Characteristics of the Analytic Network Process, a Multi-Criteria Decision-Making Method

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Abstract

The analytic network process (ANP) is one of the most complex multi-criteria decision-making methods. It was developed by Professor Thomas Saaty, who also created the analytic hierarchy process. In the network, we model the dependencies and influences between decision-making elements. A network contains much more information on the decision-making problem than the hierarchy does. By applying the ANP, we, therefore, obtain more accurate results (the decision).

As identified in the literature, the main disadvantage of the ANP is the duration of the implementation process, which is correlated with a large number of pairwise comparisons that need to be implemented. This disadvantage is decreased through different integrations of the ANP method with other methods, such as the decision making trial and evaluation laboratory approach and interpretive structural modelling.

In this study, we focus on the three characteristics of the ANP, which are (1) the inseparability of criteria and alternatives, (2) the influence of the *goal* node on the priorities in the decision-making problem and (3) the stochasticity of the supermatrix in the ANP method. *The inseparability of criteria and alternatives* means that the ANP is not designed to be used for determining only criteria weights, without inputting the alternatives into the model (which can be a real-case request). If we create a network that consists only of criteria, some of the criteria can possibly weigh 0.0 if the related supermatrix is reducible. A reducible matrix means that the related graph is weakly connected—at least two nodes have no directed path between them. *The influence of the goal node on the priorities* implies that in most decision-making problems, which consist of one *goal* node, the priorities derived from the comparisons of the elements with respect to the *goal* do not influence the final priorities of the decision-making elements. If we delete the *goal* node, we get the same priorities as if the *goal* node is present in the model. Finally, *the stochasticity of the supermatrix* is related to the method request that the sum of all columns in the supermatrix has to be equal to 1. This request relativizes the decision-making problem; the ANP often does not handle the strengths of the influences (dependencies) between criteria (ANP uses the same supermatrix for many decision-making problems).

All these three characteristics are theoretically analyzed in depth and demonstrated through examples. The paper concludes with proposals on how the ANP can be used with respect to these three characteristics.

Keywords: *analytic network process, ANP, stochasticity, supermatrix, reducibility*

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Decision-making in HE

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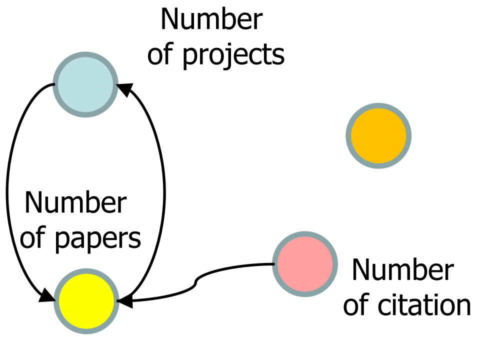
- Methodological framework for strategic decision making in HE
- HE = field which is characterized by existence of the **d**ependencies/influences between the criteria

  ⇒ ANP = the most suitable method for MCDM
- Sistematic literature review

  ⇒ ANP is rarely used

Conflict

- What is the reason of this conflict?
  - Present the method ANP
  - List the characteristics of the method



ANP method

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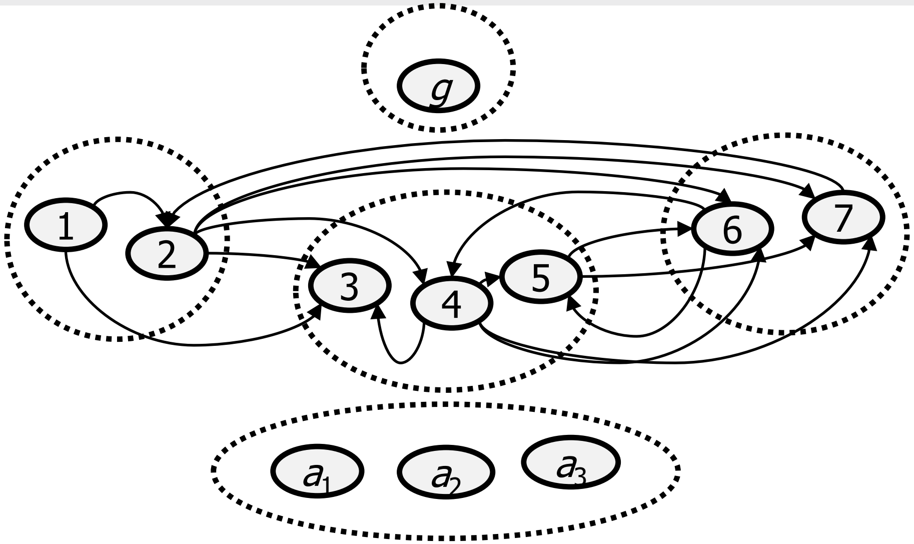

