Transportation Mode Selection for Turkish Automotive Industry Using Analytic Network Process

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Abstract: - Selection of transportation mode is a multi-criteria problem which has both tangible and intangible factors with several alternatives. In this paper the criteria, which effect the selection of transportation mode, have been identified and used to develop a generic analytic network process (ANP) model. This 38 criteria classified into four sub-networks; benefits (B), cost (C), opportunities (O) and risks (R). The priorities in all four sub-networks are calculated for each of six alternatives by using The SuperDecisions Software. The multicative formula [(BxO)/(CxR)] used to get overall results. The ability of ANP to consider interdependences and outerdependences enables realistic complex models alike in real-life. The generic transportation mode selection model developed by the authors can be used for all other industries.

Key-Words: - Transportation mode selection, ANP, Multi-criteria decision making, Automotive industry

1 Introduction

Selecting transportation mode is a difficult problem due to plenty of effecting factors and complex relations between the factors. Another difficulty of the problem is considering the factors due to limited litterateur.

Factors, which effect the selection of transportation mode (here in after called factors), aren't pointed out clearly enough by the researchers and this leads to the research being presented in this paper. Çancı and Erdal [3] noticed most of the factors and define them. To make a complete model a group, includes experts from both academia and industry, presents and defines all the factors. Later this group makes the pairwise comparisons.

The group defines 38 criteria and we adopted them into ANP (analytic network process) for the following reasons explained below. They are: (i) ANP enables establishing a complete decision model without sacrificing the realty due to limitations of the analytical tool [1, 2, 6, 8]; (ii) ANP makes it possible to deal systematically with all kinds of dependence and feedback, uses ratio scales to success [4, 6, 10, 12]; (iii) ANP can measure and link all tangible and intangible, financial and non-financial, internal and external factors and can easily adopt them to the model [1, 4, 8]; (iv) ANP is a simple intuitive that can be accepted easily by managers and other decision-makers [7]; (v) Multicriteria decision problems involving multiactors or group decision making can be easily solved by ANP [5].

The Paper is organized into four sections and begins with an explanation of the ANP methodology used in this study. Section 3 includes the case study for Turkish automotive industry. In this section the factor identified and grouped into four sub-networks; benefits, opportunities, costs and risks. The overall conclusion is given in section 5.

2 ANP Methodology

The ANP , generalized form of widely used AHP (Analytic Hierarchy Process), is first introduced by Satty [9]. The methodology contains two main structures; Pair-wise Comparison matrix, derives the priorities of criteria with respect to a criterion and super-matrix which derives the final priorities. There are three types of supermatrix; unweighted, weighted and limit. This paper represents generalized information about the methodology, for details look at [9] and [7].

To decrease the number of pairwise comparisons, all criteria divided into groups [9]. This groups called cluster and all clustered criteria called nodes.

2.1 Pair-wise Comparisons

Pair-wise comparisons in ANP are same as in AHP. But in ANP, criteria, which are compared, are linked to each other. Three types of connections are used: one way, two way and loop connections. If only one way connection is seen between two clusters one way dependence exists. And the two way dependences are represented by bi-directed arrows and loop indicates a comparison in a cluster. A loop construct indicates inner dependence and others indicate outer dependence.

AHP and ANP use the same comparison 1-9 scale, which is recommended by Saaty [9], when comparing two components. In this scale 1 represents indifference between the two components and 9 represents overwhelming dominance of the component under consideration (row component) over the comparison component (column component in the matrix). If the component has weaker level impact ranges of scales will be from 1 to 1/9, where 1 represents indifference and 1/9 represents overwhelming dominance by a column component over the row element. Single numbers are used as transition between levels of importance and doubles are used when singles do not reflect precise assessments.

2.1 Unwieghted Supermatrix, Weighted Supermatrix and Limit Supermatrix

All priorities derived from pair-wise comparisons, are take part in a matrix which has the goal, all the criteria and alternatives as both column and row elements. This matrix is called unweighted supermatrix. Each row is multiplied by the priority of the it's cluster priority and each column is normalized to 1 and called weighted supermatrix. Raising the weighted supermatrix to the power k , where k is an arbitrarily large number, allows convergences of rows. This steady state values are the overall priorities of the alternatives and criteria.

3 The Proposed ANP Model

Çancı and Erdal [3] noticed most of the factors, which effect the selection of transportation mode, and define them. To make a complete model a decision group, includes experts from both academia and industry, presents and defines all the factors and classified into four sub-networks; benefits (B), cost (C), opportunities (O) and risks (R) according to the classification method used by Shang et. all.[11]. In this method, a positive outcome that is occur in the near future is placed under benefits, whereas a definite short-term outgoing is placed under costs. Long-term, uncertain factors are placed to either opportunities or risk, depending on their positive or negative contribute to the goal. The factors, definitions and classifications are given in Table 1. In this research The Super Decisions 1.6.0 Software is used to generate the model.

