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Research paper

Strategic Plan Using Tsukamoto Fuzzy Model and VRIO THES Approaches

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Abstract

The advantage competitive is always being an issue to improve the capability of the institution even the higher education. So higher education needs to evaluate its capabilities in facing this issue so the higher education could determine its strategic plan. This paper aims at applying the Tsukamoto method in fuzzy logic to measure the implementation of a strategic plan that combined with the valuable, rareness, inimitability, and Organize (VRIO). The VRIO is an approaching that is capable to describe the competitive advantage significantly and the strategic plan in Times Higher Education Supplement (THES) is to obtain the ranking of the universities. The combination among fuzzy, VRIO framework, and THES is making a new concept in evaluating and arranging the strategic plan, especially in the university.

Keywords: *Fuzzy; THES; Tsukamoto; Strategic Plan; VRIO.*

1. Introduction

A fuzzy logic is the innovation of the Boolean logic which introduces a part of the truth concept. In the classical logic stated that all of the things that can be expressed in the term of binary (false or true, 0 or 1, etc.). The Fuzzy logic is representing the Boolean truth with the truth level. The Fuzzy logic is possible to represent the membership value between 0 and 1, grey level and also black or white, or in the linguistic representation, the concept of uncertainty like little, less, very, strong, weak, etc. It is related to the set fuzzy and the uncertainty theory. The Fuzzy was introduced by the Dr. Lotfi Zadeh from the California University, Berkeley in the year of 1965 [1].

The reasons using the Fuzzy logics are this logic is simple to be understood since the mathematics concept that bases of this logic is simple and understandable. This logic also has a flexibility, tolerance with the inappropriate data, and capable to model nonlinear functions those are very complex. The fuzzy logic can construct and apply the experience of the expert directly without having to pass the learning process, and this logic can work together with the conventional control techniques.

The first implementation of the Fuzzy logic was in the year of 1990, it was built in the washing machine. The Matsushita Electric Industrial Company, one of the companies in Japan, employed the Fuzzy logic to determine the right rotation automatically based on the types and numbers of dirty and the numbers of that would be washed. This machine was applying an optical sensor that lights to the water and measures how the light could reach the other position. The dirtier the water, the lights got dimmer. Meanwhile, the system could also determine the dirty type. In the next development. The Fuzzy logic has been employed in many applications like cars in the automatic transmission that can save on gasoline, the biology and medical for diagnosing diseases, the environmental science to control the water quality, weather prediction, earthquake prediction, and so on.

This paper addresses at the applying of the Tsukamoto method in the implementation of the strategic plan that combined with the valuable, rareness, inimitability, and Organize (VRIO). The VRIO is an approaching that is capable to describe the competitive advantage significantly [2-3]. and the strategic plan in Times Higher Education Supplement (THES) is to obtain the ranking of the universities. The concept of Fuzzy VRIO-THES has been built by [4], but it needs more developing in methods especially in deploying fuzzy logic.

2. Tsukamoto Fuzzy Model in VRIO

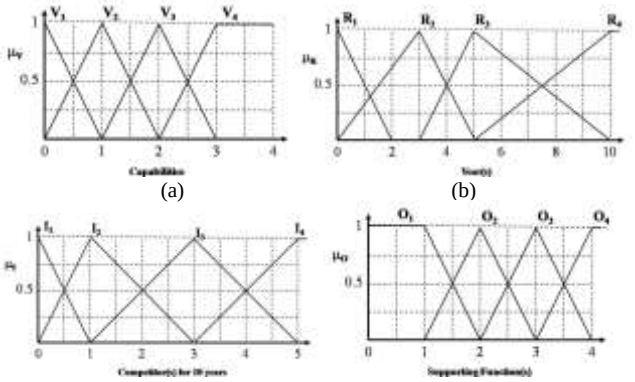
At the crisp set, the membership of item x within a set A can be written as $\mu_A[x]$ and it has 2 possibilities which are values of 1 and 0. The value of 1, it means that the x is the membership A, while the value of 0, it is not. So if the set has a universe membership as {0, 1, 2, 3, 4, 5, 6} and the membership A consists of {0, 1, 2, 3} whereas the membership B consists of {3, 4, 6} then it can be said that the membership of 1 at the A is $\mu_A[1] = 1$ because $1 \in A$. While the membership of 5 at the B is $\mu_A[5] = 0$ because $5 \notin A$. So if x has a value of fuzzy membership $\mu_A[x] = 0$ means that x is not becoming a member of the set membership A, similarly if x has a value of fuzzy membership $\mu_A[x] = 1$ means that x is a full member of the set membership A.