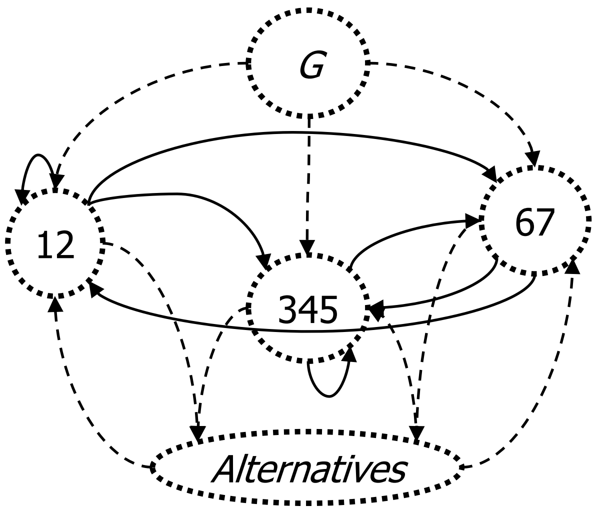

		G	12		345			67		Alternatives		
		g	1	2	3	4	5	6	7	a_1	a_2	a_3
G	g	0	0	0	0	0	0	0	0	0	0	0
12	1	0.40	0	0	0	0	0	0	0	0.40	0.60	0.80
	2	0.60	1.00	0	0	0	0	0	1.00	0.60	0.40	0.20
345	3	0.20	1.00	0.50	0	0.60	0	0	0	0.20	0.60	0.50
	4	0.40	0	0.50	0	0	0	0.70	0	0.20	0.20	0.20
	5	0.40	0	0	0	0.40	0	0.30	0	0.60	0.20	0.30
67	6	0.60	0	0.40	0	0.20	0.40	0	0	0.50	0.60	0.20
	7	0.40	0	0.60	0	0.80	0.60	0	0	0.50	0.40	0.80
Alter.	a_1	0	0.50	0.60	0.20	0.10	0.40	0.10	0.20	0	0	0
	a_2	0	0.20	0.20	0.50	0.60	0.40	0.10	0.20	0	0	0
	a_3	0	0.30	0.20	0.30	0.30	0.20	0.80	0.60	0	0	0

	G	12	345	67	Alter.
G	0	0	0	0	0
12	0.33	0.25	0	0.33	0.33
235	0.33	0.25	0.33	0.33	0.33
67	0.33	0.25	0.33	0	0.33
Alter	0	0.25	0.33	0.33	0

		G	12		345			67		Alternatives		
		g	1	2	3	4	5	6	7	a_1	a_2	a_3
G	g	0	0	0	0	0	0	0	0	0	0	0
12	1	0.13	0	0	0	0	0	0	0	0.13	0.20	0.27
	2	0.20	0.33	0	0	0	0	0	0.50	0.20	0.13	0.07
345	3	0.07	0.33	0.17	0	0.20	0	0	0	0.07	0.20	0.17
	4	0.13	0	0.17	0	0	0	0.35	0	0.07	0.07	0.07
	5	0.13	0	0	0	0.13	0	0.15	0	0.20	0.07	0.10
67	6	0.20	0	0.13	0	0.07	0.20	0	0	0.17	0.20	0.07
	7	0.13	0	0.20	0	0.27	0.30	0	0	0.17	0.13	0.27
Alter.	a_1	0	0.17	0.20	0.20	0.03	0.20	0.05	0.10	0	0	0
	a_2	0	0.07	0.07	0.50	0.20	0.20	0.05	0.10	0	0	0
	a_3	0	0.10	0.07	0.30	0.10	0.10	0.40	0.30	0	0	0

ANP method – weak points

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1. Limitations – Saaty scale (9)
2. High number of comparisons (>50 vs 26 in AHP)
3. Inconsistency analysis
4. DM structure influence the priorities
5. Misunderstanding of PC of criteria wrt other criteria (3, 4 wrt 2)
6. Misunderstanding of PC on cluster level
    1. 12 and 345 wrt G, 12, 67 and Altern.
    2. Comparing clusters wrt one of them
    3. Comparing clusters of different types (12, 345 wrt Altern; 345, Altern wrt 12)
    4. 2 + 3 (12 and Altern. wrt 12)
7. Reflexivity ??

		G	12		345			67		Alternatives		
		g	1	2	3	4	5	6	7	a_1	a_2	a_3
G	g	0	0	0	0	0	0	0	0	0	0	0
12	1	0.40	0	0	0	0	0	0	0	0.40	0.60	0.80
	2	0.60	1.00	0	0	0	0	0	1.00	0.60	0.40	0.20
345	3	0.20	1.00	0.50	0	0.60	0	0	0	0.20	0.60	0.50
	4	0.40	0	0.50	0	0	0	0.70	0	0.20	0.20	0.20
	5	0.40	0	0	0	0.40	0	0.30	0	0.60	0.20	0.30
67	6	0.60	0	0.40	0	0.20	0.40	0	0	0.50	0.60	0.20
	7	0.40	0	0.60	0	0.80	0.60	0	0	0.50	0.40	0.80
Alter.	a_1	0	0.50	0.60	0.20	0.10	0.40	0.10	0.20	0	0	0
	a_2	0	0.20	0.20	0.50	0.60	0.40	0.10	0.20	0	0	0
	a_3	0	0.30	0.20	0.30	0.30	0.20	0.80	0.60	0	0	0