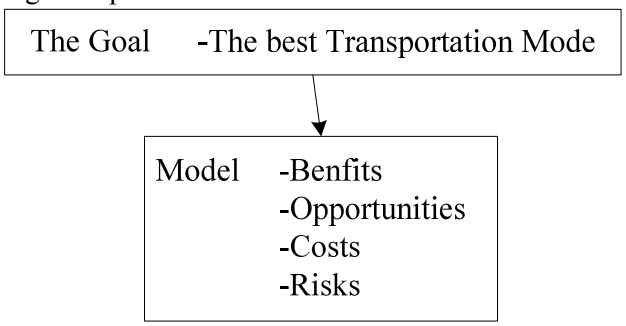
Table 1. Clusters and Factors

Cluster	**Factor**
Reliability	F1: Responsibility for delaying
	F2: Consistency on deliveries
	F3: Reliability for applied prices
	F4: The ratio for the total value of goods to the value of damaged goods
Traceability	F5: Tracing the bureaucratic factors
	F6: Traceability of the goods and vehicles
Subventions	F7: Subvention for combined transportation
Flexibility	F8: Route flexibility
	F9: Capacity flexibility
	F10: Satisfying the unexpected changes
Route flexibility	F11: Abundance of Service Locations
	F12: Current network and infrastructure
Capacity flexibility	F13: Container capacity
	F14: Average volume capacity of the vehicle
	F15: Average weight capacity of the vehicle
	F16: Party volume
	F17: Transit stock volume
Satisfying the unexpected changes	F18: Seasonal conditions
	F19: Natural disasters
	F20: Political
Speed	F21: Waited time in the terminals
	F22: Distances
	F23: Ratio of transportation distance to transportation time
	F24: Transportation time
Costs	F25: Handling costs

Costs	F26: Communication and information costs
	F27: Facility designing costs
	F28: Transportation costs
Storage risks	F29: Climatic risks
	F30: Physical risks
	F31: Chemical risks
Insecureness	F32: Value of the injured or lost goods
	F33: Reasons of accidents
	F34: Number of accidents
Quality	F35: Service quality
Features of the goods	F36:Volume
	F37: Weight
	F38: Value
	F39: Packaging
	F40: Clearance
	F41: Insurance

Decision makers defined the relations in the networks, shown in Fig. 1, Fig. 2, Fig. 3, Fig. 4 and Fig. 5.

Fig. 1 Top Level Network



Decision makers evaluate 6 alternatives; highway, seaway, airway, railway, intermodal and multimodal for Turkish automotive industry. In this study, intermodal mode evaluated as its specific type fishybacking (highway and seaway).

The model used for transportation mode selection between Turkey and EU because most of the transportation in this industry is between EU and Turkey. This shows the importance of selecting correct transportation mode.

The proposed model can be used for evaluating transportation modes between two specific locations or for a specific firm. With some changes this model also can be used for other industries or products.

