OPTIMIZATION AND REAL LIFE APPLICATIONS_1

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SESSION ABSTRACT

Real life problems usually include multicriteria factors. These factors need to be analyzed by systematic and trustworthy methods. The parameters of multicriteria optimization problems also should be estimated carefully. Because their values directly affect the performances, the validities of the models and their outcome. This session presents scientific works in this context. The methods such as goal programming, mathematical modeling, AHP and ANP are used in the same solution framework to solve different real life problems vary from vehicle routing to customer satisfaction and/or crime prioritization.

Key words: optimization, mixed methods, AHP, ANP.

THE RATIONALITY OF PUNISHMENT – MEASURING THE SEVERITY OF CRIMES: AN AHP-BASED ORDERS-OF-MAGNITUDE APPROACH

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ABSTRACT

We propose an innovative AHP-based model to assess the severity of the impairments a criminal committed to the society in a comprehensive and subtle way. Different from the traditional approach of structuring alternatives into one level, we organize the alternatives into multiple levels of that hierarchy. This arrangement and evaluation of alternatives differs from one criterion to another, which adds to the complexity of the task when dealing with numerous heterogeneous criminal activities. Structuring complex decisions with the proposed model enables us to better face the intricacy. The proposed approach systematically deals with problem of widespread orders of magnitude of criteria and alternatives. When the sizes are actually very small or very large, the accuracy of *rating alternatives one at a time* is often very low. Through our method, we derive much better accuracy. For further researches, we discuss some scenarios to derive mathematical model/or functions to provide penalty level for each crime by using an optimization model.

Key words: Decision aid, multivariate measurement, crimes, AHP

1. Introduction and objectives

The purpose of our research is to identify and structure different acts of criminality and law violation for the purpose of showing their relationships and deciding on their priorities with the eventual purpose of relating the degree of punishment of all violations in a proportionate way for better justice and greater equality and accountability. In this research, we measure alternatives through detailed relative comparisons on attributes which may vary from moment to moment as actions regularly do.

The outcome would be a table of all criminal acts and the degree of punishment: life, time in incarceration and money as punishment or payment of damages caused accidentally or intentionally. We develop an Analytic Hierarchy Process-based model to encapsulate the relationship between numerous levels of criminal activities committed by people. The criteria employed, and the judgments designated to them in this study are illustrative, not the last word, as the final conclusion requires more participation from rank and file.

2 Research Methodology: Building an AHP Structure to Prioritize Malevolent Acts

When involuntary law violation and random offenses are enacted, litigation should be used to hold perpetrators individually accountable for abuses and defiance, with the goal of advancing the rule of law in the society. In general, the multi-facets of human crimes are difficult to quantify in objective terms. The AHP model discussed in this research creates an ordered ranking that expresses revulsions for different types of wrongdoings. In our society, people may fall victim to crimes in many different forms. They include physical injury, social harm, economic damage, environmental damage, and intellectual offense. Physical Injuries are crimes that cause physical impact or accident which traumatizes or damages the body, and denies people from satisfying their physical needs. Social injury is caused by criminal acts that terrorize the public, and make the society feel insecure and draw a sense of apprehension. It may hurt people's mental capacity, resulting in suffering, upset or distress. Environmental injuries harm the earth and its bionetworks. They cause detriment to nature and natural resources. Finally, economic crime involves financial misconducts against corporate, bank, government (tax evasion, bribery, forgery, counterfeiting). Such economic and financial violation may injure the public or individuals. After identifying the five pertinent evaluation criteria, we identify different types of unlawful behaviors next.

There are multiple levels of crime activities under each evaluation criterion. In ascending order of the crimes' importance to each chosen criterion, we have: 1) Modest acts (minor offenses); 2) Intermediate acts (moderate offenses); and 3) Big acts (serious offenses). For example, under social injury, we divide small acts

into three types, medium acts into two types, and large acts into three types. In this subsection, we distinguish the infringement people make to society. We divide modest acts into three levels, intermediate acts into two levels, and big acts into three levels, and label them S1-S3, M1-M2, and L1-L3, respectively. In ascending order of importance, we have: 1) Modest acts, e.g. Traffic violation, graffiti; 2) Intermediate acts, e.g. larceny, stalking; and, 3) Big acts, e.g. copyright, embezzlement, genocide, hijacking, last two belongs to the L3 crimes under Big acts.