The examples of the variable in the fuzzy system are weather, velocity, acceleration, etc. While the example of the fuzzy set is the weather variables divided into 3 fuzzy set i.e. cold, warm, and hot. The fuzzy set itself has 2 attributes which are linguistic and numeric. The linguistic is naming a group representing a such condition e.g. cold, warm, and hot. Meanwhile the numeric is a size of such variables e.g. 1, 2, 3, etc. The universe set is all value

that can be operated in a fuzzy variable e.g. universe of temperature variables e.g. [0, 100]. The domain of the fuzzy set is all of the values allowed in the universe and could be operated in the fuzzy set e.g. cold = [0, 60], warm = [50, 60], and hot = [80, +∞]. The logic operation is an operation combining and modifying 2 or more fuzzy sets. The new membership value of the two sets operation result is known as firing strength or $\alpha_{predicate}$. There are 3 basic operations that have been proposed by Dr. Lotfi Zadeh i.e.

1. AND Operator
   It is related to the intersection operation in the set. The $\alpha_{predicate}$ is obtained with taking the minimum value of the two sets that can be written as,
   $$\mu_{A\cap B} = \min(\mu_A[x], \mu_B[y])$$
   Example if the membership value of x is $\mu_A[x]$ = 0.6 and the membership value of y is $\mu_B[y]$ = 0.8, then the $\alpha_{predicate}$ for x and y is the minimum membership value that can be taken as,
   $$\mu_{A\cap B} = \min(\mu_A[x], \mu_B[y])$$
   $$\mu_{A\cap B} = \min(0.6, 0.8)$$
   $$\mu_{A\cap B} = 0.6$$
2. OR Operator
   It is related to the union operation in the set. The $\alpha_{predicate}$ is obtained with taking the maximum value of the two sets that can be written as,
   $$\mu_{A\cup B} = \max(\mu_A[x], \mu_B[y])$$
   Example if the membership value of x is $\mu_A[x]$ = 0.6 and the membership value of y is $\mu_B[y]$ = 0.8, then the $\alpha_{predicate}$ for x and y is the minimum membership value that can be taken as,
   $$\mu_{A\cup B} = \max(\mu_A[x], \mu_B[y])$$
   $$\mu_{A\cup B} = \max(0.6, 0.8)$$
   $$\mu_{A\cup B} = 0.8$$
3. NOT Operator
   It is related to the complement operation in the set. The $\alpha_{predicate}$ is obtained with subtracting the element membership value in the set of 1 that can be written as,
   $$\mu_A'[x] = 1 - \mu_A[x]$$
   Example if the membership value of x is $\mu_A[x]$ = 0.6, then the $\alpha_{predicate}$ for x can be taken as,
   $$\mu_A'[x] = 1 - \mu_A[x]$$
   $$\mu_A'[x] = 1 - 0.6$$
   $$\mu_A'[x] = 0.4$$

Generally, the fuzzy logic has 4 steps in solving the problems, i.e. fuzzification, inference, composition, and defuzzification. The crisps of the Fuzzy and VRIO from the concept have been modeled as figure 1 respectively [4].



(a) (b) (c) (d)

Fig. 1: (a) The crisps of valuable, (b) The crisps of rareness, (c) The crisps of inimitability, and (d) The crisps of Organize.

