them for each lowest level criterion or subcriterion.
3. Rate the Benefits, Opportunities, Costs and the Risks one at a time on the intensities and then normalize.

THE BOCR MERIT CONTROL NODES
(LINK FROM SUBJECTIVE TO OBJECTIVES)

BENEFITS OPPORTUNITIES COSTS RISKS

Identify and prioritize the control criteria and subcriteria for each of the four BOCR merits.

THE PRIORITIZATION OF COMPLEX DECISIONS (cont'd)



THE BOCR MERITS OF ALTERNATIVES ARE:

• **Benefits** • **Opportunities** • **Costs** • **Risks**

COMBINE OPPOSITE VALUES USING

- **Marginal Benefit/Cost Analysis**
- **BO/CR**
- **Adding Reciprocals**

bB+oO+c(1/C)+r(1/R)

- **Subtracting Costs and Risks from 1and adding**

bB + oO+ c(1- C) + r(1-R)

- **Subtracting Costs and Risks**

bB + oO - cC - rR

OPPOSITE VALUES-POSITIVES, NEGATIVES, AND RECIPROCALS

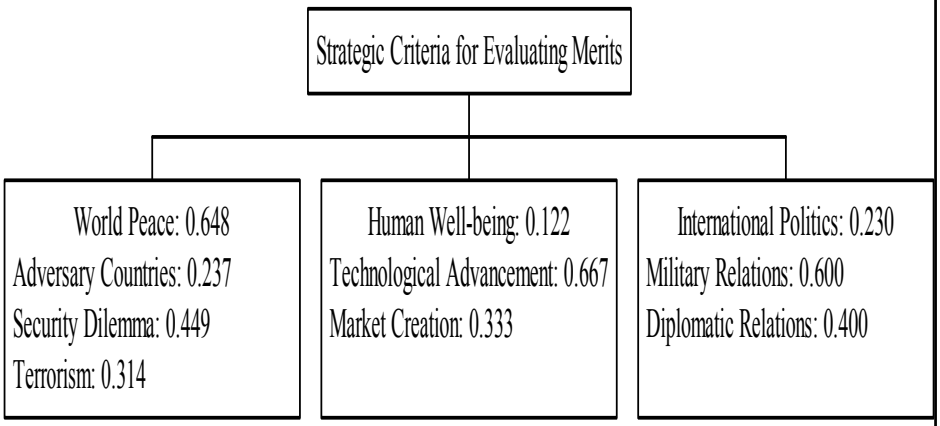
What one does when there are measurements is to combine them, using some formula that specifies how to do it for each of the BOCR separately, and then either convert them to priorities though normalization or apply pairwise comparisons to their values. In the end one needs a way to combine opposing values between positive and negative merits. If these are both measured in the same units one can simply subtract them. But if they are not measurements, one needs to combine their priorities. If one uses the ideal form for the priorities of the alternatives, one needs to determine the weights for the BOCR to obtain the final outcome. These BOCR weights are obtained by rating each one with respect to strategic criteria. In this rating one adopts the "basic"or ideal alternative as the prototype for doing the ratings of each of the BOCR or even do the rating with respect to each alternative separately. One also uses the ideal mode for the priorities of the alternatives under each control criterion. 1) One frequently uses reciprocals for C and R to combine priorities because the left principal eigenvector is the reciprocal (near reciprocal when inconsistent) of the right principal eigenvector. 2) One can also subtract C and R from one (subtract B and O from one), weight the results and add to the weighted B and O (subtract from the weighted C and R), and choose the alternative with the maximum (minimum) priority. Finally, 3) One can simply add the weighted B and O and subtract from them the weighted C and R, sometimes obtaining negative numbers.

RATING THE BOCR MERITS AND FINAL COMPOSITION

Using the ideal form for the priorities of the alternatives makes it possible to evaluate the BOCR using the composite alternative for each obtained by synthesizing the priorities of the ideals under each control criterion for that merit. These composite alternatives need not be the same for the merits. Using the **top** alternative under each, one can now **rate** the BOCR for that alternative with respect to appropriately chosen strategic criteria and use their normalized ratings to synthesize the composite priorities of the alternatives.

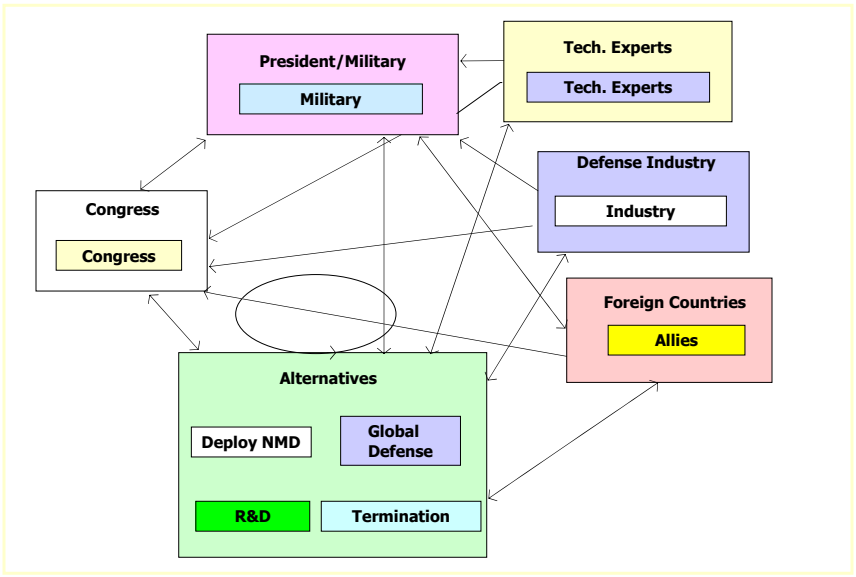
National Missile Defense (NMD)