3. Model Analysis: Applying AHP to Prioritizing the Severity of Crime Committed to Society

In Figure 1, multiple criteria are given at the top. For the purpose of illustration, we list the different levels of criminal acts on the bottom with the smallest acts listed first from the perspective of Social Harm. These eight levels of crimes hurt the society in different degree with different level of significance. They cannot be compared directly since the largest act is millions of times more important than the smallest act. A scale of 1 to 9 is not sufficient to represent these differences. Yet, we can compare the alternative in each level (group) to obtain the local priorities, divide by the weight of the pivot in that group, and, to end, multiply by the pivot's weight from the previous group (less sever) to connect the different levels of importance. Eventually, the smallest acts, such as *Graffiti and curfew violation*, end up indirectly compared with the much bigger crimes, such as *Hijacking and Genocide*.

We use the Social jeopardy as a way of illustration. We first compare a crime such as *Simple Assault* with all the modest acts in the same Level S1, such as *Offenses Flag, Gamble Violation*, etc. The act of *Bribery & Corruption* is used again in Level S2, which includes Perjury, and *Wiretapping & Surveillance*. Next, we divide all the local priority in Level S2 by the local priority of *Bribery & Corruption* (0.02), and multiply all the resulting local idealized priorities in this level by the global priority in Level S1 of *Bribery & Corruption* to arrive at the global priority. The priorities of the intermediate acts in S2 and S3 are derived in the same manner. Likewise, we have created a comparison between the smallest *acts of Flag Offenses* and the biggest act of *Hijacking.* For this *Social jeopardy* criterion, we have correspondingly extended the scale beyond 9 to 77,610,488.

Severity of the Crimes that jeopardize the Society

Physical Harm	Environmental Harm	Social Harm	Economic Harm	Intellectual Property damage
S1	Offenses Flag	Gamble Violation	Alimony Violation	Simple assault	Graffiti	Vagrancy	Traffic violation	Bribery & Corruption
S2	larceny	Curfew violation	Perjury	Stalking	Fugitive	Illegal fishing, logging	Wiretapping & Surveillance	Violate immigration law
S3	burglary	Copyright	Forgery and counterfeiting	Wildlife exploitation	Animal Abuse	Drug/liquor law violations	Patent	Embezzlement	Corporate/ white-collar crimes	Espinoage & centsorshi
M1	unlawful carrying Weapons	Money Laundering	Bankruptcy	vandalism	Police Brutality	Modern Slavery	Rape	Torture
M2	street crime	Arson	Computer and Internet Crime	Organized crime	illicit hazardous waste	Abuse & Domestic Violence
L1	Aggravated assault	Robbery	Pollution	Riot, Disorderly Conduct	Smuggling of ODS
L2	Drunk Driving ; DUI	Kidnapping/ Trafficking	Use Explosives	Homicide	Bomb
L3	Hate crimes	War Crime	Genocide	Terrorism Acts	Hijacking

The clustering approach adopted here is critical. For the other three criteria we have built the similar structures with different cluster membership, depending on their similarity in contributing to the goal of the criterion. By multiplying the global ideal priorities with the corresponding criterion weights and summing over the criteria, we are able to determine the overall final scores for each of the 54 activities.

4. Limitations

To empirically verify the soundness of our proposed approach, it will be useful to compare them with the US law so as to validate the potential applicability of our idea and to make the necessary modifications and adjustments to the AHP model.

5. Conclusions

Although various crimes result in different punishment, there has been no openly accepted standard for assessing the gravity of these malevolent acts. Without an objective means to determine the amount of equivalence of intangibles, society cannot be conscious of their true gravity. By the proposed AHP model, we uncover a better approach to assign detriment to malignant deeds taking place in our society. We also structure a mathematical model uses AHP outcome to provide a better justice for each crime.

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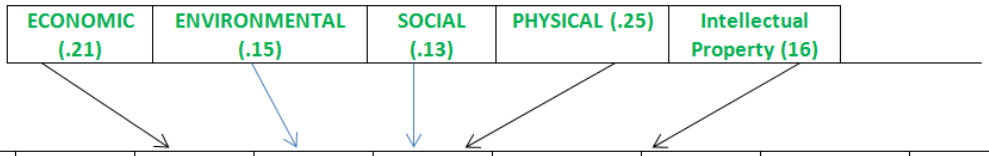
7. Appendices

Figure 2 represents final priorities.