The results from the fuzzy crisps will be referenced with the fuzzy rules. The results of the competitive advantage impacts that are outputs of the VRIO framework consist of sustained (S), temporary (T), parity (P), and disadvantage (D). The VRIO framework is shown in figure 2.

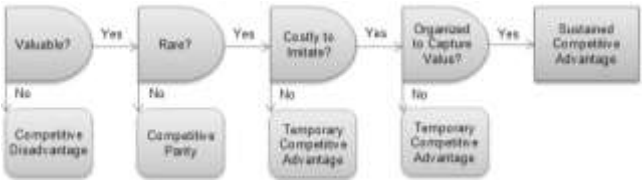


Fig. 2: VRIO framework

The results of the competitive advantage impacts in Fuzzy logic are shown in figure 3.

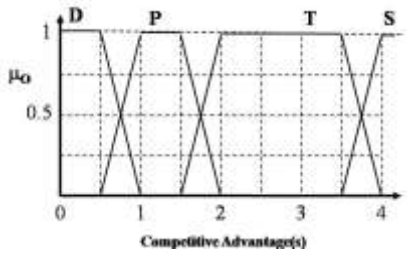


Fig. 3: Results of the competitive advantages

In the Tsukamoto Fuzzy model, the inference process is done by the rule of IF-THEN and using operation of AND where it will be chosen the minimum value (MIN) between four variables existed. For some cases, the result of prediction is accurate when using Tsukamoto model [5]. This model could also provide a worthiness value varying [6]. The fuzzy rules that are made using input variables consist of the VRIO model and using the output variable of the competitive impact of the strategic planning. The format of rules that are determined can be described as equation 1.

$$[\pi] \; IF \; x_{ij} \text{ is } A_{ij} \lozenge \ldots \lozenge x_{in} \text{ is } A_{in} \; THEN \; recommendation \text{ is } B_i \qquad (1)$$

Definition 1: *The π_i is a fuzzy rule i^{th} (i=1…m), the x_{ij} is weights of the variables j^{th} that are relevant with the rule i^{th}, A_{ij} is a fuzzy set for weights of variables j^{th} that are relevant to the rule ith, the symbol $\lozenge$ is an operator that can be used, it could be AND/OR, n is number of variables that are relevant with the rule i^{th}, and B_i is a fuzzy set for recommendation variables at the rule i^{th}.*

The examples of fuzzy rules used for determining the strategic plan in collaborating with the VRIO framework is shown in table 1.

Table 1: Examples of fuzzy rules

i	Rules (τ)
1	IF V_4 AND R_4 AND I_4 AND O_4 THEN S
2	IF V_4 AND R_4 AND I_4 AND O_3 THEN T
3	IF V_4 AND R_4 AND I_4 AND O_2 THEN T
4	IF V_4 AND R_4 AND I_4 AND O_1 THEN T
5	IF V_4 AND R_4 AND I_3 AND O_3 THEN T
6	IF V_4 AND R_4 AND I_3 AND O_2 THEN T
7	IF V_4 AND R_4 AND I_3 AND O_1 THEN T
8	IF V_4 AND R_4 AND I_2 AND O_1 THEN T
9	IF V_4 AND R_3 AND I_3 AND O_3 THEN P
10	IF V_4 AND R_3 AND I_3 AND O_2 THEN P
11	IF V_4 AND R_3 AND I_3 AND O_1 THEN P
12	IF V_4 AND R_3 AND I_2 AND O_1 THEN P
13	IF V_4 AND R_2 AND I_2 AND O_2 THEN P
14	IF V_4 AND R_2 AND I_2 AND O_1 THEN P
15	IF V_4 AND R_1 AND I_1 AND O_1 THEN P
16	IF V_3 AND R_3 AND I_3 AND O_3 THEN D
17	IF V_2 AND R_2 AND I_2 AND O_2 THEN D
18	IF V_1 AND R_1 AND I_1 AND O_1 THEN D

The combination between both the Fuzzy rules that have been made and the VRIO framework can strength the recommendation results.