Prioritization of national US criteria

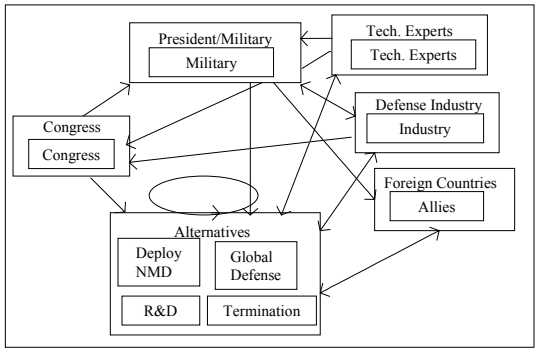


Criteria and Their Priorities

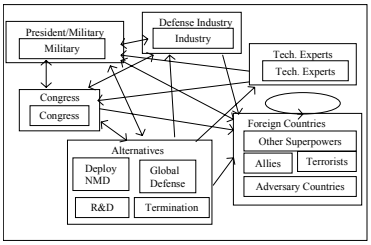
Merits	Criteria	Sub-criteria	Global Priorities (Normalized)
Benefits	Economic (0.157)	Local Economy (0.141)	0.022
		Defense Industry (0.859)	0.014
	Political (0.074)	Bargaining Power (0.859)	0.064
		U.S. Military Leadership (0.141)	0.010
	Security (0.481)	Deterrence (0.267)	0.128
		Military Capability (0.590)	**0.284**
		Anti-terrorism (0.143)	0.069
	Technology (0.288)	Tech. Advancement (0.834)	**0.240**
		Tech. Leadership (0.166)	0.048
Opportunities	Arms Sales (0.520)		**0.520**
	Spin- off (0.326)		**0.326**
	Space Development (0.051)		0.051
	Protection of Allies (0.103)		0.103
Costs	Security Threat: Vulnerability to the security threat (0.687)		**0.687**
	Economic (0.228)	Sunk Cost (0.539)	**0.123**
		Further Investment (0.461)	**0.103**
	Political (0.085)	ABM Treaty (0.589)	0.050
		Foreign Relations (0.411)	0.035
Risks	Technical Failure (0.430)		**0.430**
	Arms Race (0.268)		**0.268**
	Increased Terrorism (0.052)		0.052
	Environmental Damage (0.080)		0.080
	U.S. Reputation (0.170)		0.170



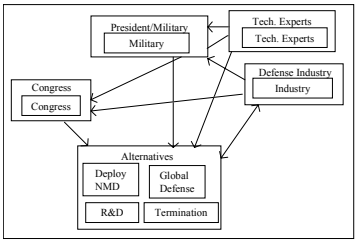
Decision Network under Military Capability Control Subcriterion of Benefits



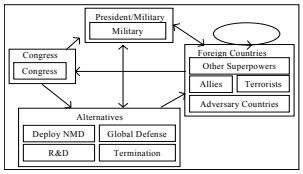
Decision Network under The Technological Advancement Control Subcriterion of Benefits



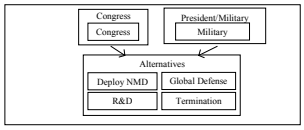
Decision Network under The Arms Sales
Control Criterion of Opportunities



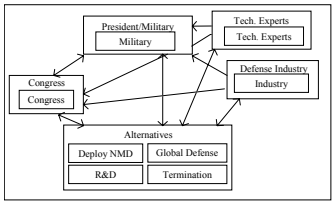
Decision Network under The Spin-Off
Control Criterion of Opportunities



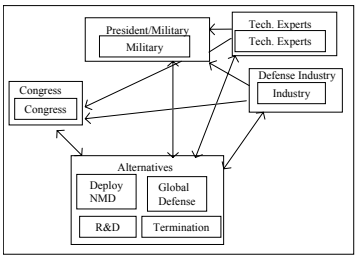
Decision Network under The Security Threat
Control Subcriterion of Costs



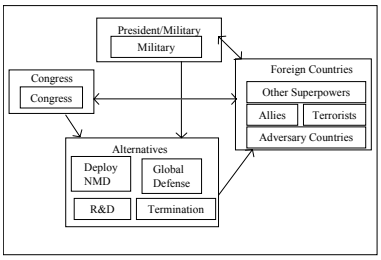
Decision Network under The Sunk Cost
Control Subcriterion of Costs



Decision Network under The Further Investment
Control Subriterion of Costs



Network under The Technical Feasibility Control Criterion of Risks



Decision Network under The Arms Race Control Criterion of Risks

The Unweighted Supermatrix

An entry in each subcolumn of the supermatrix indicates the relative priority within the block to which that subcolumn belongs that an element on the left is influence by the element on top of the column with respect to Military Capability. Each subcolumn is an eigenvector imported from a corresponding pairwise comparisons matrix not shown here because its elements can be approximately formed from the ratios of the corresponding priority vector. A subcolumn of zeros indicates no influence and therefore no comparisons matrix is needed.

MilCap		*Altern~*				*Cong~*	*Def. Ind~*	*For~*	*Pre/Mil~*	*Tech~*
Unweighted		Deploy	Glob~	R & D	Term~	Cong~	Industry	Allies	Military	Tech~
Altern~	Deploy	0.0000	0.5760	1.0000	0.0000	0.5060	0.5587	0.0000	0.5158	0.2878
	Glob~	0.0000	0.0000	0.0000	0.0000	0.2890	0.2574	1.0000	0.2929	0.2623
	R & D	0.0000	0.4240	0.0000	0.0000	0.1307	0.1382	0.0000	0.1367	0.2369
	Term~	0.0000	0.0000	0.0000	0.0000	0.0744	0.0457	0.0000	0.0546	0.2130
Cong~	Cong~	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000
Defense Ind~	Industry	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
For~	Allies	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
Pre/Mil~	Military	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000
Tech~	Tech~	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Pairwise Comparisons Matrices and Priorities of Components

Pairwise comparing components with respect to the Alternatives component

Q: Which of a pair of components is influenced more by the Alternatives component with respect to Military Capability?