Fig. 2 The Final Priorities of all Types of Crimes



Group 1	Offenses flag	Graffiti	Curfew violation	Perjury	Corporate &White collar crimes	Violate immigration law	Unlawful carrying weapons	Espionage & Censorship	Wiretapping
Global ideal	1.00	9.48	17.89	175.34	282.28	452.14	545.35	665.63	1,093

Group 2	Copyright	Vagrancy	Bribery & Corruption	Illegal fishing, loging	Animal abuse	Alimony violation	Drug & Liquor law violations	Gamble violation	Traffic violation
Global ideal	1,724	2,035	2,260	2,405	2,654	3,024	3,666	5,156	5,759

Group 3	Fugitive	Street crime	Simple assault	Larceny	Stalking	Computer& Internet crime	Patent	Burglary	Modern slavery
Global ideal	5,834	6,881	7,700	9,391	10477,	11,301	12,070	15,072	34,173

Group 4	Forgery & Counterfeiting	Vandalism	Illicit hazardous waste	Torture	Wildlife exploitation	Embezzlement	Aggravated assault	Police brutality	Pollution

A TWO-PHASED MULTIOBJECTIVE MODEL FOR A SERVICE SYSTEM
- An Application for a Touring Company

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ABSTRACT

Customer satisfaction is one of the most important factors for institutions considering with the competition among companies, especially for the service systems. This project proposes a methodology to assign customers of a tour company to its negotiated hotels.We take into account customer satisfaction by considering their preferences for hotels they want to stay. Two objectives are defined. First is the minimization of the deviation variables from the preference constraints. Second is assigning the same group of customers to the hotels which have the higher level quality as much as possible. The motivation of defining this multi objective case is due to this fact: Sometimes customers fail to decide their preferences related to hotels, by mostly preferring the low-price ones. On the other hand, tour companies have more experience; this study proposes a two-step methodology by re-assigning them to the hotels considering the hotel quality among their preferred ones, by using preemptive goal programming. Analytic Network Process is used to determine the hotel quality weights. We have not come across a similar study in this area, therefore the proposed methodology could be a motivation for future researches.

Keywords: ANP, goal programming, hotel service quality.

1. Introduction

Today, service industries is viewed as an economic development leader. Especially great importance is given to health services. Thermal tourism is a sub-branch of health services and needs to be developed in Turkey. These facilities' service quality and customer satisfaction is the most critical point before reaching the destination. For this purpose, a model has been proposed for a tour company to assign its customers to thermal hotels considering customers preferences and satisfaction. Customer satisfaction is achieved considering the hotel weights that is obtained by an ANP model.

2. Literature Review

Hsieh and others (2008), use ANP for measurement architecture for hot spring hotels in Taiwan. Chen and others (2011), proposed a hybrid MCDM method for evaluation of hot spring hotels. They used balanced scorecard approach, ANP and DEMATEL for the evaluation. Rouyendegh and Erkan (2010), used Data Envelopment Analyses (DEA) and AHP for evaluating hotel performances.

3. Hypotheses/Objectives

Although there has been many studies about the measurement the quality of the hotels using MCDM methods, we don' t come across a study related to assigning customers to hotels considering customers preferences and satisfaction by a multiobjective model.

4. Research Design/Methodology

Tour companies, hotels and thermal tourism-related people were consulted when determining alternatives and criteria. Super Decision software was used to structure an ANP model for this study.

Our methodology consists of two steps, first mathematical model assigns customers to the hotels by considering their preferences, then second model reassigns the same group of customers to their preferred hotels defined by the first model, by maximizing the assigned hotel quality. Hotel priorities are the outcome of the ANP model developed for this study. To maximize an aggregation function that shows the quality levels of the hotels assigned, we propose a goal programming model which minimizes the deviations on the assignments from the mostly preferred hotels.

5. Data/Model Analysis

Mathematical model, Goal Programming approach and ANP are used to solve the problem. Super Decision screenshot for ANP model and the mathematical model was given, in Figure 1(a) and (b), respectively.

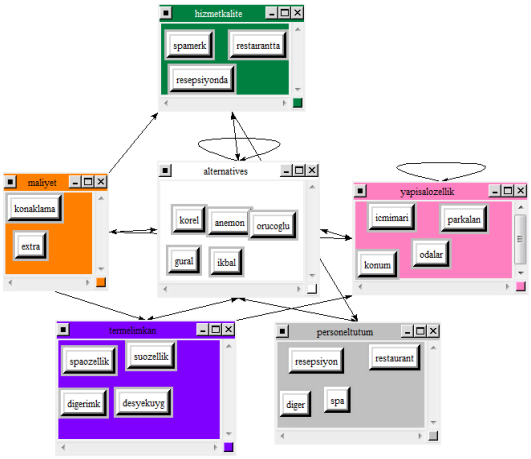

Figure 1 (a)

$$\text{Min } Z = \sum_i \sum_j s_{ij}$$

$$\text{Max } Z = \sum_i \sum_j w_i x_{ij}$$

$$\sum_j n_j x_{ij} \le \text{Cap}_i \qquad \forall (i)$$

$$\sum_i x_{ij} = 1 \qquad \forall (j)$$

$$x_{ij} - s_{ij} \le P_{ij} \qquad \forall (i, j)$$

$$s_{ij} \ge 0 \qquad \forall (i, j)$$

$$x_{ij} \in \{0, 1\}$$

Figure 1 (b)