3. THES

Times higher education or also known as the times higher education supplement (THES) was coming from the supplement of the TIMES Magazine. It is known for publishing the annual times higher education-QS world university rankings. The THES elements contain performances, criteria, and weights [7]. These elements can be shown in table 2.

Table 2: THES: Performances, Criteria, and Weights

No.	THES		
	Performances	Criteria	Weights
1	Teaching – the learning environment	a. Reputational survey - teaching	0.15
		b. Ph.D. awards per academic	0.06
		c. Undergraduates admitted per academic	0.045
		d. Income per academic	0.0225
		e. Ph.D. awards/bachelor's awards	0.0225
2	International outlook – staff and students	a. The ratio of international to domestic staff	0.03
		b. The ratio of international to domestic students	0.02
3	Research – volume, income, and reputation	a. Reputational survey - research	19.5
		b. Research income (scaled)	0.0525
		c. Papers per academic and research staff	0.045
		d. Public research income/total research income	0.75
4	Citations – research influence	Citation impact (normalized average citations per paper)	0.325
5	Industry income - innovation	Research income from industry (per academic staff)	0.025

The THES can be accessed at the link of https://www.timeshighereducation.com.

4. Discussion

By utilizing Fuzzy-VRIO which is defined in the modeling, a Fuzzy-VRIO THES model is obtained as shown in table 3.

Table 3: Fuzzy-VRIO THES

No.	THES Analysis			Fuzzy			
	Performances	Criteria	Weights	V	R	I	O
1	Teaching – the learning environment	a. Reputational survey - teaching	0.15				
		b. Ph.D. awards per academic	0.06				
		c. Undergraduates admitted per academic	0.045				
		d. Income per academic	0.0225				
		e. Ph.D. awards/bachelor's awards	0.0225				
2	International outlook – staff and students	a. The ratio of international to domestic staff	0.03				
		b. The ratio of international to domestic students	0.02				
3	Research – volume, income, and reputation	a. Reputational survey - research	19.5				
		b. Research income (scaled)	0.0525				
		c. Papers per academic and research staff	0.045				
		d. Public research income/total research income	0.75				
4	Citations – research influence	Citation impact (normalized average citations per paper)	0.325				
5	Industry income - innovation	Research income from industry (per academic staff)	0.025				

By modifying Tsukamoto's method on Fuzzy logic where each conclusion of each IF-THEN rule must be represented by a Fuzzy set with a monotonous membership function. The results obtained in the form of output from the inference of each rule are given crisp based on the $\alpha_{predicate}$ and then calculate the weighted average. Tsukamoto's model for searching for this $\alpha_{predicate}$ is written according to equation 2.

$$\alpha_{\text{predicate}} = \min\left(\mu_V \cap \mu_R \cap \mu_I \cap \mu_O\right) \tag{2}$$

After getting the crisp based on the $\alpha_{\text{predicate}}$, then determine the membership level for each category and look for all the variable values. The next step is to calculate the mean value, ψ, of all the weighted variable values, ϖ, as shown in equation 3.

$$\psi = \frac{\sum_{i=1}^{n} \alpha_{predicate_i} . \varpi_i}{\sum_{i=1}^{n} \alpha_{predicate_i}} \tag{3}$$

Then the mean value is multiplied by the weight according to the percentage of weight given by the THES model in table 1, δ, as written according to equation 4.

$$FuzzyVRIOTHES = \psi.\delta \quad (4)$$

5. Conclusion

From the discussion can be concluded that the Tsukamoto Fuzzy model has been functioned effectively in easing the solution. The collaboration between the VRIO framework and Fuzzy logic is capable to increase the flexibility in the recommendation. When it is combined with the THES that the results of the Fuzzy and VRIO are multiplied with it, the formula of the fuzzy-VRIO THES can be modeled as equation 4. The future work of this method is a comparison with other fuzzy methods. So the effectiveness and efficiency of the evaluation can be measured well in increasing the university rankings.

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