Pairwise Comparison Matrix for Components wrt Alternatives

Altern~	1.00	1/6	1/4	1.33	1/7	1/1.8	**0.0485**
Cong~	6.00	1.00	2.20	6.20	1/1.35	3.20	**0.2889**
Def. Ind~	4.00	1/2.2	1.00	4.00	1/2.43	2.26	**0.1653**
For~	1/1.33	1/6.2	1/4	1.00	1/8	1/1.9	**0.0425**
Pres~	7.00	1.35	2.43	8.00	1.00	5.10	**0.3742**
Tech~	1.80	1/3.2	1/2.26	1.90	1/5.1	1.00	**0.0805**

Pairwise comparing components with respect to the Congress component
Q: Which of a pair of components is influenced more by the Congress component with respect to Military Capability?

	Altern~	*Pres~*	***Prior.***
Altern~	1.0000	0.5638	***0.3605***
Pres~	1.7736	1.0000	***0.6395***

Pairwise comparing components with respect to the Defense Industry component
Q: Which of a pair of components is influenced more by the Defense Industry component with respect to Military Capability?

	Altern~	*Cong~*	*Pres~*	***Prior.***
Altern~	1.0000	0.6769	0.5388	***0.2292***
Congr~	1.4773	1.0000	0.6600	***0.3181***
Pres~	1.8561	1.5152	1.0000	***0.4528***

Pairwise comparing components with respect to the Foreign Countries component
Q: Which of a pair of components is influenced more by the Foreign Countries component with respect to Military Capability?

	Altern~	*Cong~*	*Pres~*	***Prior.***
Altern~	1.0000	2.5379	2.5379	***0.5593***
Congr~	0.3940	1.0000	1.0000	***0.2204***
Pres~	0.3940	1.0000	1.0000	***0.2204***

Pairwise comparing components with respect to the Presidnet/Military component
Q: Which of a pair of components is influenced more by the President/ Military component with respect to Military Capability?

	Altern~	*Cong~*	*For~*	***Prior.***
Altern~	1.0000	2.1887	3.6604	***0.5735***
Congr~	0.4569	1.0000	2.0377	***0.2799***
For~	0.2732	0.4907	1.0000	***0.1467***

Pairwise comparing components with respect to the Technical Experts component
Q: Which of a pair of components is influenced more by the Technical Experts component with respect to Military Capability?

	Altern~	*Cong~*	*Pres~*	***Prior.***
Altern~	1.0000	0.5556	0.3259	***0.1671***
Congr~	1.8000	1.0000	0.4632	***0.2781***
Pres~	3.0682	2.1591	1.0000	***0.5548***

Priorities Matrix of Eigenvectors
How much components are influenced by each component; imported from the matrices of the table above

Clusters	*Altern~*	*Cong~*	*Def. Ind~*	*For~*	*Pres~*	*Tech~*
Altern~	0.0486	0.3605	0.2292	0.1671	0.5735	0.5593
Cong~	0.2889	0.0000	0.3181	0.2780	0.2799	0.2204
Def. Ind~	0.1653	0.0000	0.0000	0.0000	0.0000	0.0000
For~	0.0425	0.0000	0.0000	0.0000	0.1467	0.0000
Pres~	0.3742	0.6395	0.4528	0.5548	0.0000	0.2204
Tech~	0.0805	0.0000	0.0000	0.0000	0.0000	0.0000

The Weighted Supermatrix
Priorities from the above table are used to weight the corresponding blocks of the unweighted supermatrix

MilCap		*Altern~*				*Cong~*	*Def. Ind~*	*For~*	*Pre/Mil~*	*Tech~*
Weighted		NMD	Glob~	R & D	Term~	Cong~	Industry	Allies	Military	Tech~
Altern~	NMD	0.0000	0.0280	0.0000	0.0000	0.1824	0.1280	0.0000	0.2958	0.1610
	Glob~	0.0000	0.0000	0.0000	0.0000	0.1042	0.0590	0.1671	0.1680	0.1467
	R & D	0.0000	0.0206	0.0000	0.0000	0.0471	0.0317	0.0000	0.0784	0.1325
	Term~	0.0000	0.0000	0.0000	0.0000	0.0268	0.0105	0.0000	0.0313	0.1191
Cong~	Cong~	0.3037	0.2889	0.3037	0.0000	0.0000	0.3181	0.2780	0.2799	0.2204
Defense Ind~	Industry	0.1737	0.1653	0.1737	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
For~	Allies	0.0446	0.0425	0.0446	0.0000	0.0000	0.0000	0.0000	0.1467	0.0000
Pre/Mil~	Military	0.3933	0.3742	0.3933	0.0000	0.6395	0.4528	0.5548	0.0000	0.2204
Tech~	Tech~	0.0846	0.0805	0.0846	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The Limit Supermatrix
The weighted supermatrix raised to sufficiently large powers to stabilize within rounded off four place decimals