6. Limitations

The validity of an ANP model comes from the expert knowledge used, as much as the model size. Our model considers expert information as well as the customer preferences. Besides mathematical model developed is able to solve the real life problems up to very large groups. Problem is not considered as NP-hard. We say that proposed methodology can be used for similar problems without very less limitation.

7. Conclusions

In this study, problem of assigning the customers to hotels for a tour company is investigated. Both multiobjective mathematical model and ANP are used. The first objective ensures customers' preferences, and the second objective maximizes customer satisfaction by assigning them to high service quality hotels. Since customer satisfaction is one of the most important criterion in today's competitive environment, our study, completed by being motivated from this, hopefully could be an encouraging work for further studies to the researchers.

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A TWO-PHASED SOLUTION METHODOLOGY FOR CAPACITATED_MULTI VEHICLE ROUTING PROBLEM WITH TIME WINDOW AND CUSTOMER PRIORITIES
- A case for Pharmacy routing

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ABSTRACT

Vehicle routing problems, attempt to define optimal delivery methods of goods to places, attract considerable attention because of their implications for delivery businesses. Their inevitable goal usually is the minimization of travelling distance or travelling cost. In this study, we propose a different objective function which aims to reach some prioritized delivery points as early as possible. To determine the pharmacies have the higher priority, we propose an Analytic Hierarchy Process model. Time window is already in use as a criterion for routing problems but our motivation comes from two different perspectives: First, providing specific delivery times may not conclude with applicable routes, deliver the goods as soon as possible could be preferable, and second the way to prioritize delivery points which have not be considered by now, need some systematic procedures. Proposed two-phased model is solved for a pharmacy chain, promising outcomes are achieved.

Keywords: Vehicle Routing Problem, Time Window, ANP, Customer Priorities

1. Introduction

The vehicle routing problem with time window (VRPTW) is a well known optimization problem. In addition to the capacity constraint, a vehicle has to visit a customer with a certain time frame. The vehicle may arrive before time window opens but cannot be serviced until the time windows open. It is not allowed to arrive after the time window has closed (El-Sherbeny, 2010). We consider a real life pharmacy routing problem with some customer priorities and time windows. Our motivation comes from the need of arriving to some pharmacies earlier than some others have less priority. In order to prioritize the customers which are some local pharmacies in our case, we use an ANP model. The outcome of the model is then incorporated to the optimization model, already in use in the literature but is modified in terms of objective function for our case. This presents the contribution of our work.

2. Literature Review

As an extension of well-known VRP, VRPTW is commonly studied in the literature. Besides the minimization of the total travelling distance (Oliveira and Vasconcelos, 2008; Ombuki et al., 2006), various objectives are also considered such as; number of vehicles, total duration of the routes, total waiting times due to time windows constraints etc. Additionally, VRP combined with multi criteria techniques are also used in the recent studies. Sattayaprasert et al. (2008) discussed an application of Hazardous Materials Routing considering prioritization with AHP. A multi-objective dynamic vehicle routing problem with fuzzy time windows is presented by Ghannadpour et al. (2014). This model involves routing vehicles according to customer-specific time windows, which are highly relevant to the customers' satisfaction level.

3. Objectives

The aim of this study is to develop a solution methodology for VRPTW with customer priorities. We propose an ANP model in order to prioritize the customers which are some local pharmacies, then presenting a mathematical model that uses the outcome of this ANP model, for routing.

4. Research Design/Methodology

We proposed a two phased approach to define the best route for a pharmacy depot. First step prioritizes the pharmacies (customers) by using an ANP model, then a VRPTW mathematical model is solved which characterizes the second step of the methodology.

5. Data/Model Analysis

Figure 1 (a) represents the ANP model. The VRPTW mathematical formulation, used by Cordeau et al (2001), modified by describing a different objective function for this study, is presented in (b). Proposed objective function takes into account the pharmacy priorities in such a way that the higher prioritized one is preferred to have the earlier delivery service. Model achieves this goal by presenting a time window for each pharmacy. The

binary variable x_{ijk} assumes a value of 1, if the vehicle k traverses arc (i; j); and 0, otherwise.