	G	12	345	67	Alter.
G	0	0	0	0	0
12	0.33	0.25	0	0.33	0.33
345	0.33	0.25	0.33	0.33	0.33
67	0.33	0.25	0.33	0	0.33
Alter	0	0.25	0.33	0.33	0

		G	12		345			67		Alternatives		
		g	1	2	3	4	5	6	7	a_1	a_2	a_3
G	g	0	0	0	0	0	0	0	0	0	0	0
12	1	0.13	0	0	0	0	0	0	0	0.13	0.20	0.27
	2	0.20	0.33	0	0	0	0	0	0.50	0.20	0.13	0.07
345	3	0.07	0.33	0.17	0	0.20	0	0	0	0.07	0.20	0.17
	4	0.13	0	0.17	0	0	0	0.35	0	0.07	0.07	0.07
	5	0.13	0	0	0	0.13	0	0.15	0	0.20	0.07	0.10
67	6	0.20	0	0.13	0	0.07	0.20	0	0	0.17	0.20	0.07
	7	0.13	0	0.20	0	0.27	0.30	0	0	0.17	0.13	0.27
Alter.	a_1	0	0.17	0.20	0.20	0.03	0.20	0.05	0.10	0	0	0
	a_2	0	0.07	0.07	0.50	0.20	0.20	0.05	0.10	0	0	0
	a_3	0	0.10	0.07	0.30	0.10	0.10	0.40	0.30	0	0	0

ANP method – weak points

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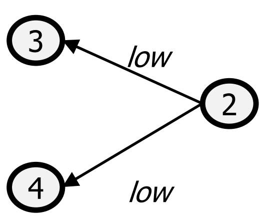
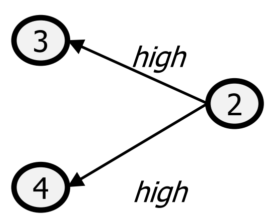
8. The priorities wrt node G do not influence the finale priorities
9. The inseparability of the criteria and alternatives (ex. calculating only the criteria weights – public procurement)
10. The stochasticity of the supermatrix in the ANP relativizes the problem
    - Column 12 (adjusting to the connections within the clusters)
    - Col 7, row 2
    - …





		G	12		345			67		Alternatives		
		g	1	2	3	4	5	6	7	a_1	a_2	a_3
G	g	0	0	0	0	0	0	0	0	0	0	0
12	1	0.40	0	0	0	0	0	0	0	0.40	0.60	0.80
	2	0.60	1.00	0	0	0	0	0	1.00	0.60	0.40	0.20
345	3	0.20	1.00	0.50	0	0.60	0	0	0	0.20	0.60	0.50
	4	0.40	0	0.50	0	0	0	0.70	0	0.20	0.20	0.20
	5	0.40	0	0	0	0.40	0	0.30	0	0.60	0.20	0.30
67	6	0.60	0	0.40	0	0.20	0.40	0	0	0.50	0.60	0.20
	7	0.40	0	0.60	0	0.80	0.60	0	0	0.50	0.40	0.80
Alter.	a_1	0	0.50	0.60	0.20	0.10	0.40	0.10	0.20	0	0	0
	a_2	0	0.20	0.20	0.50	0.60	0.40	0.10	0.20	0	0	0
	a_3	0	0.30	0.20	0.30	0.30	0.20	0.80	0.60	0	0	0

	G	12	345	67	Alter.
G	0	0	0	0	0
12	0.33	0.25	0	0.33	0.33
235	0.33	0.25	0.33	0.33	0.33
67	0.33	0.25	0.33	0	0.33
Alter	0	0.25	0.33	0.33	0

		G	12		345			67		Alternatives		
		g	1	2	3	4	5	6	7	a_1	a_2	a_3
G	g	0	0	0	0	0	0	0	0	0	0	0
12	1	0.13	0	0	0	0	0	0	0	0.13	0.20	0.27
	2	0.20	0.33	0	0	0	0	0	0.50	0.20	0.13	0.07
345	3	0.07	0.33	0.17	0	0.20	0	0	0	0.07	0.20	0.17
	4	0.13	0	0.17	0	0	0	0.35	0	0.07	0.07	0.07
	5	0.13	0	0	0	0.13	0	0.15	0	0.20	0.07	0.10
67	6	0.20	0	0.13	0	0.07	0.20	0	0	0.17	0.20	0.07
	7	0.13	0	0.20	0	0.27	0.30	0	0	0.17	0.13	0.27
Alter.	a_1	0	0.17	0.20	0.20	0.03	0.20	0.05	0.10	0	0	0
	a_2	0	0.07	0.07	0.50	0.20	0.20	0.05	0.10	0	0	0
	a_3	0	0.10	0.07	0.30	0.10	0.10	0.40	0.30	0	0	0

The goals of the new method

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- Lower user complexity:
  - Lower duration of giving inputs
  - Lower number of inputs that have to be inserted by user
  - Understanding all method steps
- Importance of the criteria wrt goal has to have the influence on element priorities
- No relativizing the influences between the criteria
- Applicable without knowing the alternative
- Structure of decision making problem has not to influence of the elements of the priorities

Thank you for your attention

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