MilCap		*Altern~*				*Cong~*	*Def. Ind~*	*For~*	*Pre/Mil~*	*Tech~*
Limited		NMD	Glob~	R & D	Term~	Cong~	Industry	Allies	Military	Tech~
Altern~	NMD	0.1532	0.1532	0.1532	0.0000	0.1532	0.1532	0.1532	0.1532	0.1532
	Glob~	0.0968	0.0968	0.0968	0.0000	0.0968	0.0968	0.0968	0.0968	0.0968
	R & D	0.0438	0.0438	0.0438	0.0000	0.0438	0.0438	0.0438	0.0438	0.0438
	Term~	0.0201	0.0201	0.0201	0.0000	0.0201	0.0201	0.0201	0.0201	0.0201
Cong~	Cong~	0.2224	0.2224	0.2224	0.0000	0.2224	0.2224	0.2224	0.2224	0.2224
Defense Ind~	Industry	0.0513	0.0513	0.0513	0.0000	0.0513	0.0513	0.0513	0.0513	0.0513
For~	Allies	0.0619	0.0619	0.0619	0.0000	0.0619	0.0619	0.0619	0.0619	0.0619
Pre/Mil~	Military	0.3255	0.3255	0.3255	0.0000	0.3255	0.3255	0.3255	0.3255	0.3255
Tech~	Tech~	0.0250	0.0250	0.0250	0.0000	0.0250	0.0250	0.0250	0.0250	0.0250

IDEALIZED DECISION NETWORK VECTORS times NORMALIZED CONTROL CRITERIA

Benefits	Military Capability		Technical Advancement		SUM of
Control Criterion wt. (CC)	0.075		0.063		wtd Alts
Normalized CC	*0.542*	*Col. 1*	*0.458*	*Col. 2*	*Col 1 + Col 2*
Alternatives	*Idealized*	*(CC x Ideal.)*	*Idealized*	*(CC x Ideal.)*	*SUM*
Deploy	1.000	0.542	0.928	0.425	**0.967**
Global	0.623	0.338	1.000	0.458	**0.796**
R&D	0.282	0.153	0.448	0.205	**0.358**
Terminate	0.129	0.070	0.085	0.039	**0.109**

Opportunities	Arms Sales		Spinoff		SUM of
Control Criteria (CC)	0.096		0.06		wtd Alts
Normalized CC	*0.614*	*Col. 1*	*0.386*	*Col. 2*	*Col 1 + Col 2*
Alternatives	*Idealized*	*(CC x Ideal.)*	*Idealized*	*(CC x Ideal.)*	*SUM*
Deploy	1.000	0.614	1.000	0.386	**1.000**
Global	0.674	0.414	0.521	0.201	**0.614**
R&D	0.341	0.209	0.288	0.111	**0.321**
Terminate	0.190	0.117	0.166	0.064	**0.181**

Costs	Sec. Threat		Sunk Cost		Further Inv.		**Costs**	**1/Costs**
Control Criteria (CC)	0.687		0.123		0.105		*Sum of*	
Normalized CC	*0.751*	*Col. 1*	*0.134*	*Col. 2*	*0.115*	*Col. 3*	*Col's 1+2+3*	*Inverted*
Alternatives	*Idealized*	*(CC x Ideal.)*	*Idealized*	*(CC x Ideal.)*	*Idealized*	(CC x Ideal.)	*SUM*	
Deploy	0.183	0.137	1.000	0.134	1.000	0.115	**0.386**	**2.590**
Global	0.344	0.259	0.574	0.077	0.496	0.057	**0.393**	**2.548**
R&D	0.579	0.435	0.332	0.044	0.279	0.032	**0.512**	**1.955**
Terminate	1.000	0.751	0.193	0.026	0.147	0.017	**0.794**	**1.260**

Risks	Tech Failure		Arms Race		**Risks**	**1/Risks**
Control Criteria (CC)	0.43		0.268		*Sum of*	
Normalized CC	*0.616*	*Col. 1*	*0.384*	*Col. 2*	*Col's 1 + 2*	*Inverted*
Alternatives	*Idealized*	*(CC x Ideal.)*	*Idealized*	*(CC x Ideal.)*	SUM	
Deploy	1.000	0.616	1.000	0.384	**1.000**	**1.000**
Global	0.621	0.382	0.693	0.266	**0.648**	**1.542**
R&D	0.375	0.231	0.441	0.169	**0.401**	**2.496**
Terminate	0.262	0.161	0.302	0.116	**0.277**	**3.606**

Priority Ratings for the Merits: Benefits, Opportunities, Costs and Risks

Very High (0.419), High (0.263), Medium (0.160), Low (0.097), Very Low (0.061)

		Benefits	Opportunities	Costs	Risks
World Peace	Adversary Countries	Very High	Medium	High	Very Low
	Security Dilemma	Very Low	Very Low	Very High	Very Low
	Terrorism	Medium	Very Low	High	High
Human Well-Being	Technological Advancement	High	High	Low	Very Low
	Market Creation	Medium	High	Very Low	Very Low
International Politics	Military Relations	High	High	Medium	Very Low
	Diplomatic Relations	Low	Low	Low	Very High
		0.264	**0.184**	**0.363**	**0.188**

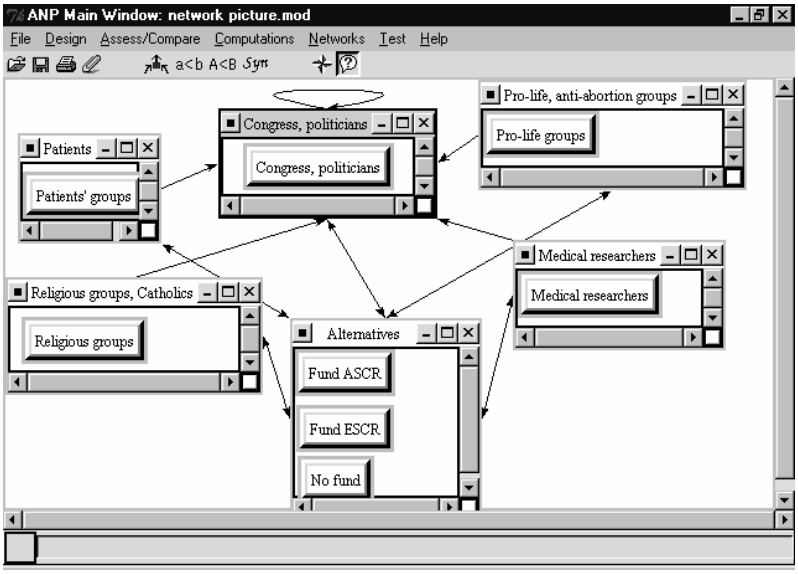
Sum of the BOCR merit priorities times the "Totals" for their control criteria