Fig. 2 Costs Subnetwork

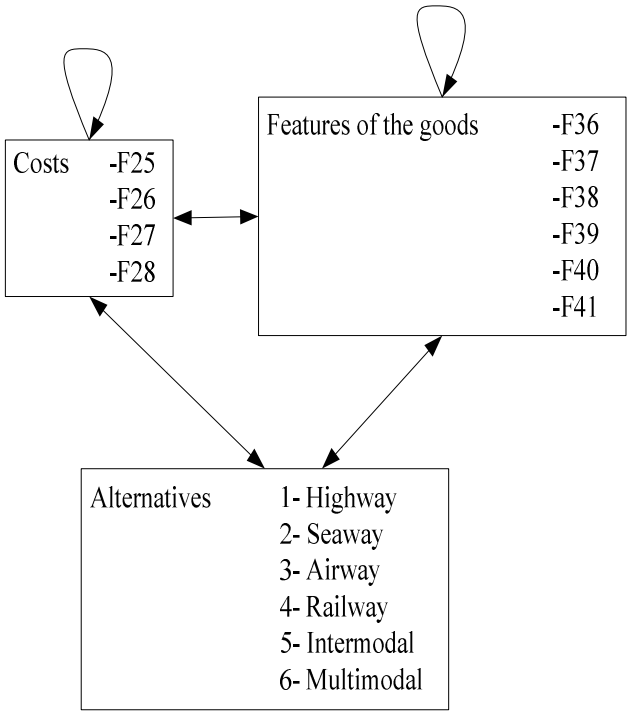


Fig. 3 Risks Subnetwork

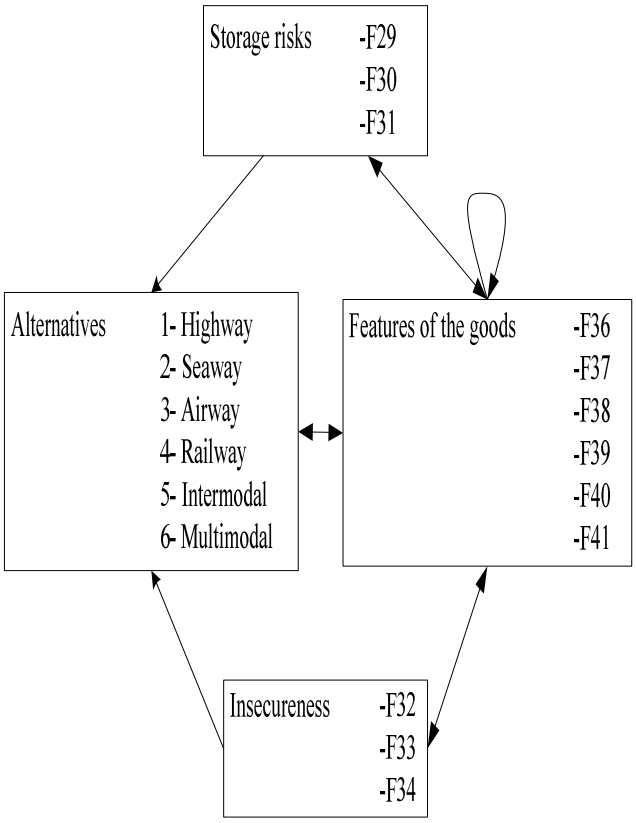


Fig. 4 Opportunities Subnetwork

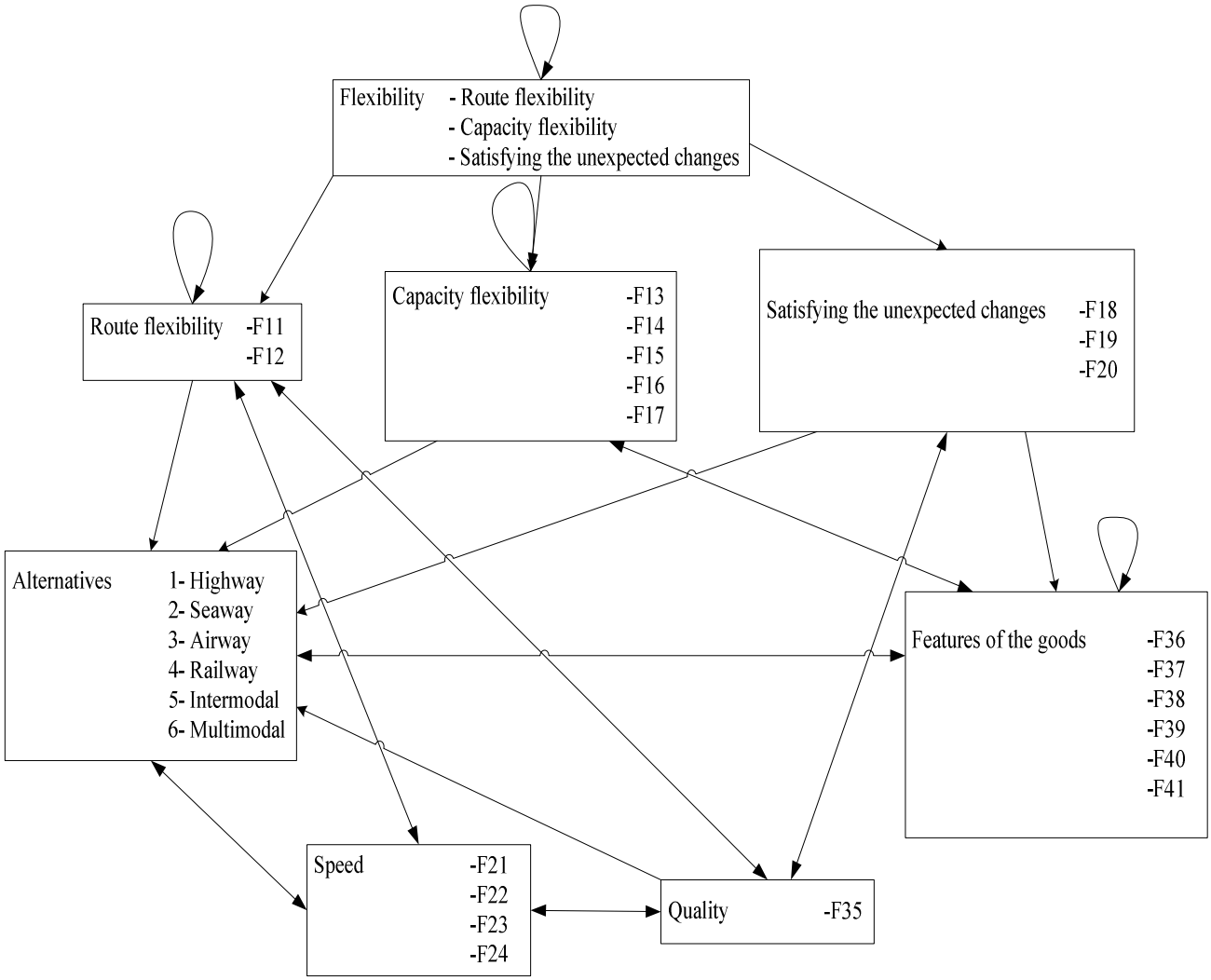
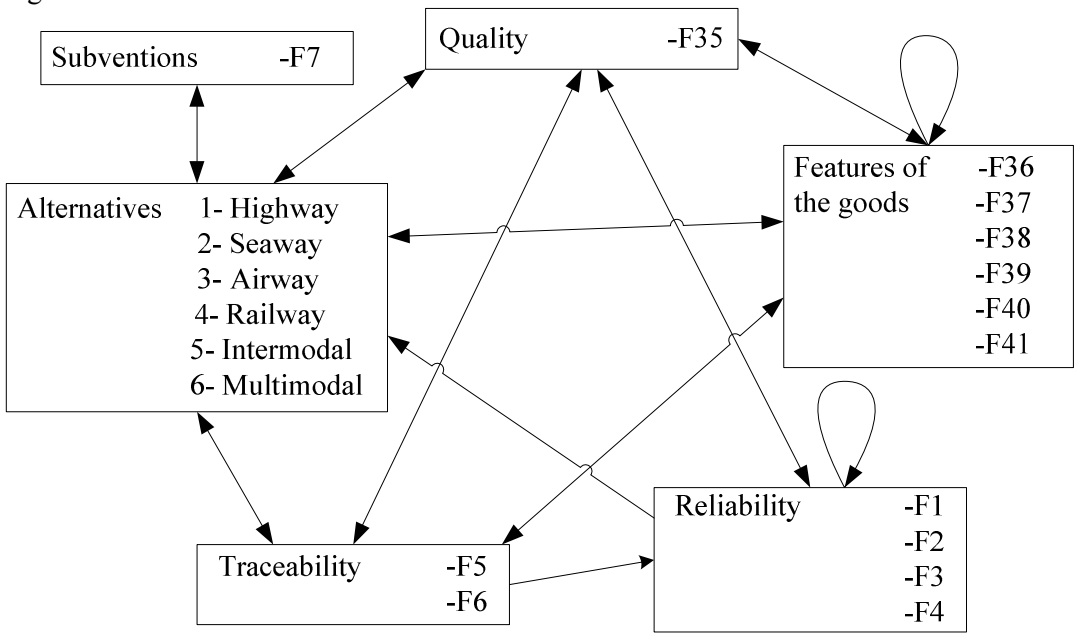


Fig. 5 Benefits Subnetwork



In this study the multicative formula [(BxO)/(CxR)] used to get overall results. The results are given in Table 2. Intermodal (Fishybacking type) gets the highest priority (0.2354) and followed by Highway (0.2287). The other alternatives get low scores from the ANP model. The worst option is airway in this study (0.1200).

Table 2 Overall results

Graphic	Alternatives	Normal	Ideal	Rank
	Highway	0.2287	0.9718	2
	Seaway	0.1345	0.5713	5
	Airway	0.1200	0.5100	6
	Railway	0.1412	0.5998	3
	Intermodal	0.2354	1.0000	1
	Multimodal	0.1403	0.5960	4

4 Conclusion

This study clearly shows that Turkish automotive industry should use intermodal or highway alternative when selecting transportation mode between Turkey and EU.

The proposed model can be modified easily to solve other transportation mode selection problems. For example the proposed model can be used for evaluating transportation modes between two specific locations or for a specific firm. With some changes this model also can be used for other industries. In that case the relations between the factor should redefine and pair-wise comparisons should be redone.

Fur further researches new alternatives such as piggybacking or birdybacking can be evaluated. This model can use to develop software which selects the best transportation mode between two specific points.

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