Figure 1 (a) ANP Model

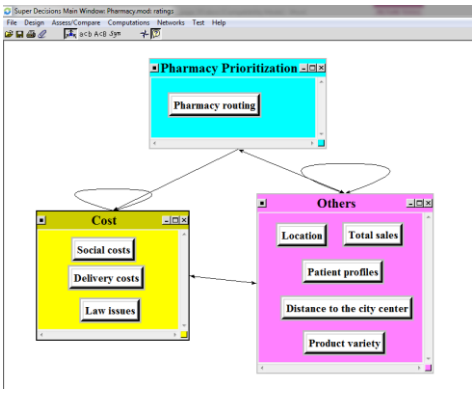

Figure 1 (b) Mathematical Model

$$\sum_{k\in K}\sum_{j\in V} x_{ijk} = 1 \qquad \forall i \in N$$

$$\sum_{j\in V} x_{0jk} = 1 \qquad \forall k \in K$$

$$\sum_{i\in V} x_{ijk} - \sum_{i\in V} x_{jik} = 0 \qquad \forall k \in K, \forall j \in N$$

$$\sum_{i\in V} x_{i(n+1)k} = 1 \qquad \forall k \in K$$

$$\sum_{i\in N} q_i \sum_{j\in V} x_{ijk} \le Q \qquad \forall k \in K$$

$$b_{ik} + d_i + t_{ij} - (1 - x_{ijk})M_{ij} \le b_{jk} \qquad \forall k \in K, \forall (i,j) \in A$$

$$e_i \le b_{ik} \le l_i \qquad \forall k \in K, \forall i \in V$$

$$x_{ijk} \in \{0,1\} \qquad \forall k \in K, \forall (i,j) \in A$$

We obtained Pharmacy priorities by using an ANP model via Ratings since we have 231 Pharmacies. Figure 2 (a), (b) and (c) show a partial view of criteria weights, ratings model and Pharmacies' overall priorities, respectively.

Figure 2 (a)

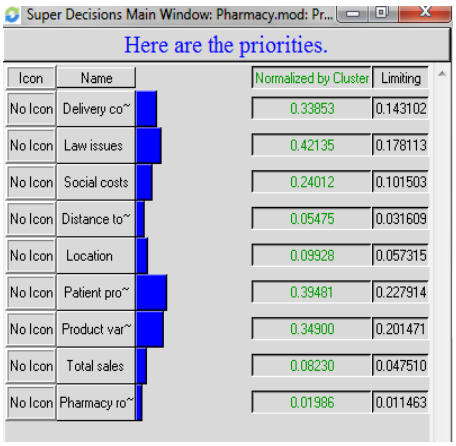

Figure 2 (b)

	Deliv 0.14						Total sales 0.04806
Pharmacy 1	Low	Medium	Close	Simple	Average	Far	Complex variety 3
Pharmacy 2	High	High	Close	Simple	Average	Average distan	Above average 1
Pharmacy 3	Low	Low	Reasonable	Average	Needs seriosity	Far	Complex variety 2
Pharmacy 4	Low	Low	Reasonable	Average	Average	Average distan	Smooth 1
Pharmacy 5	Low	Medium	Far	Simple	Average	Close	Complex variety 2
Pharmacy 6	Low	Medium	Far	Simple	Easily handlable	Close	Smooth 3
Pharmacy 7	Medium	Medium	Far	Intensity Varied	Easily handlable	Average distan	Smooth 4

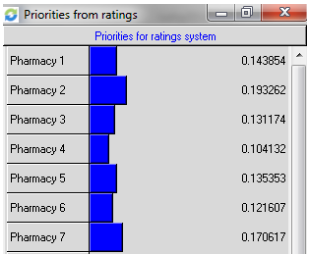

Figure 2 (c)

6. Limitations

The ANP priorities are strictly up to the analysis in accordance with information gained from experts. Here required paired comparisons are performed via expert chemists. Besides, since the model has NP-hard characteristic, as the model size gets bigger, it becomes hardly solvable. In our case, mathematical model has a reasonable size to obtain optimum solution. On the other hand, for larger instances, heuristics approaches could be needed.

7. Conclusions

In this work, by prioritizing the pharmacies in a local area via ANP, the proposed study of this paper has implemented a VRPTW to investigate the best route for a real life case by using a mathematical model. We don't come across a study that prioritizing the pharmacies on related routing problems which was our motivation.

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