	Benefits		Opportunities		Costs		Risks	
	0.264		0.184		0.363		0.188	
Alts	*Sum(from above)*	*(Sum x .264)*	*Sum(from above)*	*(Sum x .184)*	*Sum(from above)*	*(Sum x .363)*	*Sum(from above)*	(Sum x .188)
Deploy	0.967	**0.255**	1.000	**0.184**	0.386	**0.140**	1.000	**0.188**
Global	0.796	**0.210**	0.614	**0.113**	0.393	**0.142**	0.648	**0.122**
R&D	0.358	**0.094**	0.321	**0.059**	0.512	**0.186**	0.401	**0.075**
Terminate	0.109	**0.029**	0.181	**0.033**	0.794	**0.288**	0.277	**0.052**
	*If a sum column is not ideal, that is, the largest value not 1.0, idealize by dividing by largest value in the column							

Synthesis of the Alternatives in Three Ways

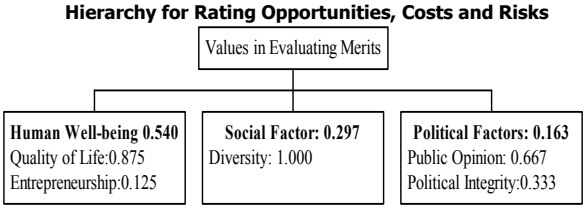
	BO/CR		**bB+oO+c(1-C)+r(1-R)**		**bB+oO-cC-rR**		
	(from unw td columns		(from unw eighted cols.		(from w eighted col's	(Unitized by dividing by number	
Alternatives	in table above)	Normalized	in table above)	Normalized	in table above)	w ith smallest absolute value)	
Deploy	2.504	0.493	0.662	0.333	0.111	**1.891**	
Global	1.921	0.379	0.610	0.307	0.059	**1.000**	
R&D	0.560	0.110	0.444	0.223	-0.108	**-1.831**	
Terminate	0.090	0.018	0.274	0.138	-0.278	**-4.736**	

STEM CELL Decision Network for Four Criteria: Medical Treatment, Oversight, Funding, Moral Issue and Religious Issue



Stem Cell Decision (ANP)

Hierarchy for Rating Opportunities, Costs and Risks



Priority Ratings for the Merits: Benefits, Opportunities, Costs and Risks

Very High (0.419), High (0.263), Medium (0.160), Low (0.097), Very Low (0.061)

	Criteria	Opportunities	Costs	Risks
Human well-being (0.468)	Quality of life (0.875)	Very high	Medium	High
	Entrepreneurship (0.125)	High	Low	Very high
Social Factor (0.297)	Diversity (1.000)	Low	High	High
Political factors (0.163)	Public opinion (0.667)	Medium	High	Very high
	Political integrity (0.333)	Very low	Medium	High
Priorities		**0.352**	**0.262**	**0.386**

Priorities of Criteria and Subcriteria

	Criteria	Subcriteria	Global priorities
Opportunities	Medical advancement (0.631)	Medical treatment (0.750)	0.473
		Economic profits (0.250)	0.158
	Social (0.369)	Oversight (1.000)	0.369
Costs	Funding (0.602)		0.602
	Commercialization (0.398)		0.398
Risks	Medical development (0.393)	Losing competition (1.000)	0.393
	Social risks (0.607)	Moral issue (0.690)	0.419
		Religious issue (0.310)	0.188

Matrices for The Religious Issue Decision Network of Risks

Unweighted Supermatrix		Alternatives			Congress	Medical researchers	Patients	Antiabortion groups	Religious groups
		ASCR Fund	ESCR Fund	No Funding	Congress	Medical researchers	Patients	Antiabortion groups	Religious groups
Alternatives	ASCR Fund	0.0000	0.0000	0.0000	0.3331	0.3196	0.3339	0.3237	0.3126
	ESCR Fund	0.0000	0.0000	0.0000	0.5695	0.5584	0.5013	0.5862	0.5996
	No Fund	0.0000	0.0000	0.0000	0.0974	0.1220	0.1649	0.0901	0.0878
Congress	Congress	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Medical Researchers	Medical Researchers	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Patient	Patient	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Antiabortion groups	Antiabortion groups	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Religious groups	Religious groups	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

	Alternatives	Congress	Medical researchers	Patients	Antiabortion groups	Religious groups
Alternatives	0.0000	0.6667	0.6667	0.6667	0.6667	0.6667
Congress	0.1314	0.3333	0.3333	0.3333	0.3333	0.3333
Medical researchers	0.1977	0.0000	0.0000	0.0000	0.0000	0.0000
Patients	0.2237	0.0000	0.0000	0.0000	0.0000	0.0000
Antiabortion groups	0.2237	0.0000	0.0000	0.0000	0.0000	0.0000
Religious groups	0.2237	0.0000	0.0000	0.0000	0.0000	0.0000

