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by Hayati Asih

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A combine MCDM and robust optimization approach for capacity planning

Muhammad Faishal[1,2,], Effendi Mohamad[1,*], Hayati Mukti Asih[2], Azrul Azwan Abd Rahman[1]

[1)] Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[2)] Jurusan Teknik Industri, Fakultas Teknologi Industri, Universitas Ahmad Dahlan Jl Ringroad selatan, Banguntapan, Bantul, Yogyakarta, Indonesia.

*Corresponding e-mail: effendi@utem.edu.my

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ABSTRACT –An electronic company has difficulty managing capacity determination in the final product testing process due to demand uncertainty, high costs and rapid changes in the technology applied. This study aims to help decision makers to determine the optimal strategy with the Multi Criteria Decision Making (MCDM) and Robust Optimization (RO) approaches. In the RO model, there are various scenarios that represent the deviation of demand uncertainty. And the AHP model is used to choose the best scenario. The results show, if the company wants to fulfill consumer demand, scenario 2 is the best with the highest Final Combined Priority.

1. INTRODUCTION

Due to erratic demand and capacity, the company has difficulty determining the amount of equipment to be installed, especially the characteristics of the product itself that has a variety of mixed products, short product life and also long lead times. This has become a very important issue in the framework of companies investing capacity to be able to meet customer demand [1]. Therefore, accurate estimation of the amount of capacity needs to be done to avoid underutilizing the use of equipment or lack of capacity [2]. This condition can make the process of multi-criteria decision-making (MCDM) involving trade-offs between the amount of capacity to be paired with meeting the demand.

Lou et al. [3] have developed a robust pair of discrete deterministic network designs for uncertain demand conditions. There are several scenarios of various levels of conservatism - to estimate the investment needed to improve the network to meet certain service level requirements. Yin et al. [4] offers a robust model for estimating the amount of investment that must be spent in the face of uncertain conditions of demand for travel companies with uncertain facility conditions as well.

Based on observations in the production process and from discussions with managers, PPIC, factory supervisors and workers on the production line it was found that the characteristics of conditions in this factory area are quite complicated. The installed automatic tester has nearly three thousand slots that can load many product families simultaneously. In addition, there are more than fifteen models in all product families with different testing durations. In addition, for high product varieties, each product family has a different production process flow, making the problem more complicated

2. METHODOLOGY

2.1 Robust optimization (RO)

RO is the latest approach to optimize decisions because of uncertainty. In this modeling framework, uncertain requests are assumed to be limited to a series of uncertainties and then the number of testers is optimized for the worst demand scenario realized from the set [3][5]. In this section, RO models for uncertain capacity planning have been formed [6]. This model is used to evaluate production capacity in uncertainty. This results in several alternatives with various criteria that make it difficult to choose decisions as shown in Table 1 below.

Table 1 Model RO results by Eng & Asih [6]

Level of conservatism (Γ)	Number of machine (units)	The prob. of meet demand (%)
0 (deterministic)	28	65.35%
1	33	82.63%
2	41	91.53%
3	44	97.42%
4 (worst scenario)	50	100%

2.2 Multi criteria decision making (MCDM)

Multi Criteria Decision Making (MCDM) is a sub-discipline of operations research to assist in decision making which is useful for evaluating several criteria with various objectives. [7]. There are several techniques used in MCDM, such as, Analytic Hierarchy Process (AHP). According to Patrovi [8] one of the advantages of AHP is being able to measure the extent of the level of comparison consistently (called consistency ratio (CR)). Figure 1 below shows the AHP model for structuring problems hierarchically.

3. RESULTS AND DISCUSSION

Absolute measurement methods are applied in this study to rank values. According to Chen et al. [9], the criterion value is classified based on the very high, high, average, low and extreme low level of impact. Pair-wise comparison is done to get the priority of each class as shown in Table 2.

Then, a hierarchy of capacity planning issues is formed. On the criteria of the difference in the number of machines when $\Gamma = 0$ is 0, it means the value of pair-wise is 0.513, and so on. Likewise, the value of pair-wise on the probability difference criteria fulfilment of consumer desires. The combined priority matrix for the two criteria is shown in Table 3.

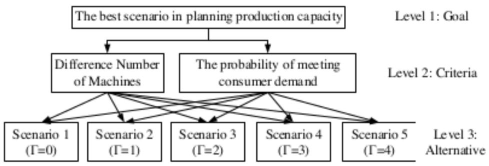

Figure 1 AHP model.

Table 2 Pairwise comparison of AHP techniques.

Grade	Very high	High	Average	Low	Very low
Priority	0.513	0.261	0.129	0.063	0.033

Table 3 Hierarchy of capacity planning problems.

Criteria	Difference Number of Machines	Probability of meeting demand
	(Investment -oriented)	(Oriented to customer satisfaction)
Scenario / Level Conservatism	**Combined Priority Matrix**	
Scenario 1 (Γ=0)	0.513	0.033
Scenario 2 (Γ=1)	0.129	0.513
Scenario 3 (Γ=2)	0.033	0.261
Scenario 4 (Γ=3)	0.261	0.129
Scenario 5 (Γ=4)	0.063	0.063

At the final combined priority, several weights are implemented for each criterion (ie the difference in the number of machines: the difference in the probability of meeting consumer demand) such as 0.5: 0.5, 0.25: 0.75, and 0.75: 0.25. For example, for weights of 0.25: 0.75, the final combined priority in scenario 2 ($\Gamma = 1$) is $0.129 \times 0.25 + 0.513 \times 0.75 = 0.417$. The same is true for other weights and scenarios. Based on the calculation of the final combined priority, at weights 0.5: 0.5 and 0.25: 0.75, scenario 2 is the highest. Whereas in the weight of 0.75: 0.25, scenario 1 is the highest. In essence, the proposed model uses AHP to rank by combining existing criteria. This model can produce different capacity plans by changing criteria or adjusting criteria weights.

Table 4 Final combined priority.

Scenario / Level of Conservatism	Final Combined Priority		
	0.5 : 0.5	0.25 : 0.75	0.75:0.25
Scenario 1 (Γ=0)	0.273	0.153	0.393
Scenario 2 (Γ=1)	0.321	0.417	0.225
Scenario 3 (Γ=2)	0.147	0.204	0.09
Scenario 4 (Γ=3)	0.195	0.162	0.228
Scenario 5 (Γ=4)	0.063	0.063	0.063

4. CONCLUSIONS

An integration of RO and AHP is applied in order to determine how much the optimal number of machines must be installed in conditions of uncertain demand. In the RO model, there are several scenarios that represent the deviation of the magnitude of the demand value to the specified uncertainty. And the AHP model is used to choose the best scenario for the RO model from two conflicting criteria with different weightings. The two criteria are the difference in the number of machines and the difference in the probability of meeting consumer demand. The model proposed in this research considers different weights for each criterion which wants to emphasize criteria that will increase customer satisfaction or increase investment costs to be undertaken by the company or a draw between the two. This can assist managers in making decisions for production capacity planning when consumer demand is uncertain.

For further work, other decision-making tools for selecting an appropriate scenario of various degrees of conservatism can be employed. Also, the comparison of the results of the TOPSIS method with other methods is suggested.

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