Weighted Supermatrix		Alternatives			Congress	Medical researchers	Patients	Antiabortion groups	Religious groups
		ASCR Fund	ESCR Fund	No Funding	Congress	Medical researchers	Patients	Antiabortion groups	Religious groups
Alternatives	ASCR Fund	0.0000	0.0000	0.0000	0.2220	0.2131	0.2226	0.2158	0.2084
	ESCR Fund	0.0000	0.0000	0.0000	0.3797	0.3723	0.3342	0.3908	0.3998
	No Fund	0.0000	0.0000	0.0000	0.0649	0.0813	0.1099	0.0601	0.0585
Congress	Congress	0.1314	0.1314	0.1314	0.3333	0.3333	0.3333	0.3333	0.3333
Medical Researchers	Medical Researchers	0.1977	0.1977	0.1977	0.0000	0.0000	0.0000	0.0000	0.0000
Patient	Patient	0.2237	0.2237	0.2237	0.0000	0.0000	0.0000	0.0000	0.0000
Antiabortion groups	Antiabortion groups	0.2237	0.2237	0.2237	0.0000	0.0000	0.0000	0.0000	0.0000
Religious groups	Religious groups	0.2237	0.2237	0.2237	0.0000	0.0000	0.0000	0.0000	0.0000

Limit Supermatrix		Alternatives			Congress	Medical researchers	Patients	Antiabortion groups	Religious groups
		ASCR Fund	ESCR Fund	No Funding	Congress	Medical researchers	Patients	Antiabortion groups	Religious groups
Alternatives	ASCR Fund	0.130785	0.130785	0.130785	0.130785	0.130785	0.130785	0.130785	0.130785
	ESCR Fund	0.225947	0.225947	0.225947	0.225947	0.225947	0.225947	0.225947	0.225947
	No Fund	0.043268	0.043268	0.043268	0.043268	0.043268	0.043268	0.043268	0.043268
Congress	Congress	0.252546	0.252546	0.252546	0.252546	0.252546	0.252546	0.252546	0.252546
Medical Researchers	Medical Researchers	0.079073	0.079073	0.079073	0.079073	0.079073	0.079073	0.079073	0.079073
Patient	Patient	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461
Antiabortion groups	Antiabortion groups	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461
Religious groups	Religious groups	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461	0.089461

Final Outcome

	Opportunities(0.352)	Costs(0.262)	Risks (0.386)	Final Outcome
Fund ASCR	0.350	0.374	0.316	0.343
Fund ESCR	0.501	0.332	0.306	0.381
No fund	0.148	0.293	0.378	0.275

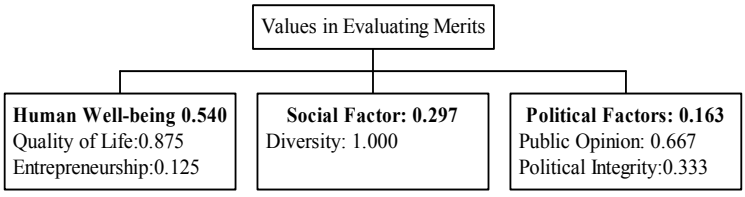
The priorities of the alternatives under the Costs and Risks are reciprocals

Sensitivity Analysis

		Original priorities (local)	Priorities that begin to change the ranks
OCR	Opportunities	0.352	0.126 and less
	Costs	0.262	0.626 and more
	Risks	0.386	0.711 and more
Criteria/subcriteria	Medical advancement	0.631	0.932 and more
	Funding	0.602	0.942 and more
	Commercialization	0.398	0.058 and less
	Medical development-Losing competition	0.393	0.105 and less
	Moral issue	0.690	0.908 and more
	Religious issue	0.310	0.671 and more

Stem Cell Research Decision (AHP)

Hierarchy for Rating Opportunities, Costs and Risks



Priority Ratings for the Merits: Opportunities, Costs and Risks

Very High (0.419), High (0.263), Medium (0.160), Low (0.097), Very Low (0.061)

	Criteria	Opportunities	Costs	Risks
Human well-being (0.468)	Quality of life (0.875)	Very high	Medium	High
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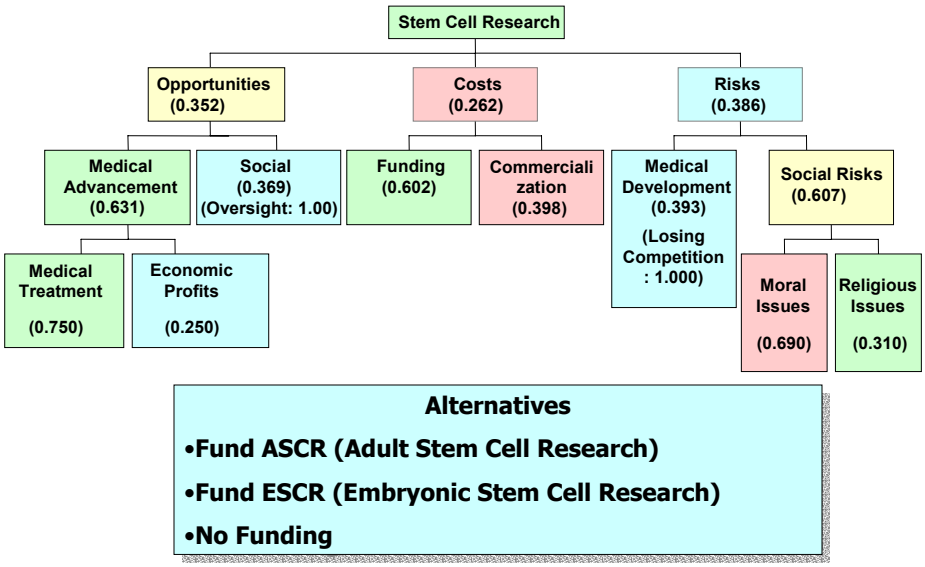
Priorities		0.352	0.262	0.386

Priorities of Criteria and Subcriteria



Alternatives

- **Fund ASCR (Adult Stem Cell Research)**
- **Fund ESCR (Embryonic Stem Cell Research)**
- **No Funding**

Stem Cell Opportunities, Costs and Risks Data and Synthesis

	Opportunities		Costs			1/Costs	Risks			1/Risks
Priority of BOCR Merit	0.33		0.28				0.39			
	Ideal	Normalized	Ideal	Normalized	Inverted	Norm.Inv.	Ideal	Normalized	Inverted	Norm.Inv.
Conditional funding (ASCR)	0.702	0.350	0.576	0.304	3.285	0.363	0.699	0.350	2.857	0.315
Continue funding (ESCR)	1.000	0.499	0.677	0.358	2.794	0.309	0.717	0.359	2.784	0.307
Terminate funding	0.303	0.151	0.639	0.338	2.961	0.327	0.580	0.291	3.439	0.379

	O/(CR)				oO-cC-rR	Unitized
Priority of BOCR Merit					(x OCR wts)	
	(Using Ideals)	Normalized			(Using Ideals)	(Divide by 0.139)
Conditional funding (ASCR)	#DIV/0!	**#DIV/0!**			-0.041	**0.811**
Continue funding (ESCR)	#DIV/0!	**#DIV/0!**			0.050	**-1.000**
Terminate funding	#DIV/0!	**#DIV/0!**			-0.126	**2.509**

Three Auto Industry Models

1. Best strategy for Ford with respect to the Ford Explorer/Firestone tire controversy
2. Should Porsche, a luxury car maker, introduce a Sports Utility Vehicle (SUV)?
3. Validation Exercise: Estimating the market share of Toyoto

Ford Explorer/Firestone Tire

What is the best strategy for the Ford Company to follow for its Ford Explorer SUV? It has been a very popular brand in recent years, but a series of accidents involving Explorers with Firestone tires has tarnished its image. There are four possible strategies that Ford can follow:

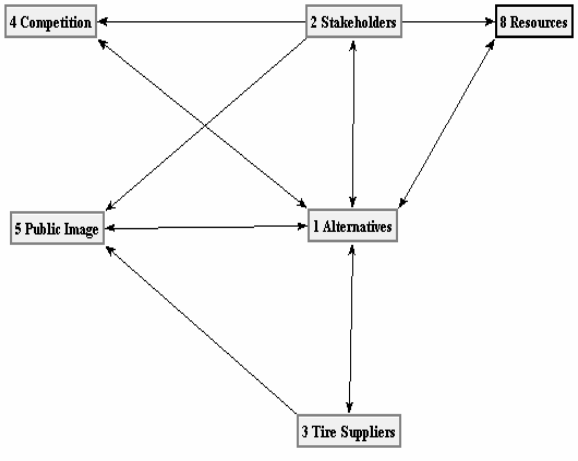
1. Discontinue Explorer
2. Redesign the model
3. Maintain the current model
4. Maintain the current model and change the tire supplier

Top Level View of Model : **Benefits, Costs and Risks**

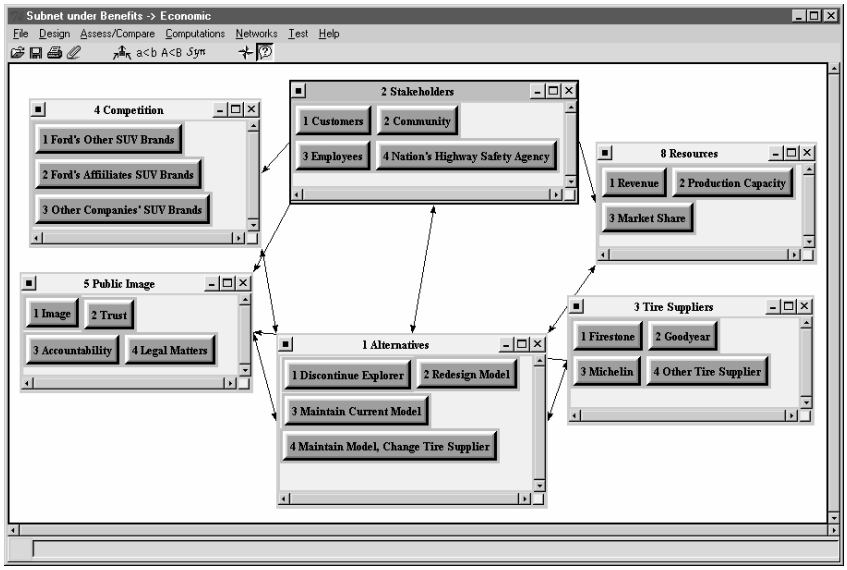
The Six Decision Networks under Benefits, Costs and Risks

Benefits	Costs	Risks
▪Economic ▪Social	▪Economic ▪Political ▪Social	▪Economic ▪Social

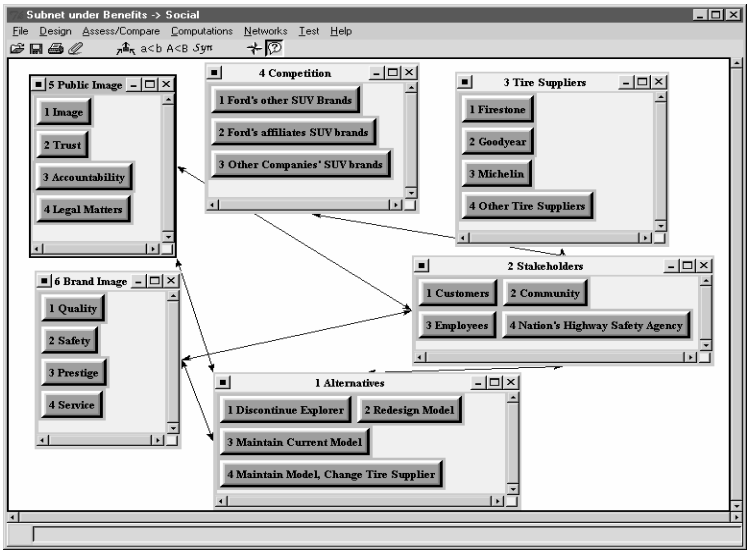
Macro View of the Decision Network under Benefits, Economic



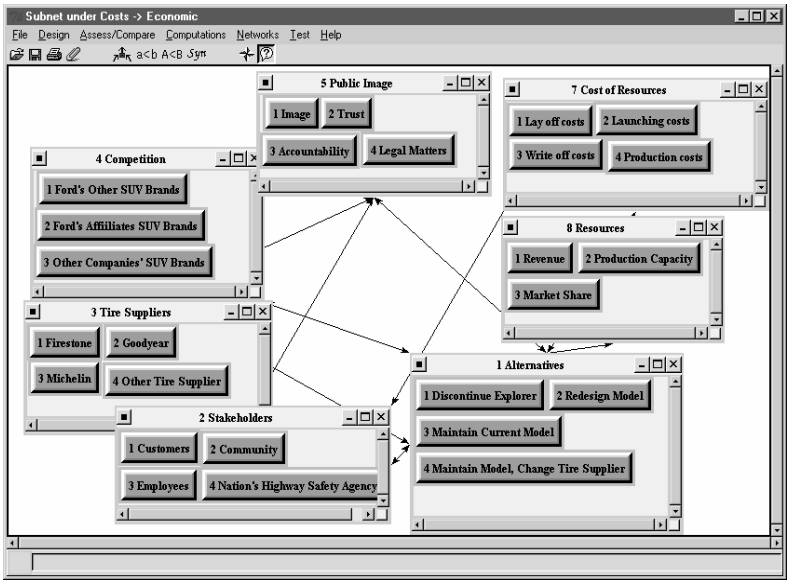
Expanded View of the Decision Network under Benefits: Economic



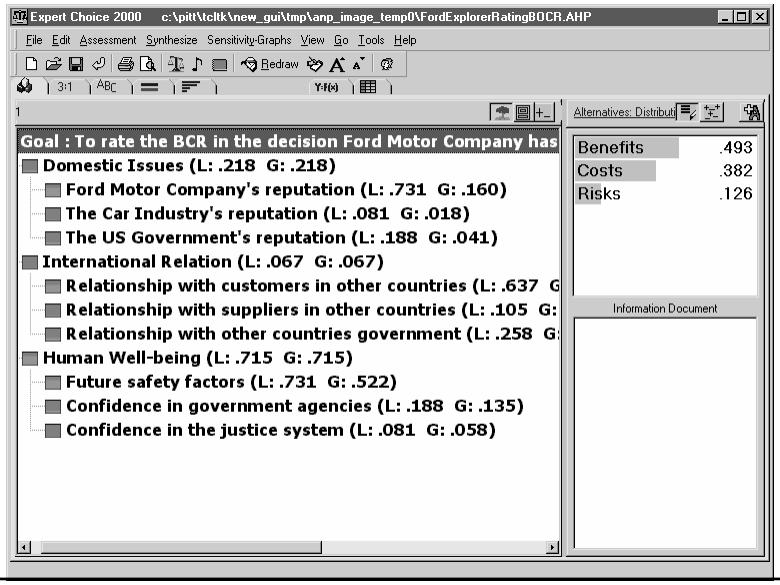
Expanded View of the other Decision Network under Benefits: Social



Expanded View of the Economic Decision Network under Costs



The Strategic Criteria used to Rate and Normalized Benefits, Costs and Risks



Results of Ford Strategy Model Shown using Three Methods of Synthesizing the Benefits, Costs and Risks

Alternatives	B/(CR)		bB+c(1-C)+r(1-R)		bB-cC-rR	Unitized
			(x b,c,r wts.)		(x b,c,r wts)	
	(Using Ideals)	Normalized	(Using Ideal.)	Normalized	(Using Ideals)	(Divide by 0.173)
Discontinue Explorer	0.171	**0.113**	0.996	**0.259**	0.334	**1.931**
Redesign Model	1	**0.659**	1	**0.260**	0.376	**2.173**
Maintain Current Model	0.024	**0.016**	0.868	**0.226**	-1.000	**-5.780**
Maintain Model, Change Tire Suppl	0.322	**0.212**	0.980	**0.255**	-0.173	**-1.000**

The Best Strategy for Ford under any Method of Synthesis is to Redesign the Explorer Model

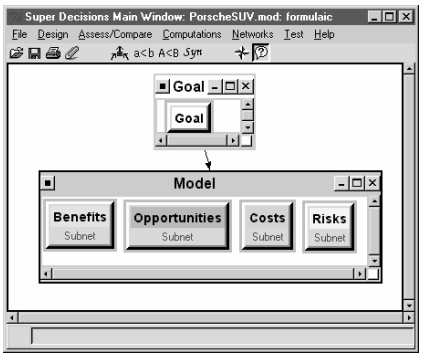
Should Porsche enter the SUV Market?

Should Porsche, a manufacturer of luxury sports cars and the world's most profitable automaker, have introduced a Sports Utility Vehicle (SUV)? Is the decision justified financially, socially and politically with respect to Benefits, Opportunities, Costs, Risks?

The Alternatives are:

- Introduce SUV
- Do not introduce SUV

Top Level View of Model : the Benefits, Costs and Risks



The Twelve Decision Networks under Benefits, Costs, Risks and Opportunities

Benefits	Opportunities	Costs	Risks
▪Financial	▪Financial	▪Financial	▪Financial
▪Social	▪Social	▪Social	▪Social
▪Political	▪Political	▪Political	▪Political